MASTER THESIS

A Strategy
for Procurement of Natural Gas
at Royal FrieslandCampina

Industrial Engineering & Management
Financial Engineering

2015

J.R. Willemink

Supervisor University of Twente: Reinoud Joosten
Supervisor II University of Twente: Henk Kroon
Supervisor Royal FrieslandCampina: Tim Schröder

The study is performed at the Head Office of FrieslandCampina in Amersfoort, The Netherlands. Support is provided by the University of Twente.
Management Summary

The purpose of this Master Thesis is to develop an improved Purchasing Strategy for Natural Gas at FrieslandCampina, including a review on Risk Management and a tool which supports in purchasing decisions. The current Purchasing Strategy has been developed more than five years ago by the predecessor of Category Manager Utilities Schröder, and the Natural Gas Market in Europe has been changed since then. Moreover Risk Management is not incorporated in the current Purchasing Strategy.

To come to recommendations regarding the Purchasing Strategy of Natural Gas at FrieslandCampina, the followings steps are made during the project:

- Review of Literature about Commodity Procurement.
- Description of the development of the Natural Gas Market in Europe and the current Market Dynamics in Supply and Demand.
- Research about Purchasing Strategies of other comparable industrial users, like Cargill, Heineken, Tata Steel, Yara, KPN, and NS.
- Review of the Purchasing Strategy of FrieslandCampina, by gathering and analysing historical demand figures, analysing historical purchasing performance, and backtest other Purchasing Strategies on historical market data.
- Development of a Purchasing Decision Support Tool, which can recognize low market moments in historical market data, by making use of Technical Analysis indicators.

The most important results and conclusions from this research are:

- The European Natural Gas Market is in development and subject to changes. A shift is taking place from Oil-indexed pricing to pricing via exchanges like ICE Endex. Furthermore world’s capacity of Liquid Natural Gas is expected to increase dramatically, which can have huge influence on the European Natural Gas Market.

- Other industrial users of Natural Gas mainly focus on hedging their commodity price risks. The main driver for the chosen Strategy by other companies is the (un)certainty of demand. FrieslandCampina is best compared with Heineken.

- Until the appointment of Schröder, the Purchasing Strategy was not followed by FrieslandCampina. Backtesting shows that the current Purchasing Strategy limits opportunities to make use of good market moments and gives financial risks in the stochastic (Profile) part of the forecasted demand.

- The Purchasing Decision Support Tool based on Relative Strength Index and Moving Average Relative Strength Index outperforms the market on seven years of historical data by an average of €2,523,762 per year, calculated on FrieslandCampina’s demand.

I recommend to change the current Purchasing Strategy to a Purchasing Strategy which has more space for opportunities on the long-term and a tightened bandwidth closer to maturity. More attention is needed on the stochastic Profile part of the demand. Furthermore I recommend to use the Purchasing Decision Support Tool as a support in daily buy-decisions.
Preface

In August 2014 I started a journey at the Procurement Department of FrieslandCampina. For me this was an acquaintance with procurement, with a large corporate, and with the Natural Gas-, Electricity- and Oil-market. I have seen a lot, I have learned a lot, and I have enjoyed it a lot.

Therefore I want to thank at first my supervisor at FrieslandCampina, Tim Schröder. Tim, you were a real mentor to me. You gave me insight in the world of Procurement, and you gave me the opportunity to do a Master Thesis Project with serious business impact. Besides my thesis, you gave me the opportunity to set up and support projects in Veghel and Beilen, and the opportunity to support in market analysis and buy-decisions. You also gave me insight in how to act in the political arena of a multinational company. I am sure these lessons will be valuable for me in my further career. Finally we made a lot of fun together during meetings, lunches, and drinks. Thanks for the fantastic time.

Secondly I want to thank my first supervisor from the University of Twente, Reinoud Joosten. Reinoud, you always had a critical view, in a positive sense. You pushed me to develop the Purchasing Decision Support Tool. Without your encouragement it probably would not have been more than a fantasy. I think my style of writing and the style of the paper have been improved a lot after your comments, and these tips will definitely help me as well in the future. Finally the meetings were always nice and fun. We talked about everything and the meetings could last easily for two hours or more. Thanks.

Henk Kroon, you joined in the last period of my thesis. Nonetheless you have given me useful comments, from another perspective as Reinoud and Tim. These remarks have helped me think again about the structure of the report, which I believe, improved the readability of this report. Thanks.

I also want to thank Pim Spackler and Nick Huffmeijer from EnergieMakelaar. Pim for the insight and knowledge about Energy markets and Nick for the always fun analysis-meetings about the Energy Market.

Furthermore thanks to some friends who have read this paper and made comments: Jasper Veurink, Bas van Baar, and Patrick Bonouvrie.

Finally I would like to thank my parents. Thanks for the patience during my whole study time, for supporting me in my decisions, and giving me the space to fill up my student life on my own way.

Arno,

Utrecht, April 2015.
Contents

Management Summary ................................................................. 3

Preface .................................................................................. 5

1 Conceptual Design ................................................................. 9
   1.1 Background Information FrieslandCampina .................................. 9
   1.2 Project Context .................................................................... 10
   1.3 Research Motivation .............................................................. 11
   1.4 Research Objective ............................................................... 14
   1.5 Research Framework ............................................................ 14
   1.6 Research Questions .............................................................. 16
   1.7 Information Sources ............................................................. 17
   1.8 Outline of Report ................................................................. 18

2 Literature ............................................................................ 19
   2.1 Procurement - a General Look ................................................. 19
   2.2 Procurement of Commodities ................................................ 22
      2.2.1 Spot and Forward Markets .............................................. 22
      2.2.2 Actors in the Market ....................................................... 22
      2.2.3 Spot-Forward Relationship for a Storable Commodity ............ 23
      2.2.4 Futures- vs. Forward-contracts ....................................... 24
      2.2.5 Forward Curves ............................................................ 24
   2.3 Commodity Price Models ....................................................... 25
      2.3.1 Rational Expectation Hypothesis ....................................... 25
      2.3.2 Fundamental Models ..................................................... 26
   2.4 Conclusions ........................................................................ 28

3 Natural Gas Market ............................................................... 29
   3.1 Introduction to the Natural Gas Market .................................... 29
      3.1.1 History .................................................................... 29
      3.1.2 Long-Term Oil-Indexed Contracts .................................. 29
   3.2 Characteristics of the European Natural Gas Market ................. 31
      3.2.1 Natural Gas Infrastructure Europe ................................... 31
      3.2.2 Market Dynamics ......................................................... 32
   3.3 Development of the Natural Gas Market .................................. 34
      3.3.1 Introduction of Trading Hubs ......................................... 34
      3.3.2 Situation after 2008-2009 .............................................. 34
      3.3.3 Renegotiation of Contracts .......................................... 36
      3.3.4 Current Long-term Contracts ....................................... 37
   3.4 Market Dynamics - 2015 ....................................................... 38
      3.4.1 Market Dynamics in Europe .......................................... 38
      3.4.2 LNG Market ............................................................. 39
      3.4.3 Price Drivers of Natural Gas in Europe ............................. 40
   3.5 Conclusions ....................................................................... 42

THESIS - J.R.WILLEMINK
4 Purchasing Strategies other Industrial Users

4.1 Purchasing Strategy .......................................................... 44
4.2 Risk-Management ............................................................ 46
4.3 Purchasing Moment .......................................................... 48
4.4 Recommendations ........................................................... 49
4.5 Conclusions ................................................................. 49

5 Purchasing Strategy FrieslandCampina .................................. 51

5.1 Current Purchasing Strategy ............................................. 51
  5.1.1 Natural Gas Contracts ............................................. 51
  5.1.2 Historical Natural Gas Demand .................................. 52
  5.1.3 Risk on the Spot Market .......................................... 54
  5.1.4 Principal-Agent Problem ......................................... 56
5.2 Risk Profile FrieslandCampina ......................................... 57
5.3 Backtests of Purchasing Strategies - Baseload ..................... 58
  5.3.1 Optimization Model ............................................... 58
  5.3.2 Results Optimization Model ..................................... 62
5.4 Backtest of Purchasing Strategies - Total Demand ............... 66
5.5 Risk Management Dashboard in Microsoft Excel ................... 71
5.6 Conclusions ................................................................. 72

6 Purchasing Decision Support Tool ....................................... 73

6.1 Technical Analysis Indicators .......................................... 73
  6.1.1 Introduction to Technical Analysis ............................ 73
  6.1.2 Relative Strength Index .......................................... 73
  6.1.3 Moving Average Relative Strength Index ..................... 74
  6.1.4 Moving Average Convergence/Divergence ..................... 74
6.2 The Purchasing Decision Support Tool ............................... 75
  6.2.1 RSI - and Moving Average RSI - PDST ....................... 76
  6.2.2 Combination RSI and Moving Average RSI - Algorithm ..... 77
  6.2.3 MACD - Algorithm ............................................... 78
  6.2.4 Mathematical Formulation ....................................... 79
6.3 Backtesting the Algorithm ............................................. 82
  6.3.1 Performance of the Algorithm ................................. 82
  6.3.2 Limitations and Under-Performance of the Algorithm ........ 84
  6.3.3 Sensitivity of the Parameters ................................. 85
6.4 Discussion ................................................................. 88
6.5 Conclusions ................................................................. 88

7 Conclusions and Recommendations ..................................... 89

7.1 Conclusions ................................................................. 89
7.2 Recommendations ........................................................ 91

References ................................................................. 94

A Results Optimal Strategy Total Demand ............................... 97

B Microsoft Excel-files ........................................................ 98
1 Conceptual Design

To better understand the project context, I provide in this Chapter background information about FrieslandCampina, I describe the department in which the research took place, the products Natural Gas and Electricity, the current Purchasing Strategy, and the purchasing process.

1.1 Background Information FrieslandCampina

"Every day FrieslandCampina provides millions of consumers all over the world with dairy products containing valuable nutrients. With annual revenue of 11.4 billion euro, FrieslandCampina is one of the world’s 5 largest dairy companies."

FrieslandCampina supplies dairy products, like cheese, milk, desserts, products in infant nutrition, and dairy-based products to customers mainly in Europe, Asia and Africa. FrieslandCampina also supplies cream- and butter products, ingredients, and half-finished products to manufacturers in infant nutrition, the food industry, and the pharmaceutical sector.

The company has offices in 28 different countries and employs around 22,000 people worldwide. It is owned by Zuivelcoöperatie FrieslandCampina U.A., which has 19,224 member dairy farmers in the Netherlands, Belgium and Germany. The head-office is located in Amersfoort, The Netherlands.

The company is divided in 4 different Business Groups:

- Consumer Products Europe, Middle East & Africa (CPEMEA).
- Consumer Products Asia (CPA).
- Cheese, Butter & Milkpowder (CBM).
- Ingredients (ING).

Some key figures are shown in Figure 1:

![Figure 1: Results 2014 (Royal Frieslandcampina NV, 2014).](image-url)
1.2 Project Context

Utilities Procurement Department. The research took place at the Procurement department of FrieslandCampina, in the category Utilities. Tim Schröder is Category Manager Utilities, which means he is Head of the Utilities Procurement. He is responsible for purchasing utilities like Natural Gas, Electricity, Water, and Fuel (Gas Oil) in Europe and he is also partly responsible for reducing Energy usage. The scope of this research is on procurement of the commodities Natural Gas and Electricity. In 2013 FrieslandCampina spent about €84 million on Natural Gas and €25 million on Electricity, according to Schröder.

Natural Gas. In the Netherlands, trading of Natural Gas takes place at the Title Transfer Facility (TTF). TTF has a Day-Ahead Spot-market, ICE Endex TTF Gas Spot, and a futures market, ICE Endex TTF Gas Futures (Week-, Month-, Quarter-, Season-, and Year-quotes). Derivatives like options are also traded at ICE Endex (ICE Endex, 2015b). Natural Gas is traded regionally, there is not a world-market like there is for corn or coffee. The development of the Natural Gas market is treated in Chapter 3.

The Netherlands has a significant level of supply-insurance regarding Natural Gas, as it is nowadays still a net exporter. However, the Natural Gas-field in Groningen is depleting and in 2012 it was expected that the Netherlands will become a net importer between 2020 and 2025 (International Energy Agency, 2012). In 2013 production in Groningen reached a record level of 54 billion cubic meter (bcm) Natural Gas, but in December 2014 Dutch Minister Henk Kamp announced a lower maximum production level of 39.5 bcm/year (Den Brinker & Willems, 2014). In February 2015 Kamp lowered the production for the first half of 2015 to 16.5 bcm (Berentsen & Koot, 2015).

Electricity. In the Netherlands, Power is traded at the APX Power Spot Exchange for Day-Ahead auctions and Power Futures can be bought on the ICE Endex Power Futures market (ICE Endex, 2015b).

Purchasing Strategy. According to Klaas Springer, Corporate Head Treasury, FrieslandCampina wants to be certain about budget-prices and does not want to be exposed to volatile commodity markets. Therefore in 2009, after the merger of Friesland Foods and Campina, the ‘25%-25%-35% Purchasing Strategy’ has been developed. FrieslandCampina wants to cover its forecasted Energy demand (both Natural Gas and Electricity) divided in time, starting 3 years before a certain year. How this works is illustrated in Figure 2. If the forecast of FrieslandCampina is a demand of 350 MW in 2017, the Strategy is: at the first of July 2014 12.5% (44 MW) needs to be covered, at the end of 2014 25% has to be purchased (88 MW), end 2015 50% (175 MW), and December 2016: 85% (298 MW). The remaining 15% (52 MW) will be bought on the Spot market during 2017, because the demand for Energy is subject to daily- and seasonal fluctuations.

When you exactly want to follow this line linearly in time you have to buy one piece of the demand every trading day, from 3 years before maturity to maturity. Then it is not needed to have a view on the market and the purchase price is the weighted (25-25-35%) average of the TTF Year Forward-price from 3 years before maturity to maturity. Schröder is allowed to ‘deviate’ from the linear line in time. The maximum deviation is 7 percentage point. In our
example this is 7% of 350 MW = 25 MW. So at the end of 2014 at least 63 MW needs to be covered and the maximum purchased amount is 112 MW, see Figure 2 again. This Strategy is perceived (by FrieslandCampina) to be a risk-avoiding Strategy and results in ‘average’ purchase prices through the years, according to Schröder and Springer.

**Purchasing Process.** Currently FrieslandCampina closes Forward Over-the-Counter (OTC) contracts with their Energy supplier GDF Suez. The OTC-market follows the prices at ICE Endex (in Section 2.2.4 is explained why). A third-party, the EnergieMakelaar, advises FrieslandCampina about market developments and buy-decisions, and manages the Energy portfolio. Moreover they advise in emission management and check invoices from Energy suppliers.

### 1.3 Research Motivation

In June 2013 Tim Schröder became Category Manager Utilities. He is not sure whether the procurement of Energy is optimal and believes it can be improved. This is supported by a Benchmark-research of VEMW (a Union for Energy, Water and Environment), where FrieslandCampina did not score well compared to other companies (VEMW, 2014). Schröder thinks the two main-causes for the underperformance are the long-term Strategy and the way how buy-decisions are made. In this Section I describe the situation at FrieslandCampina at the start of this research, and I break down the main-causes in sub-problems, visualized by a Problem Tree (Hovland, 2005). This is shown in Figure 3.
Purchasing Strategy. The first main-cause is the Purchasing Strategy. This Strategy has been developed in 2009, after the merger of FrieslandFoods and Campina, in collaboration with EnergieMakelaar. Since 2009 the Natural Gas and Electricity markets changed a lot. The Electricity market is evolving from a country-specific market into one pan-European market, the TTF and APX exchanges become more liquid each year since their foundation in 2008, and since the disaster in Fukushima renewable Energy has been playing a bigger role. This happens especially in Germany, due to the EnergieWende\(^1\), which is causing shifts in the merit-order of Electricity. The market is changed to such an extent that the Strategy is probably out of date.

Furthermore Schröder doubts whether the Strategy matches the characteristics of the company. The current Strategy defines FrieslandCampina as one risk-averse company, according to Schröder and Springer. But characteristics of the Business Groups (BGs) are different. Some BGs sell their products B2C, making long-term contracts with for example Ahold. Other BGs sell B2B, with a shorter horizon. These different characteristics probably ask for a segmented approach, because the BGs might have different risk appetites. At this moment there is no clear picture about the risk profile of the BGs. A Finance Director of one the BGs confirmed the need for a correct determination of the risk profile.

\(^{1}\)the transition from nuclear and fossil fuels to renewable sources of Energy.
Moreover little scientific knowledge about Purchasing Strategies and knowledge about best practices by other industrial users is available at FrieslandCampina.

**Daily buy-decisions.** A second reason why Schröder thinks the procurement is not optimal is found in Daily buy-decisions. At this moment not enough knowledge and human resources are available to make optimal buy-decisions. This has several causes. EnergieMakelaar provides FrieslandCampina with information about price-developments and factors influencing the markets, but this information still has to be aggregated and interpreted. Limited resources are available to aggregate and interpret information given by EnergieMakelaar. Market information is not up-to-date, as the information stream from EnergieMakelaar to FrieslandCampina does not flow on a constant basis.

Another reason why there is not sufficient information available is the fact that there is no permanent link between real-time data and risk exposure. A link can be established between Reuters and Microsoft Excel, but at this moment the knowledge about different Risk Management tools is not available within the Utilities department and the Reuters-account activation is pending.

There is also limited knowledge of Best Practices and scientific literature about how to make optimal buy-decisions and how to set-up Risk Management tools.

**Optimal Energy Procurement.** Finally Schröder wants to know: what is optimal Energy Procurement?

**Summary of the Problem.** Summarized, the wishes of Schröder are: a Purchasing Strategy which fits the needs and the risk-profile of the business (long-term perspective), and next to that Schröders wants a tool or model which supports in daily buy-or-wait decisions.

Not all of these problems can or will be solved in this research. In Figure 4 I categorize how much influence I have on these problems and how much influence FrieslandCampina could possibly have on these problems. The focus is on the problems I can influence. FrieslandCampina could think about solving the problems they have influence on, like Human Resources, but that is not in the scope of this research.

![Figure 4: Box of Influence.](image-url)
1.4 Research Objective

After analysing problems at FrieslandCampina, taking notice of the wishes of Schröder and categorize their feasibility, the following Research Objective has been determined:

- **To make recommendations concerning a Purchasing Strategy for Natural Gas optimized for Royal FrieslandCampina, by determining the risk appetite of the Business Groups, applying theoretical knowledge, using best practices from other companies and testing the Strategy with historical data.**

- **To make a Purchasing Decision Support Tool to support buy-decisions and to make a Risk Management tool which monitors risks, by making a Dashboard in Microsoft Excel which links with Thomson Reuters Eikon and includes the developed Purchasing Strategy.**

1.5 Research Framework

Figure 5 gives more insight in the Research Objective. In this Section I explain the Research Framework. The most-important deliverables of this research are an improved Purchasing Strategy, a Risk Management Dashboard and a Purchasing Decision Support Tool. These deliverables are reached in different Phases.

The first Phase (a) is to perform a literature review about theories on Purchasing Strategies, Risk Management in Energy and development of Energy-prices, to research best practices of other companies regarding Purchasing Strategies and forecasting price-developments, and to determine the risk profile of FrieslandCampina.

By combining the collected information of Phase (a) the following Steps can be made in Phase (b):

- Developing an improved Purchasing Strategy, with input of the risk-profile of FrieslandCampina, theory on Purchasing Strategies, and best practices of other companies regarding Purchasing Strategies. Accordingly I test the Purchasing Strategy with historical data and perform iterations to optimize the Strategy.

- Developing a real-time model which measures risk exposure, with input of theory regarding Risk Management of Energy-products and real-time data from Reuters.

- Developing a model which displays factors influencing the market, price-developments and which if possible has predicting value, with input of theory on price-developments of Energy, and best practices regarding forecasting price-developments of Energy.

The third and final Phase (c) is combining the newly developed Purchasing Strategy, the Risk Management tools and price-development model into a practical decision-model which supports Schröder and FrieslandCampina in daily buy-or-wait decisions.
1.5 Research Framework

Figure 5: Research Framework.
1.6 Research Questions

The Research Questions are derived from the Research Objective and Research Framework. By answering the Research Questions I want to achieve the Research Objective.

1. Which Purchasing Strategy fits with the risk-profile of FrieslandCampina?
   1.1. What is the risk-profile of FrieslandCampina?
   1.2. Which Purchasing Strategies are known in the literature?
   1.3. What can we learn from Purchasing Strategies other companies use?
   1.3.1. Which Strategies do other companies use?
   1.3.2. Why do other companies use a particular Purchasing Strategy?
   1.3.3. What is the risk vs. return of other companies?

2. How can Risk Management be applied to Procurement of Natural Gas at FrieslandCampina?
   2.1. Which risks are present in Procurement of Natural Gas?
   2.2. Which connections between Thomson Reuters Eikon and Microsoft Excel can be made, in order to have real-time risk measures?

3. Which models or factors influencing the market can be applied to predict price-development of Energy prices?
   3.1. Which Energy-price development models and factors influencing the market are known in the literature?
   3.2. Which factors influence the European Energy market?
   3.3. What can we learn from other companies about how they predict future prices?

4. How can the Purchasing Decision be supported, taking into account the Purchasing Strategy and forecasted price development?
### 1.7 Information Sources

The following sources will be used to get an answer on the sub-questions. When the answers on the sub-questions are given, these answers can be analysed and used to answer the central questions.

<table>
<thead>
<tr>
<th>(Sub-)Question:</th>
<th>Source(s):</th>
<th>Accessing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which Purchasing Strategy fits with the risk-profile of FrieslandCampina?</td>
<td>Controllers BGs, Controller Procurement, CPO, Head Treasury, Schröder.</td>
<td>Interviews.</td>
</tr>
<tr>
<td>What is the risk-profile of FrieslandCampina?</td>
<td>Theory on procurement strategies.</td>
<td>Content Analysis.</td>
</tr>
<tr>
<td>Which Purchasing Strategies are known in the literature?</td>
<td>Companies with comparable energy spend or Food-companies.</td>
<td>Interviews.</td>
</tr>
<tr>
<td>What can we learn from Purchasing Strategies other companies use?</td>
<td>Theory on procurement strategies.</td>
<td>Content Analysis.</td>
</tr>
<tr>
<td>How can Risk Management be applied to Procurement of Natural Gas at FrieslandCampina?</td>
<td>Historical Demand Data.</td>
<td>Content analysis.</td>
</tr>
<tr>
<td>Which risks are present in Procurement of Natural Gas?</td>
<td>Manuals Reuters &amp; Excel, and commodity buyers FC.</td>
<td>Content analysis and interviews.</td>
</tr>
<tr>
<td>Which connections between Thomson Reuters Eikon and Microsoft Excel can be made, in order to have real-time risk measures?</td>
<td>Theory on price-developments of energy prices.</td>
<td>Content analysis.</td>
</tr>
<tr>
<td>Which models or factors influencing the market can be applied to predict price-development of Energy prices?</td>
<td>Theory about energy markets and experts.</td>
<td>Content analysis and interviews.</td>
</tr>
<tr>
<td>Which factors influence the European energy market?</td>
<td>Companies with comparable energy spend or Food-companies.</td>
<td>Interviews.</td>
</tr>
<tr>
<td>What can we learn from other companies about how they predict future prices?</td>
<td>Theory on procurement strategies.</td>
<td>Content Analysis.</td>
</tr>
<tr>
<td>How can the Purchasing Decision be supported, taking into account the Purchasing Strategy and forecasted price development?</td>
<td>Historical Demand Data.</td>
<td>Content analysis.</td>
</tr>
</tbody>
</table>

FrieslandCampina’s risk-profile is determined by interviewing the Chief Procurement Officer, Corporate Head of Treasury, Controllers of different Business Groups, Controller Procurement, and Schröder. The CPO and Corporate Head of Treasury are responsible for Risk-Management, therefore they are interviewed. The Controllers can give better insights in the needs of different Business Groups.

Furthermore I choose to interview companies which have comparable (or higher) spend on Energy or are as well active in the food industry. Via this way I will get insight in Strategies used by other big Energy consumers and how companies in the same sector as FrieslandCampina purchase Energy. Moreover it can give insight how other Energy-Buyers analyse the market.

Other (sub-)questions are answered by content analysis, own analysis, and by combining answers of sub-questions.
1 CONCEPTUAL DESIGN

1.8 Outline of Report

To make a logical reading order, the report is outlined as follows:

In Chapter 2 Literature I answer the sub-questions:

- 1.2 Which Purchasing Strategies are known in the literature?
- 3.1 Which Energy-price developments models and factors influencing the market are known in the literature (Fundamental Models)?

In Chapter 3 Natural Gas Market I answer the sub-questions:

- 3.2 Which factors influence the European Energy market?

In Chapter 4 Purchasing Strategies Other Industrial Users I answer the sub-questions:

- 1.3 What can we learn from Purchasing Strategies other companies use?
- 3.3 What can we learn from other companies about how they predict future prices?

In Chapter 5 Purchasing Strategy FrieslandCampina I answer the sub-questions and research questions:

- 1.1 What is the risk-profile of FrieslandCampina?
- 2.1 Which risks are present in Procurement of Natural Gas?
- 2.2 Which connections between Thomson Reuters Eikon and Microsoft Excel can be made, in order to have real-time risk measures?
- 1 Which Purchasing Strategy fits with the risk-profile of FrieslandCampina?
- 2 How can Risk Management be applied to Procurement of Natural Gas at Friesland-Campina?

In Chapter 6 Purchasing Decision Support Tool I answer the sub-question and research questions:

- 3.1 Which Energy-price developments models and factors influencing the market are known in the literature (Technical Models)?
- 3 Which models or factors influencing the market can be applied to predict price-development of Energy prices?
- 4 How can the Purchasing Decision be supported, taking into account the Purchasing Strategy and forecasted price development?

In Chapter 7 Conclusions & Recommendations I give brief answers to the Research Questions and make Recommendations.
2 Literature

In this Chapter I review literature about procurement, in particular procurement of commodities. First I treat procurement in general. Then I zoom into the features of commodity markets and Purchasing Strategies of commodities.

2.1 Procurement - a General Look

Procurement has become more and more of strategic value to (food) companies. “Procurement was never that high on the agenda in the boardrooms of food companies as in 2008” (Van de Kamp, Van der Sommen, Kroese, & Versendaal, 2009). “Many companies rely on commodity markets for their operations. As a result, their cost structure is affected by the volatility seen in commodity prices that sometimes can be very high” (Berling & Martinez-de Albeniz, 2011).

In the run-up to the financial crisis of 2008 commodity prices went sky-high, as we see in Figure 6. Figure 6 displays the Thomson Reuters/Jefferson CRB Index, a commodity futures price index. This index comprises commodities such as: Aluminium, Cocoa, Corn, Crude Oil and Natural Gas (Thomson Reuters Eikon, 2015). In Van de Kamp et al. (2009) a substantial part of the companies interviewed declared that they could not raise the end-product prices by the same percentage as the commodity prices increased. This put pressure on margins of companies with substantial commodity raw materials. Van de Kamp et al. (2009) interviewed amongst others FrieslandCampina, Cargill, Danone, Heineken, DSM and Nutreco.

Kraljic (1983) argues that it is essential to define the right Strategy when dealing with volatile and uncertain circumstances. He presents the Kraljic-matrix, which can help managers to make strategic decisions about different raw materials to purchase. It divides raw materials on a scale between supply risk and profit impact. Where a raw material can be placed determines the strategic action followed. This approach is quite high-level and strategic. Natural Gas is in terms of Kraljic between a ‘routine item’ and a ‘leverage item’. It has low supply risk. He recommends to use full purchasing power, substitute suppliers and place high-volume orders if economies of scale are present.

This research at FrieslandCampina zooms into a specific part of procurement, namely commodity procurement. Van de Kamp et al. (2009) describe the difficulties food and beverages companies have to deal with as “the market is very complex, many factors influence the price and availability of raw materials”. They describe typical (agricultural) commodities needed for the food industry. In the Dutch Energy market availability is not an issue. Natural Gas pipelines or Electricity cables are connected to the factories of FrieslandCampina. This makes the commodity (almost) always available, when a supply contract has been settled which allows to consume Energy and pay afterwards the Spot price. Therefore I assume Natural Gas and
Electricity are always available at the plants of FrieslandCampina in the Netherlands, Belgium and Germany. Recent developments in Belgium in the Power Sector teach us this is not always the case, but it goes beyond the scope of this project to deal with this.

Van de Kamp et al. (2009) propose the matrix displayed in Figure 7 to use for commodity procurement. This is a generic model for Procurement Strategy formation and realization. The authors found that objectives for companies in the food and beverages industry mostly aim for one or more of the following three goals: cost minimization, stable costs and security & safety of supply. The Strategy which helps to achieve these goals is dependent on a few variables. In Figure 7 below we can see these variables and the related Strategy. When for example the variable ‘Demand uncertainty’ is high, ‘Spot market sourcing’ or ‘inventory building’ is recommended and ‘Forward contracting’ is not recommended.

![Figure 7: Purchasing Strategies (Van de Kamp et al., 2009).](image)

Projecting this on procurement of Natural Gas and Electricity, we directly see some variables which need further research. How certain is the demand for Natural Gas and Electricity? Does the demand fluctuate heavily through the years? How much strategic value do Natural Gas and Electricity have? Notable: when facing highly uncertain demand it is recommended to buy via Spot markets and it is not recommended to buy via Forward contracting. Furthermore Van de Kamp et al. (2009) recommend to use hedging tools instead of Spot sourcing when the raw material is of strategic importance for the company. When the raw material is a commodity they recommend more options for Forward contracting. For an extensive explanation of the matrix I refer to Van de Kamp et al. (2009).

To have a better understanding about the influence factors in purchasing raw materials I describe here some issues and variables which have impact in procurement. We will see that Energy procurement is a very typical commodity and therefore also hard to compare with for example grains or coffee beans. Van de Kamp et al. (2009) determine the following five variables as decision-variables:
2.1 Procurement - a General Look

- **Specification grade.** How specified is the raw material? Are there sustainability constraints?
- **Innovation-intensity.** Is it a material which is still innovation-driven?
- **Strategic positioning.** How complex is the supplier-market? How much bargaining power do the suppliers have?
- **Volume.** How much volume? More volume means more power in some cases.
- **Total costs.** What are the total costs of the raw material? Sourcing from low-wage countries can give higher transportation costs and quality-risks.

Furthermore there are variables which cannot be influenced by the company itself:

- **Demand uncertainty.** To what extent does the demand for the raw material fluctuate?
- **Commodity.** Is the raw material a commodity good? For example milk, coffee and grains are traded on exchanges and it therefore becomes an option for companies to buy on the Spot market. Also when a raw material has a clear linkage to a certain commodity hedging techniques can be applied to hedge risks.
- **Harvest dependence.** Is it a material that has to be harvested? The harvest has a huge influence on supply and demand. Also the availability during the year has influence on the Purchasing Strategy.
- **Preservability.** Is the raw material non-perishable? Can it be stored?
- **Market sentiment.** What kind of market are you in? Is it a regional market? Do currencies have influence on the price? What is the role of upcoming parts in the world? How competitive is the supplier market?

Decisions and consequences of these variables have a substantial impact on operating income. Heineken for example took part in discussions with Euronext, where farmers, cooperatives, malt houses and brewers are discussing about a possible introduction of malting barley at the commodity exchange Matif in France (Van de Kamp et al., 2009). Van de Kamp et al. (2009) conclude it is highly advisable to have involvement of different disciplines within the organization. Integral Risk Management appears to be a success factor in raw material procurement.

As mentioned before, Natural Gas and Electricity can be seen as a leverage or routine item. E.g. hedging, Spot market sourcing, indexing and robotic buying are recommended in case of leverage items. Van de Kamp et al.

**Figure 8:** Strategies in Kraljic-Matrix (Van de Kamp et al., 2009).
(2009) only recommend Forward contracting in case of a strategic product, not when the raw material is a leverage or routine product. Finally they note that organizations use mathematical techniques and models to optimize costs, profits or efficiency under multiple constraints. These techniques are for example used in composition of recipes or in case of FrieslandCampina in the optimization problem how to maximize added value to the raw milk supplied by the member farmers. Van de Kamp et al. (2009) experienced these optimization techniques are hardly used in procurement. They think the application of these techniques can be the next step in professionalization of procurement.

2.2 Procurement of Commodities

2.2.1 Spot and Forward Markets

Natural Gas and Electricity can be bought via Spot-markets or Forward/Futures contracts. This Section explains these contracts. **Forward contracts** are traded over-the-counter (OTC) between two parties, it is a bilateral agreement. The delivery point, date and time of arrival are exactly specified. A contract between FrieslandCampina and an Energy supplier like GDF Suez is a typical Forward contract. In Forward contracts the credit risk is fully present (Borovkova & Geman, 2008). In the OTC market financial institutions often act as a market maker for commonly traded Futures, which means they are ‘always’ prepared to quote a bid- or ask-price (Hull, 2012). In the Natural Gas market GDF Suez is a typical market maker. **Futures** are standardized in terms of delivery point, delivery time and amount. Futures are traded on exchanges like the InterContinental Exchange (ICE) in London and the New York Mercantile Exchange (NYMEX) in New York. One of the most liquid Futures markets is the Oil Futures market (Geman, 2005). Transaction costs are usually low for Futures. On an exchange the clearing house stands between the buyer and the seller and takes away the credit risks for the parties involved in the transaction. The risk of default is almost reduced to zero, as margin calls happen on a daily basis. When the market value has declined compared to the previous day an additional margin is needed. According to Borovkova and Geman (2008) Futures markets such as ICE and NYMEX provide the most liquid and reliable Forward curves. However, they state it can be beneficial to use OTC Forward prices for the construction of Forward curves. For example in Electricity markets Futures contracts are rather illiquid and Forwards are a better alternative.

Futures prices in liquid markets provide price discovery and are essential for daily marking to market the positions in a portfolio. They also influence storage, production and other strategic decisions. In terms of the total volume traded the OTC market (Forwards) has become much larger than exchanges (Futures) (Borovkova & Geman, 2008).

2.2.2 Actors in the Market

The actors in the market can be divided into three groups: hedgers, speculators and arbitragers (Geman, 2005) (Hull, 2012). The first exchange markets were founded for farmers, so they could lock in their future profits for their harvests. Their aim is to hedge risks. The second group are the speculators, for example a bank. They have a view on the market and ‘bet’ on the price in the future. Commodities become more and more attractive for investors and hedge funds as an
alternative investment. The third group are arbitragers. They try to lock in \textit{riskless} profit due to small price differences in different markets.

### 2.2.3 Spot-Forward Relationship for a Storable Commodity

When a Forward contract for a commodity like Corn reaches maturity the Futures prices must converge to the Spot price. If this would not be the case, traders would have an arbitrage opportunity. Suppose the Forward price is above the Spot price at delivery: traders could sell a Forward contract, buy the asset and deliver the physical asset (Hull, 2012). From a theoretical perspective we assume the market is arbitrage free. Under this assumption Geman (2005) shows that the following relationship must hold for storable commodities:

\[ f_T(t) = S(t)e^{(r-y)(T-t)}, \]  

where \( f_T(t) \) is the Forward price for maturity \( T \) at day \( t \). \( S(t) \) is the Spot price at day \( t \), \( r \) is the continuously compounded interest rate and \( y \) is the convenience yield. We can also write the convenience yield as:

\[ y = y_1 - c, \]  

where \( y_1 \) is the benefit of holding the physical commodity and \( c \) is storage costs. Users of a consumption commodity (e.g. needed for production) may feel that physical ownership gives benefits that are not obtained by holders of a Futures contract. In general it allows a manufacturing company to have a safety stock and to be able to keep a production process running or profit from temporary local shortages. The benefits of holding a physical commodity is called the convenience yield (Hull, 2012).

Because the relationship between Spot and Forward contracts is linear (Geman, 2005), we can rewrite Equation (1) as follows:

\[ f_T(t) = S(t)[1 + \frac{r(T-t)}{Cost of financing} + \frac{c(T-t)}{Cost of storage during (t,T)} - \frac{y_1(T-t)}{Benefit from holding the physical commodity (t,T)}]. \]  

Equation (3) must hold: if the current Forward price \( f_T(t) \) is greater than the right hand side of the equation, one can sell the Forward contract, buy via a loan the physical commodity, store it during the time interval \((t, T)\), and make at maturity \( T \) a cash and carry arbitrage. If the situation is the other way around one could make the reverse cash and carry arbitrage. The convenience yield has a minus sign, since the holder of the Forward contract does not profit from holding the physical commodity and should therefore not pay for these benefits (Geman, 2005).

Fundamental properties: because of the linearity of the Forward price as a function of the Spot price, we can focus on the Spot price \( S(t) \). This is in contrast with managing options, as an option is the second derivative of the Spot-price. So Forward prices do not depend on volatility of the Spot price, as is the case with an option (Geman, 2005).
2.2.4 Futures- vs. Forward-contracts

Futures are denoted as $F^T(t)$. As mentioned Forward contracts can be described as an agreement between two parties to exchange a certain quantity of a commodity on a specific future date $T$ for an amount of dollars, defined at date $t$. Forward contracts are traded over-the-counter (OTC). A Future is a standardized (in terms of maturity, quantity and quality or variety) contract and is traded via an exchange, such as NYMEX, CME or ICE. As an example: the price of a Future $F^T(t)$ at time $t$ is $x$, when a buyer agrees to buy the contract from seller. The next day, time $t + 1$, the price of the Future, $F^T(t+1)$, can be changed due to the arrival of new information. If $F^T(t+1) < F^T(t)$, the buyer faces a loss and has to pay a margin call, equal to $F^T(t+1) - F^T(t)$. So at the end of the contract the gain or loss on a Futures contract is $F^T(T) - F^T(t)$ and $F^T(T) = S(T)$, as there is no Spot/Futures arbitrage possible.

Geman (2005) shows that under deterministic interest rates, Forward and Futures prices for the same underlying and maturity are equal (assuming no credit risk in the Forward contract transaction). Under both deterministic and stochastic interest rates, the Spot-Forward relationship for a commodity can be written as:

$$f^T(t) = \frac{S(t)}{B(t, T)}$$  \hspace{1cm} (4)

where $B(t, T)$ is the price at date $t$ of a zero-coupon bond maturing at date $T$. Under constant interest rates $B(t, T) = e^{-r(T-t)}$. So that makes $f^T(t) = S(t)e^{r(T-t)}$. If one borrows one dollar at date $t$, it is at $T$ worth $1/B(t, T)$. So investing $B(t, T)$ at $t$ giving a final payment of one dollar. Then:

$$f^T(t) = F^T(t)$$  \hspace{1cm} (5)

In the case of stochastic interest rates it no longer holds that $B(t, T) = B(t, t+1), \ldots, B(T-1, T)$, and the price of the Futures contract at date $t$ is not per se equal to the price of a Forward contract.

Finally Geman (2005) comments:

- When analysing Forwards and Futures contracts on for example Oil, interest-rate risk is of secondary importance and may be viewed as negligible. That is why traders and market participants speak mostly indifferently about Futures and Forward prices.
- When interest rates are stochastic, Equation 5 only holds when the covariance between commodity prices and interest rates are zero. For example raising Oil prices can influence inflation and therefore nominal interest rates.
- Equation 5 does not hold if credit risk is non-negligible. The Forward price should reflect the rating of the two counterparties.

2.2.5 Forward Curves

A typical Forward curve in the Crude Oil market is in backwardation or contango. When Futures prices with short maturities are higher than Futures prices with longer maturities, the market is in backwardation. Contango is the other way around. See Figure 9. Whether a market is in backwardation or contango depends on factors like inventory levels, storage and
transportation costs, equilibria between supply and demand, (geo)political and strategic issues and many other factors. In a backwardated market it is interesting to physically store the commodity. As we saw, the benefits of holding a physical commodity are called the convenience yield. The cost of interest and storage represent the cost of carry. The shape of the Forward curve should summarize the expectations of market participants about the current and future state of the specific market. When for example participants in the Oil market think demand will be lower than expected, and new Oil rigs are expected to start producing, it can result in a backwardated Forward curve. The Forward curve of seasonal commodities is influenced by seasonal demand (for Energy) or supply (for agricultural commodities). For seasonal commodities the transportation or storage capabilities are limited, which result in premiums on Futures contracts in times of high demand. This can be during winter for Natural Gas or at moments of low supply before the harvest. Borovkova and Geman (2008) review several Forward curve modeling approaches. However these models are used for derivatives pricing. It assumes a risk-neutral world and these models do not have predictive value. Therefore I will not elaborate on these models.

### 2.3 Commodity Price Models

#### 2.3.1 Rational Expectation Hypothesis

An interesting question is: do Futures prices provide valid forecasts for the Spot prices in the future. Famous economists like Keynes and Lucas examine this in the ‘Rational Expectation Hypothesis’. “An economic idea that people in the economy make choices based on their rational outlook, available information and past experience”. This should result in an efficient market and all available information is priced in the Futures prices. However Borovkova and Geman (2008) argue that the actual forecasting ability of Futures prices is rather poor in commodity markets, especially in Oil markets. They give the example that if Futures prices were right in predicting the Spot price of Oil, the Oil price in February 2008 should be around 67 $/bbl, given the Futures prices in February 2006 and February 2007. In fact the Spot price of Oil was about 100 $/bbl. Schwartz (1997) investigated the influence of the Spot prices on the Forward curve and sees the Spot price as the most important factor driving the Forward curve. The influence of Spot prices increases when time to maturity of Futures decrease. In fact, the Futures price must converge to the Spot price, as we already argued.
2.3.2 Fundamental Models

For a better understanding of commodity prices we should aim for the fundamental models. The most basic division is between storable and non-storable commodities. A fundamental model derives commodity prices as the equilibrium result of basic supply and demand factors. This is in contrast with reduced form models, which specify the dynamics of the Forward curve in the form of a stochastic differential equation, as we also know from option pricing.

According to Pirrong (2008) the Theory of Storage is the standard fundamental commodity price model. Very early versions are described by Kaldor (1939) and Working (1949). They both state that commodity storages generate a certain stream of benefits, the convenience yield, and therefore the marginal convenience yield is inversely related to the storage level. In other words: one benefits from holding the physical commodity as holding inventories give a productive value to meet for example unexpected demand and therefore avoiding the cost of frequent revisions in the production schedule or even disruption in manufacturing. Kaldor (1939) and Working (1949) describe it as the benefit that “accrues to the owner of the physical commodity, but not to the holder of a Forward contract”. It can be seen as the same benefit of the dividend yield a holder of stock has compared with the holder of a derivative contract.

The convenience yield is more or less an embedded timing option attached to the commodity, as inventory allows to put the commodity on the market when prices are high and hold it when prices are low (Telser, 1958). Also statistical research has been done on the role of inventory in explaining commodity Spot price volatility. Fama and French (1987) show for amongst others metals, wood and animals that the variance of prices decrease with inventory levels. Geman & Nguyen (2002) showed for soybeans that volatility can be written as an exact inverse function of inventory. Geman (2005) claims this is the same for Oil markets: when there is a downward adjustment of the estimated Oil storage levels in a certain region, the volatility of Oil prices (and the Oil prices as well) increases sharply.

Geman (2005) summarizes the important implications of the Theory of Storage:

- The volatility of commodity prices is likely to be inversely related to stock levels.
- The price of a commodity and its volatility are positively correlated, as both are negatively related to the inventory level. This is in contrast to equity markets, where volatility increases when stock prices decline (the ‘volatility smile’).
- Volatility tends to decrease together with the time to maturity, called the ‘Samuelson effect’. News about e.g. inventories or weather will impact short-term Forward prices immediately, while it should not have influence on long-term contracts. According to Geman (2005) the ‘Samuelson effect’ is seen especially at Energy contracts, with a steep increase in volatility around 6 months before maturity.

A more recent version of the Theory of Storage is described by Scheinkman and Schechtman (1983). In their model a random amount of commodities is produced every period and competitors in the market have the option to sell the commodity directly or to store it. Two state variables have influence on this decision: the current output and the current inventory level. In a competitive market the equilibrium between selling and storing should maximize the discounted expected utility of the respective competitors.
The boom in commodity prices in 2008 (see Figure 6 earlier) has led to claims that the steep increases of the prices of agricultural commodities, metals and Oil cannot only be caused by the supply and demand dynamics, but also have been driven by speculation. In 2005-2006 the price of Oil rose and the same held for Oil inventories, where historically the price of Oil was inversely related to the level of inventory. In this period the speculative activity also had increased. As we saw, the commodity storage problem says that prices and storage levels move together. But Pirrong (2012) notes that the relationship between variables as inventories and prices can shift in response to structural shocks. One can argue that such a shift to the market is irrational, Pirrong (2012) argues that in fact a rational response to a structural shock causes a shift and is not per se caused speculative behavior.

The period 2005-2006 was a typical period in which a lot of events influenced price and storage movements. Increasing hurricane activity in the Gulf region put pressure on this major Oil production region. Furthermore the United States faced difficulties in Iraq, there was concern about the response to Irans nuclear program, the war in Lebanon could spread to other countries in the Middle East, production problems occurred in Nigeria, there was political uncertainty in Russia and there was a conflict between Venezuela and other OPEC members. It is believed that these uncertainties were a trigger to hold inventories, which have effect on the Spot price of Oil. Pirrong (2012) claims that an increase in volatility of those fundamental shocks results in agents in the market increasing the level of inventory.

Some citations in 2006 explain the view on the speculation in the market. Citibank: “We believe the hike in speculative positions has been a key driver for the latest surge in commodity prices”. Goldman Sachs: “Unlike Natural Gas we estimate that the impact of speculators on Oil prices is roughly equivalent in magnitude to the impact of shifts in supply and demand fundamentals (as reflected in stocks)”. OPECs chairman, Al Badri: “Inventory data continue to demonstrate that Crude Oil stocks are ample. US stocks are now at nine-year highs. Inadequate refinery capacity, ongoing glitches in US refinery operations, geopolitical tensions and increased speculation in the Futures market are, however, driving high Oil prices” (Pirrong, 2012).

In 2006 the Senate Permanent Committee on Investigations reported: “Figures clearly indicate that there has been a fundamental change in the Oil industry, such that the previous relationship between Oil prices and inventories no longer applies. One of the reasons for this change is the influx of billions of dollars of speculative investment in the Crude Oil and Natural Gas Futures markets. As Energy prices have not only increased but become more volatile, Energy commodities have become an attractive investment for financial institutions, hedge funds, pension funds, commodity pools, and other large investors. One Oil economist has calculated that over the past few years more than $ 60 billion has been spent on Oil Futures in the NYMEX market. This frenzy of speculative buying has created additional demand for Oil Futures, thereby pushing up the price of those Futures. The increases in the price of Oil Futures have provided financial incentives for companies to buy even more Oil and put it into storage for future use, resulting in high prices despite ample inventories” (Pirrong, 2012).

These opinions are a few examples of the widely spread view on the Oil markets, that speculation has caused prices to be artificially high, because ‘normally’ the prices and inventory levels are inversely related. But what also was the cause in 2006-2007: the Oil market was in a steep...
contango, instead of what the case is in about 80% of the cases: backwardation. Pirrong (2012) made a modification of the standard rational expectations dynamic storage model. It expands the traditional model to let the random demand shock vary stochastically. His conclusion is that identifying the impact of speculative excess on prices is a difficult task. Speculators build up inventories when demand and prices are low and try to sell if demand and prices are high, typical physical arbitrage. But next to that: when demand uncertainty is high, it is more desirable to store than in more certain times. The model from Pirrong (2012) implies that a positive shock to demand uncertainty will lead to an increase in storage. As building up inventory means more demand, the prices will also increase. “Disparate co-movements in inventories and prices are completely consistent with an efficient, rational expectations equilibrium. Those searching for evidence of speculative excess need to look elsewhere than the price-inventory relation” (Pirrong, 2012).

2.4 Conclusions

A few conclusions can be made from this Chapter.

- Van de Kamp et al. (2009) recommends Forward contracting when the raw material to purchase is a commodity and demand is certain. But, when demand uncertainty is high Van de Kamp et al. (2009) advises Spot market sourcing instead of Forward contracting. In Chapter 5 Purchasing Strategy FrieslandCampina we will see that part of Friesland-Campina’s demand can be labeled as certain and a part as uncertain.

- In the Spot-Forward relationship of a storable commodity convenience yield, the benefits of holding the physical asset, is an important factor (Geman, 2005). The Theory of Storage implies: volatility of commodity prices is likely to be inversely related to stock levels. The price of a commodity and its volatility are positively correlated, as both are negatively related to inventory level (Geman, 2005).

- For a better understanding of future commodity prices we should aim for fundamental models and not for reduced form models with stochastic differential equations. A fundamental model derives commodity prices as the equilibrium result of Supply and Demand factors. Therefore I elaborate in Chapter 3 Natural Gas Market about Fundamentals and Supply and Demand factors of the Natural Gas Market in Europe.
3 Natural Gas Market

To understand Fundamentals and Dynamics of the Natural Gas Market in Europe we firstly look into the history of Natural Gas in Europe, especially in the Netherlands. Furthermore I elaborate about the development of different contract forms known in the European Natural Gas market, and I explain what Oil-indexation and hub-indexation means. Moreover we have a look on the different suppliers of Natural Gas and how there influence developed. At the end of the chapter we have a look on the future of the Natural Gas Market.

3.1 Introduction to the Natural Gas Market

3.1.1 History

In 1959 a Natural Gas field was found near the Dutch village Slochteren, the ‘Groningen’ Natural Gas field, at that moment one of the largest Natural Gas fields known in the world. Before 1960 there was not much trade in Natural Gas in Europe and it was traded with a ‘cost plus’ pricing approach. Natural Gas was sold for the cost price plus margin mark-up. But after the Natural Gas in Slochteren was found the Dutch government began to think about a system how to price and export Natural Gas. Cost-plus pricing would not maximize return for the Dutch, as the cost price of an on-shore Natural Gas field is much lower than the cost-price of off-shore Natural Gas fields, which were at that time mostly seen (Clingendael, 2008). To give other countries and industrial users an incentive to use Dutch Natural Gas, it should be competitive with other fuels. The competing fuel in The Netherlands was Gas-Oil, as this was the heating fuel in new homes. Larger consumers, like industrial users, used the cheap Heavy Fuel Oil (HFO) as an Energy source. Coal already shifted to use for power generation and metals (Melling, 2010).

To maximize profit on Groningen Natural Gas, the Dutch government wanted to sell Groningen Natural Gas at ‘market-value’ instead of a ‘cost-plus’ value. Something had to be thought of that maximizes profit, but also gives competitive prices in comparison to substitute fuels. The Dutch minister of Economic Affairs, J.W. de Pous, introduced the Oil-indexed Natural Gas contracts (Clingendael, 2008).

3.1.2 Long-Term Oil-Indexed Contracts

The most widely used contract-form the last 50 years was the long-term Oil-indexed contract. These contracts are usually signed for 10-30 years and have complex price clauses (Stern & Rogers, 2011). How does an Oil-indexed contract look like and why do producers want long-term contracts? As mentioned before: the thought was that Natural Gas should be competitive with other Energy sources. Furthermore Natural Gas needed huge investments in transportation infrastructure. To cover the investment risks, producers needed long-term contracts.

An Oil-indexed contract typically looks like this:

\[ P = P_0 + a(X - X_0) + b(Y - Y_0), \]

(6)

here \( X \) and \( Y \) are averages of a certain Oil-product over for example the last 3- to 9-month period. In Europe an Oil-indexed contract for industrial users could look like this:

\[ P = P_0 + 60\%(GO - GO_0) + 40\%(HFO - HFO_0), \]

(7)
where $GO$ is the price of Gas-Oil and $HFO$ is the price of Heavy Fuel Oil.

Geman (2005) explains the Natural Gas is indexed against an Oil-product and it contains typically a lagged price. An Oil-indexed contract basically consists of an indexation with one or more Oil products like Crude Oil, Gas-Oil or Heavy Fuel Oil. Different end-users had different weightings in their contracts, for example 60% Gas-Oil and 40% Heavy Fuel Oil.

In Figure 10 I give an example of a 6-3-3 pricing formula with the Brent Crude Oil price as underlying.

- **6:** Pricing Period. In this example the average Brent Crude Oil price from April to October (6 months).
- **3:** Time Lag. In this example the time lag is 3 months, from October to January.
- **3:** Price Validity Period. This is the number of months the price is valid. In this example the Oil-indexed price will be valid from January to April.

![Figure 10: Oil-indexation 6-3-3 Brent Crude Oil Example (WinGas, 2015).](image)

To be sure investments were covered, producers mostly negotiated a ‘Take-or-Pay’ clause, where customers commit to buy at least around 80 to 90 percent of the total agreed quantity. The buyer takes the volume risk and the seller takes the price risk. Dutch Oil-indexed Natural Gas contracts became the benchmark for the rest of Continental Europe and also for the pricing of Liquid Natural Gas (Melling, 2010).

According to Tsygankova (2013) an Oil-indexed contract can look as follows:

- Indexed against an Oil-product.
- Annual flexibility typical 110-90% of Annual Contract Quantity (ACQ).
- Daily flexibility typical 120-50% of ACQ/365.
- Price review clause in contract due to its long duration.
- Duration about 20-25 years.
- Take-or-Pay obligations on buyer.
  - If buyers takes 90% of ACQ, buyer still has to pay for 90%.
3.2 Characteristics of the European Natural Gas Market

3.2.1 Natural Gas Infrastructure Europe

Natural Gas in Europe is supplied by different sources. These sources have different characteristics and therefore their own influences on the European Natural Gas markets. Figure 11 shows actual European Natural Gas flows and capacity in 2012 (Clingendael, 2013).

We can divide the trade flows in basically five sources (Stern, 2014):

1. **Russian supply:**
   - Long-term supply contracts, Oil-indexation, some volume flexibility and Take-or-Pay clauses. Price levels have been under negotiation the last years.
   - Between 130 and 180 bcm per year.

2. **Norwegian supply:**
   - In the past long term Oil-indexed supply contracts like Russia.
   - Flexible supply triggered by hub-prices/Spot, partly contracted, partly un-contracted.
   - Shift is taking place from Oil-indexed contracts to hub-indexation.
   - Between 100 and 120 bcm per year.
3. **North African supply:**
   - Mostly contracts with Italy and Spain, contracts are Oil-indexed.
   - Between 30 and 40 bcm per year.

4. **LNG supply:**
   - Long-term Oil-indexed contracts, mostly to Southern Europe.
   - Flexible supply that is triggered by hub-prices/Spot, partly contracted, partly un-contracted. Mostly to UK, Belgium or the Netherlands.

5. **Domestic (declining) production, mostly from UK and the Netherlands:**
   - Dutch production in 2013 around 80 bcm.
   - UK production in 2013 around 36 bcm.

Storages are another source of flexibility. Typically storages are injected during summer, when Spot prices are usually lower than Futures prices expiring in winter-months. Storages are used during winter as an extra source of flexibility and are therefore a physical arbitration tool (Stern, 2014). Natural Gas storage capacity in the Netherlands is about 10 bcm, with a maximum send-out rate of 240 mcm/day. Total LNG send-out capacity in UK, Belgium, the Netherlands, France and Spain is about 160 bcm/year, which means a maximum send-out rate of 450 mcm/day (Thomson Reuters Eikon, 2015). To put this in perspective: 500 bcm/year is about 1370 mcm/day.

### 3.2.2 Market Dynamics

To understand the dynamics in the Natural Gas market in Europe it is interesting to look at marginal costs of sourcing Natural Gas. Figure 12 stacks the volumes of the different sources based on marginal costs. The lowest marginal costs are seen at the the inflexible parts (under Take-or-Pay level) of long term contracts: Russian pipeline supply, North African pipeline supply, domestic production and Norwegian supply. These volumes will flow and have to be paid, because of the ToP-clauses. In the situation that demand will be above minimum contracted volumes the flexible supply tranches are the drivers of Spot prices. Below the characteristics of these flexible supply tranches are explained (Stern, 2014)(Franza, 2014).

**LNG:** (Stern, 2014)(Franza, 2014)

- Delivered under long-term Oil-indexed contracts to buyers in Italy, Spain and Southern France. These contracts have an option that supply can be re-directed to higher priced markets, if both buyer and supplier agree.
- LNG delivered under medium or long term contracts to buyers in North West Europe, based on hub prices.
- LNG delivered on a Spot basis. Supplies on Spot basis depend on world market LNG prices. Natural Gas will flow to the place where the seller thinks he will maximize his profit.
3.2 Characteristics of the European Natural Gas Market

**Figure 12:** Supply Stack Natural Gas (Stern, 2014).

**Russian flexible and un-contracted volumes:** (Stern, 2014)(Franza, 2014)
There are in fact two ways of sourcing extra Russian Natural Gas. First under the long-term contract flexible volumes. During 2012 and 2013 Russian contracts prices were estimated at around €25 and €28 (this relates to an Oil-price of $100 - $120/bbl). Secondly Gazprom, world’s largest Natural Gas extractor, has the ability to sell directly to European Natural Gas markets. The Russian government currently holds a majority stake in Gazprom.

How does this flexible supply influence the hub prices? Figure 12 shows that in 2012 last part of the demand was met by LNG supply and that there was almost no need for flexible Russian supply. The average National Balancing Point (the British Natural Gas Exchange) price that year was €25.1/MW and it looks like the market was controlled by Russian and LNG supply. In 2013 the average NBP price was €27.3/MW.

Mid-2014 something different happened. In July and August 2014 hub prices came down to a level between €17 and €19. How can we explain this?

- First of all, the winter of 2013/2014 was quite mild and Natural Gas storages remained at higher levels.
- Demand for Spot LNG in Asia was lower than anticipated, resulting in decline of the Natural Gas Spot price in Japan and a re-direction of Spot cargoes to Europe in April and May 2014, to prevent a total oversupply of Asia.
- Pipeline import seemed also low, consequently Russian flexible supply was possibly not needed.
In this scenario Spot LNG becomes the price taker, which might explain why prices fell so steeply in 2014. An open question which remains: how does Gazprom, Russia’s biggest supplier of Natural Gas, compensate buyers for the difference between contract prices and hub prices? It is believed that this is something to be negotiated in new contracts. How will Gazprom react if they have to compensate buyers? Will they use their power to influence the market via for example limiting the physical supply and rectify the situation? Gazprom can also buy volumes on the Spot market and use it to partially fulfill the contract nomination volumes. This will raise demand at European hubs, give upward pressure on European hub-prices, and narrow the gap between Spot and Oil-indexed prices (Stern, 2014).

3.3 Development of the Natural Gas Market

3.3.1 Introduction of Trading Hubs

In the 90’s the UK, together with Norway and the Netherlands the largest producers of Natural Gas in Europe (not taking into account Russia), shifted from Oil-indexed prices to other types of indexation. Huge investments were done in the past and partly written off, the time was ripe for another way of pricing Natural Gas in UK. In 1996 the National Balancing Point was founded in UK, the first European Gas Trading Hub/Exchange (Clingendael, 2008). The NBP developed into a liquid mature market. In the meantime (1998) the ‘Interconnector’ was build, connecting the UK from Bacton (UK) to Zeebrugge, Belgium (capacity 20 bcm/year). In 2006 the BalgzandBactonLine (BBL) was constructed, to connect UK to the Netherlands. The BBL has as well a capacity of 20 bcm/year. These connections made a link between the Natural Gas prices in UK and in Continental Europe, as arbitrage opportunities popped-up.

Since 2008 the Natural Gas pricing scheme has changed remarkably. Oil-indexation has declined rapidly and significantly, while Spot pricing has become the benchmark for Natural Gas trading in North West Europe. The Dutch trading hub Transfer Title Facility (TTF) serves as the benchmark for the rest of continental Europe these days (Franza, 2014).

3.3.2 Situation after 2008-2009

In the second half of the 2000s European Energy regulation and transparent hub-pricing created a much more competitive environment for suppliers (Stern & Rogers, 2011). In September 2008 the world faced the collapse of Lehman Brothers and went into what we now know as the financial crisis. In the run-up to September 2008 commodity prices went sky-high, mainly because of high demand expectations. Brent Crude Oil peaked at $140/bbl and prompt-year TTF price rose to €40/MW, shown in Figure 13.

The financial crisis, in combination with the US Shale Gas revolution, became a turning

Figure 13: Brent Crude Oil, TTF Day Ahead and TTF year Ahead (Thomson Reuters Eikon, 2015).
3.3 Development of the Natural Gas Market

point for the Natural Gas market in Europe. As for a lot of commodities, instead of the expected high demand, the demand for Natural Gas totally collapsed. Also other forces influenced the decline of prices in Natural Gas. Europe was already in a shift to liberalization. Different parts of Europe became more and more interconnected with pipelines such as the IUK, BBL and Langeled. Furthermore LNG regasification capacity was built or expanded on large scale in UK (Isle of Grain, Dragon, South Hook) and Belgium (Zeebrugge). At the end of the previous decade a boom in US Shale Gas production resulted in high volumes of Natural Gas available in the United States and a steep fall of Henry Hub prices, the US benchmark for Natural Gas. Moreover world’s Coal prices declined, mainly because of a switch in power generation from Coal to Shale Gas in the US and lower demand from China. Lower Coal prices resulted in higher Coal demand for power generation in Europe, which therefore lowers Natural Gas demand for power generation. Also Qatar, traditionally transporting LNG to USA, had to make a shift. High volumes of LNG came available for the European market, imports from Qatar rose from 5.87 bcm in 2008 to 31.61 bcm in 2011 (Melling, 2010).

Oil-indexed contracts were still mainstream and huge volumes with Take-or-Pay clause were fixed. Melling (2010) estimates that around 321 bcm was fixed via long-term Oil-indexed contracts with amongst others Russia, Norway and Algeria. Taking 15% volume flexibility gives 48 bcm downward possibility. US Shale Gas came into play, demand for Natural Gas in Asia went down even more and Europe became last resort for LNG suppliers like Qatar. Therefore supply capacity to Europe rose to approximately 600 bcm per year, instead of 520 bcm. But instead of the forecasted growing market demand, demand went down in Europe with approximately 40 bcm/year, from a total of 560 bcm/year (EU-27 + Turkey + Switzerland). Where pipeline supplies were down dramatically, LNG supplies increased in 2009, because of the commissioning of new LNG terminals both in Qatar and Europe. Furthermore bullish demand forecasts in 2008 resulted in over-purchasing by midstream companies (Melling, 2010).

According to Franza (2014) mid-streamers like GDF Suez, E.On and RWE were also trapped between the long-term Oil-indexed contracts and customers, who wanted hub-prices. The CEO of E.On Ruhrgas in 2010: “Hubs are the reference point when customers talk to us... Long-term contracts in their current form no longer reflect the market... we have to re-engineer the long-term contracts to anticipate the future needs of the market in terms of price levels, indexation and review mechanism”. Renegotiation of long-term contracts with Gazprom happened in two phases (Stern, 2014). Between 2009 and 2012 customers were obliged to buy the minimum contract quantities at an Oil-indexed level. After 2012 Gazprom agreed to different individual companies a complicated mix of base price reductions and partly hub-indexation. It is also believed that minimum contract quantities are lowered down from 85 percent to 70 percent.

What has happened since 2012? In 2011 the nuclear power station Fukushima in Japan faced a meltdown. Japan decided to make a complete 180 degrees-turn and shifted from nuclear power to Natural Gas-fired power. As Japan does not have any Natural Gas-reserves at all, Natural Gas had to be imported. Since then the majority of world’s LNG volume is going to Japan (and Asia) and LNG imports from Qatar fell down to 17.23 bcm in 2013 (Franza, 2014). Moreover European demand fell due to the economic crisis. European demand was in 2013 around 63 bcm less than pre-crisis levels.
Spot-prices responded quickly to new supply/demand dynamics, but Oil-linked Natural Gas prices diverged slowly. In Figure 14 we can clearly see the price difference between the TTF Spot price and the Oil-indexed prices. The red line represents the TTF-Spot, the blue line represents the German LTC-import prices, according to the Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA). The BAFA-price is seen as the benchmark for German import prices. In fact the BAFA import price is the only official price available for European Oil-linked long term Natural Gas contracts, given the confidentiality of the long-term contracts.

![Figure 14: TTF vs. Oil-indexed (Tsygankova, 2013).](image)

Some importers were trapped between long-term Take-or-Pay contracts and the Spot prices. German company E.On lost for example an amount of EUR 2,000,000 per day, making a loss of 700 million euro’s on Natural Gas trading in 2012 (Reuters, 2012a). These big spreads triggered contract-renegotiations and this resulted in much more Spot-linked contracts. The exact content of the contracts is not public, but according to information gathered from journalists articles and companies’ press-releases most of the contracts have now approximately 10% discount or approximately 15% Spot indexation (Tsygankova, 2013).

Qatar perseveres in long-term LNG supply contracts based on Oil-indexation, but short-term LNG supplies are based on Spot-indexation and will flow to the place where the LNG suppliers will get the best price (Franza, 2014).

### 3.3.3 Renegotiation of Contracts

As we saw there are a few big competing suppliers like Norway and Russia in the Natural Gas Market. Because of its capacity, Russia always had a tight grip on the European market. In November 2011 Russia built the first part of the Nord Stream (capacity 27 bcm/year) and in October 2012 the second part of the Nord Stream was built, which added another 27 bcm/year to Russia’s capacity. The Nord Stream is a pipeline from Vyborg in Russia to Greifswald in Germany. Despite the extra capacity, Russia began to lose grip in 2012 and lost market share to Norway. Import from Russia at European landing points (Mallnow, Landshut, Baumgarten...
and Greifswald) declined with 9% from 83 bcm in 2011 to 77 bcm in 2012. Especially the first half of 2012 contributed to the decline. In the first 7 months the supply declined with 19% compared to 2011, after July 2012 supply recovered with a 12% increase Y-o-Y (Tsygankova, 2013).

![Figure 15: Flows from Russia and Norway in 2011-2012-2013 (Tsygankova, 2013).](image)

The first half of 2012 can be characterized by mild weather, economic downturn and lower Coal prices. But Russia’s biggest competitor, Norway, saw its supply increasing by 10% from 66 bcm in 2011 to 74 bcm in 2012. When Russia’s supply increased in August 2012, Norway’s supply began to decline. See Figure 15 for the exact flows. The total supply (Russia + Norway) remained stable (Tsygankova, 2013).

The Oil-indexed contracts became probably out-of-the-money, as we saw in Figure 14. Buyers have a so called “price-review” option in their contract. It gives the right to periodically renegotiate the contract. According to Tsygankova (2013), Gazprom renegotiated contracts with amongst others E.On, GDF Suez and Eni. After the contract-negotiations a revival of Russian Natural Gas import is seen in 2013. It seems that Gazprom renegotiated their contracts in such a way that Russian prices can compete again with other competitors.

### 3.3.4 Current Long-term Contracts

**Norway:** Norwegian companies have renegotiated contracts since 2009. According to Franza (2014), StatOil made changes in their contracts with E.On in March 2012 and with RWE in August 2014. In November 2012 StatOil signed a 10 year full Spot-indexed contract with the German company Wintershall (Reuters, 2012b). Exact ratios how much is sold on Spot and how much with Oil-indexed contracts are not available. In 2012 StatOil’s Head of Trading, Bjornson, declared that around three-quarters of StatOil’s Natural Gas is sold at Spot prices. It is estimated that Oil-linked pricing currently accounts for about 15 percent of the sales
volume of StatOil, compared with 45 to 50% a year ago and around 70% 4 years ago. “In those markets, where you have liquid price quotation, we do not have Oil-indexation, even on the long-term contracts.”, says Bjornson (Reuters, 2014).

GasTerra: GasTerra, the Dutch Natural Gas-supplier, stated in their 2011 Annual Report that they see the TTF as “an efficient way to trade Natural Gas and a good opportunity to stimulate supply and demand” (GasTerra, 2011). According to Franza (2014) GasTerra offers in the Netherlands almost all the Natural Gas at Spot-indexation and they are also introducing Spot-indexation in their export contracts.

Russia: Where Norway renegotiated long-term contracts since 2009, Russia resisted for long renegotiations. As mentioned, in August 2011 E.On declared they opened a case against Gazprom, because they paid too much under long-term Oil-indexed contracts. It is assumed that Gazprom agreed by end 2012 to introduce a discount of 7-10% to Oil-indexed contracts. According to Franza (2014) also a modification of the Oil indexation took place, from 12-0-6 structures to 6-0-3 or 3-0-3 structures, which makes the Natural Gas price more reactive to changes in the Oil price.

3.4 Market Dynamics - 2015
3.4.1 Market Dynamics in Europe

We now can roughly categorize UK, the Netherlands and Norway into the Spot-indexed market and Russia still in the Oil-indexed market. This difference can be very interesting for customers. As we know, the Spot-market has a seasonal factor in it, so Norwegian long-term contracts also have this seasonal factor priced in. But the world Oil-market does not know this seasonal factor and the Oil-indexation is made by 3 to 9 months averages, so spikes are averaged out. In principal this makes Russian Natural Gas more attractive during cold winter times and UK, Dutch and Norwegian Natural Gas more attractive during summer. Buyers can choose for the cheapest option and price differences will serve as a ceiling to the market. As details about long-term contracts are confidential, it is hard to make a good assessment of real prices. With Norwegian contracts having a higher share of Spot-indexation, the attractiveness of Russian Natural Gas relatively to Norwegian Natural Gas will probably increase during the coming summer and winter season. Everything else equal, this gives incentives for European consumers to intensify their import of Russian Natural Gas and slow down the Norwegian off-take within the limits specified in the volume flexibility clauses in the contracts.

With Oil prices now around $50/bbl (see Figure 16) the Oil-indexed price will serve as a ceiling. In February 2013 Gazprom’s Head of Export division Alexander Medvedev declared that Gazprom has no intention to further increase the share of Spot price indexation. But in May 2014 Italian distributor Eni made the first non Oil-indexed Natural Gas deal since 50 years with Russia, which maybe has set a precedent for other European customers of Gazprom (Franza, 2014).

Arbitrage opportunities.

Spot price < Oil-indexed price

In this case, midstream-companies will buy more Natural Gas via the Spot market and buy as little as possible via Oil-indexed contracts. Demand for Spot Natural Gas will rise, demand for
Oil-indexed will fall. In theory this process will iterate until the Spot-price reaches the same level as the Oil-indexed price, or the supply of Oil-indexed Natural Gas has been reduced to minimum contracted quantity.

**Spot price > Oil-indexed price**
In this case it is the other way around. Midstream companies will buy more Oil-indexed Natural Gas and less on the Spot market. Less demand for Spot Natural Gas, means lower prices. In theory this process will iterate until the prices are equalized, or the supply of Oil-indexed Natural Gas has increased to the maximum contracted quantity.

Arbitrage can be executed by injecting Natural Gas into storages. In the past storages were mostly used for supply security. But nowadays more and more old salt caverns are used for Natural Gas storage and driven by the arbitrage opportunity between Oil-indexed and Spot (Stern, 2014). An interesting question is: how flexible are the Annual Contracted Quantities? Does it have to be leveled on a monthly basis? According to Stern (2014) it is too simplistic to assume that ACQ has to be leveled on a monthly basis. They believe there is a greater short term flexibility as long as the ACQ will be taken off at the end of the ‘Natural Gas contract year’. A Natural Gas contract year runs from October 1st to September 30th. Reuters stated in their daily report from 26 January 2015: “Imports from Russia are largely unchanged but for a continuation of Nord-Stream flows at just 29 GWh/d. This is now more than ten times lower than the 334 GWh/d noted at the start of January. It likely represents a sign that Continental buyers are moving away from Russian Natural Gas and relying more on storage withdrawals, at the same time decreasing exposure to the risk of taking Russian Natural Gas, but most likely with the intention of filling storages with large volumes of Russian Natural Gas in the summer as term contracts linked to Oil become cheaper than hub Natural Gas.” (Thomson Reuters Eikon, 2015). So it looks as if the long-term contracts have this flexibility and buyers are going to make use of the arbitrage possibilities.

### 3.4.2 LNG Market
The LNG Market is an increasingly important driver of the shorter term global Natural Gas market balance. We saw it already in 2015, a shift is taking place from Asia to Europe. Figure 17 shows the price pattern of the TTF Day Ahead (orange line) and the by Waterborne estimated LNG landing prices in Japan (purple line). As mentioned earlier Japan prices rose

---

**Figure 16**: Brent Crude Oil Front Month (Thomson Reuters Eikon, 2015).
steeply after the nuclear disaster in Fukushima in 2011. But prices converged again. This trig-
gers extra supply to Europe, which will put further pressure on European Spot prices, as we
saw 5 years ago (Stern, 2014).

Figure 17: Natural Gas Prices Japan and the Netherlands (TTF) (Thomson Reuters Eikon, 2015).

Moreover the world liquefaction capacity is expected to grow the coming years with a 9% year-
on-year average from 2016 to 2020. Figure 18 shows LNG capacity growth in Australia, USA,
and Russia the coming years. This will probably give extra pressure on Natural Gas prices.

Figure 18: Extra LNG capacity Australia and USA (Brevik, 2015).

3.4.3 Price Drivers of Natural Gas in Europe

From the previous parts we can derive the following drivers of Natural Gas prices in Europe:

- Supply and Demand.
- Flexible Russian supply, therefore Oil prices.
- The world LNG market.
During 2009-2012 pipeline imports in Europe faced lower demand and higher LNG imports. Figure 19 shows between 2009-2012 Asian demand gradually increased and after Fukushima more and more LNG have been pulled away from Europe to Asia. How will this balance be in the future? Stern (2014) sees four important variables:

- European demand growth.
- Japanese demand, influenced by the rate at which nuclear power generation comes back in to play.
- Future LNG projects, still influenced by Oil prices.
- Chinese demand.

Does the European market become a battlefield between (declining) domestic production, Russian pipeline supply (about 80-100 bcm spare capacity) and world LNG (about 200 bcm extra regasification capacity)?

![Figure 19: LNG Balance (Stern, 2014).](image)

In the last years global LNG supply (from US and non-US sources) is first taken by the Asian LNG markets, as Japan, Korea and Taiwan do not have own natural Natural Gas reserves. They are therefore price takers and will pay a premium up to European prices. Figure 20 shows how the Global LNG market works as a waterfall. Prices given in the picture are in million British Thermal Units (MMBTU). 1 MW = 3.4 MMBTU. The orange ‘warning light’ is shown where midstream companies can become trapped between long-term contracts with suppliers and hub-prices to customers (Rogers, 2013).
3.5 Conclusions

To summarize, between 2008 and 2014 we saw a shift taking place from Oil-indexation to hub-indexation. As Stern (2014) mentions: “Persistence of Crude Oil prices at or above $110/bbl (average 2011-2013) will support this trend”. But at the end of 2014 Oil prices fell (as we saw in Figure 16), with the Brent Crude Oil in January 2015 averaged under $50/bbl, which brings the Oil-indexed Natural Gas back into play.

The period 2008-2014 gives evidence of the impact of LNG supply as a driver in Europe, with a price fall between 2009-2011 caused by extra supply flows to Europe, rising prices after Fukushima and a fall again in summer 2014 due to extra supply. Russian price policy has slightly changed due to out-of-the-money contracts and big losses by European midstream companies. Shale Gas developments in North America have had a huge impact on world Natural Gas and Coal demand. Before the Shale Gas revolution LNG from Qatar was transported to USA, USA is now planning to build liquefaction facilities which can add significant volume to global LNG supply. Lastly, Chinese regasification capacity continues to expand, which can result in extra demand for LNG.
4 Purchasing Strategies other Industrial Users

This Chapter treats how a selection of other companies purchase Energy. The selected companies have comparable (or higher) spend on Energy or they are just as FrieslandCampina active in the food-industry. The aim is to get more insight in Purchasing Strategies en Best Practices from a mix of different companies. The following companies are interviewed or briefly spoken to:

The Netherlands:
- Natural Gas consumption around 360 TWh per year.
- Electricity consumption around 118 TWh per year.

FrieslandCampina:
- Natural Gas consumption (The Netherlands, Belgium, and Germany) around 3.1 TWh per year.
- Electricity consumption (The Netherlands, Belgium, and Germany) around 0.53 TWh per year.

Cargill: an American privately held multinational company. Major businesses are trading, purchasing and distribution of agricultural products. Annual turnover in 2013 $ 137 billion. Cargill has different production locations in Europe.
- Natural Gas consumption in Europe is around 10 TWh per year.
- Tom Schurmans, Energy Supply Chain Lead EMEA Cargill.

Tata Steel: former ‘Hoogovens’, a steel producing company. Worldwide turnover of Tata Steel was $ 25 billion in 2013.
- Natural Gas consumption in IJmuiden is around 3.3 TWh per year.
- Electricity consumption in IJmuiden is around 3 TWh per year.
- Bart Bartelds, Account Manager Energy Tata Steel.

- Exact Gas consumption figures are not shared.
- Lawrence Hambling, Risk Management Director Heineken.

Yara: Norwegian chemical company, Yara produces e.g. nitrogen fertilizer, nitrates and ammonia. In 2013 their turnover was around €10 billion. Yara is among the biggest Natural Gas users in the Netherlands.
- Natural Gas consumption at plant in Sluiskil: 18 TWh per year.
- Total Natural Gas portfolio from Purchasing department in Brussels: 40-45 TWh per year.
- Maximilien Michiels, Energy Analyst Yara.

KPN: Dutch telecommunications company with turnover of €8.5 billion in 2013. Large consumer of Electricity.
- Electricity consumption is around 0.8 TWh per year.
- Frans Hoogland, Senior Information Analyst Energy KPN.

NS: the Dutch Railways, the biggest passenger railway operator in the Netherlands. Annual turnover €4.6 billion.
- Electricity consumption is around 1.2 TWh per year.
- Carola Wijdoogen, CSR Director NS.
I discuss the following three topics in this Chapter:

- Procurement Strategy.
- Risk-Management.
- Purchase-moment.

### 4.1 Purchasing Strategy

The strategies the different companies use are quite diverse. Similar to FrieslandCampina, Heineken applies as well a 3-years ahead view on the market. Tata Steel has a rolling 9 Quarters view and hedges their order portfolio, with some space left for opportunities. KPN starts to buy one year before a certain year. Before the budget is determined, 80% of the forecasted demand has to be covered. NS believes they cannot beat the market and has a contract with their supplier that they can purchase volumes on base of the average TTF Calendar 1 Year-Ahead price of the year before. Cargill hedges their Energy-demand and matches the Energy-portfolio with their sales portfolio. Yara buys their whole volume on the Spot market.

**Heineken.** Heineken has a 3 years ahead view on the market, but not a strict linear Strategy with a tight bandwidth like FrieslandCampina. Heineken has a more rolling perspective on the market. The last part of the forecasted demand is fulfilled with Quarter- and/or Month-products, see Figure 21. So in October 2014 Heineken covered almost the whole forecasted demand for Q1 2015, but still left a significant position open for Q3 and Q4 2015. More than a year ahead the bandwidth in terms of allowed open position are quite big. If the view on the market is bearish the buyer can leave the whole position open.

But if Hambling thinks the market moment is right, he can fulfill a significant part of the expected demand. For the short term the bandwidth is set tighter, to not have a too big open position and therefore short-term financial risk. Because the prompt market is also more volatile than the market for the Forward products with maturity further ahead.

Hambling believes that having a view on the market 3 years ahead is quite a long time and sees that other companies in the market have mostly a shorter view on the market. They believe that the driver behind a long or short view on the market is the demand-uncertainty. For companies with uncertain Energy demand it involves more risk to fix positions. Heineken has, just as FrieslandCampina, a lot of factories. Therefore the demand for Energy is quite stable.
and they do not face big daily fluctuations.

The goal for the Risk Management team at Heineken is:

- Eliminate volatility and keep prices at a stable level through the years.
- Make use of market opportunities.

The performance of the Risk Director will also be measured against these goals. Hambling does not have a specific goal to ‘beat’ the market, because his job is ‘Risk Management’ and not ‘buy at the lowest level’. As the function is quite new at Heineken the exact way to quantify his performance is not yet determined. But he believes that his performance target should not be too much figures-driven. He wants to avoid the principal-agent problem with conflicting interests for company and buyer, as individual performance targets can encourage risk-taking behavior instead of risk-management behavior from a buyer. In the summer of 2014 Hambling organized a Commodity Risk Management roundtable with buyers and risk managers from other companies and they encountered the same principal-agent problem with benchmarking their performance.

**Tata Steel.** Before the financial crisis of 2008 Tata Steel had a 3 years ahead view on the market as well and the purchases were mostly based on historical demand. But the demand for Gas and Electricity is highly linked to demand for steel. The market for steel collapsed after 2008, which left Tata Steel with an over-purchased amount of Gas, bought for the high pre-crisis Natural Gas prices (> €30/MW). This had to be sold for much lower prices than the purchase price, as Natural Gas Spot prices went down to levels under €15/MW (see Figure 13). It resulted in a loss of millions of euros and afterwards Tata switched to a hedging perspective, matching the amount of Natural Gas to purchase with the order portfolio. Bartelds has still room for making use of good market moments and can decide to buy more or less than the amount derived from the order portfolio, but within boundaries.

Bartelds does not benchmark his performance.

**Cargill** Cargill has the most advanced way of purchasing Energy. For a bit more background perspective: Cargill is one of the biggest traders in the agricultural commodities-market and has a European trading floor in Geneva. Having experience with trading Cargill set up an advanced way of purchasing their Energy. The starting point is hedging their order portfolio. The contract with suppliers is based on volume and is European-wide. All the European contracts are conversed to TTF-prices. Cargill has agreed financial swaps with their suppliers, with a Spot-contract as a basis. The Spot-price Cargill uses is the TTF settlement price of LEBA-Heren. With the swaps and the contracted volumes Cargill builds up the ‘hedge book’. Next to Cargill’s hedge book Cargill builds up a trading book. The hedged contracts are ‘sent’ to Geneva, where the proprietary traders can trade with the position, within certain VaR-margins.

Cargill benchmarks the trading portfolio compared to their hedging portfolio. With proprietary trading Cargill has beaten their hedging price every year with more than 5% over the last 10 years. Cargill hedges their portfolio maximum 24 months ahead, on a rolling basis.
Yara

From the companies interviewed Yara is by far the biggest Natural Gas consumer. Natural Gas is for Yara not only a source of Energy, but also material for their products. Synthesis Gas is the basis for the ammonia production at Yara. Let alone the plant of Yara in Sluiskil (the Netherlands) uses already 18 TWh of Natural Gas per year. The Purchasing department in Brussels has about 40-45 TWh of Gas under management. Which is approximately 40 TWh $\times \; €25 / MW = 40,000,000 \times €25 / MW = €1,000,000,000$.

The selling prices of ammonia are highly linked to the Spot market price of Natural Gas. For this reason it does not make sense for Yara to purchase Natural Gas years ahead. Therefore Yara purchases their whole volume on the Spot market. The last years also learned that on average the Spot price was cheaper than Forward products.

Other huge chemical companies like OCI Nitrogen and SABIC use the same reasoning as Yara. Their end-product price is highly linked to the Spot-price of Natural Gas, so it does not make sense to have a long view on the market. OCI and SABIC combine between Spot- and Month-Forwards, according to Mathieu Moling, Natural Gas buyer of OCI.

NS and KPN

KPN buys a year ahead and wants to cover 80% of the forecasted demand before the budget of the company is determined. Wijdoogen, NS, believes she cannot beat the market and “lets a monkey start buying a year before maturity and lets the monkey buy every day 1/250 part of the total forecasted volume.” This is an average TTF Cal contract with the supplier.

Just as FrieslandCampina, both NS and KPN buy only green Electricity. KPN cooperates with Eneco to use wind Energy from the ‘Prinses Amalia Windpark’. In 2013 around 23% of their Electricity was delivered by this windmill park. NS goes even a step further. They set up a partnership with Eneco to build an extra 150-200 windmills to add 1.2 TWh of renewable Energy to the market.

4.2 Risk-Management

Heineken. As the function Risk Director is new, Risk Management at Heineken is in the starting phase. The procurement department at Heineken has another set-up as FrieslandCampina has. Category Buyers are responsible for the contract management and the Risk Management team advises on commodity purchases like Natural Gas, Barley, and Aluminium. Hambling is not a big fan of Value-at-Risk. At first the Value-at-Risk is standard greater in the beginning of the year, if you express open positions in Calendar-products. Hambling believes that if you understand the fundamentals you can estimate the likeliness of an extreme scenario. And if you come into an extreme scenario, will the swing not be bigger than estimated by VaR? Furthermore he says: “Look out with sending numbers to senior managers, they will remember it and it can make them unnecessary anxious.”. Especially a VaR for one or two years ahead can be a big number. Do you want to communicate that?
In terms of qualitative Risk Management, Heineken has some factories in Poland, Hungary, Bulgaria and Slovakia. With the dispute between Russia and Ukraine the Natural Gas supply to these countries was and can be again under serious threat. Hambling made scenarios to be able to change rapidly from Natural Gas to Heating Oil in factories Eastern Europe.

**Tata Steel.** In terms of Financial Risk Management Tata Steel hedges the amount of Natural Gas derived from the order portfolio. Tata aims to eliminate risks and to achieve an average price through the years. At this moment Tata looks about 8 to 9 Quarters ahead. If the market moment is right Tata Steel buys Year-Forwards, but also a significant part of the demand is fulfilled with Quarter-Forwards.

Tata Steel has a much more volatile hourly/daily demand, which can fluctuate between 200 MW and 800 MW. In terms of Supplier Risk, Tata Steel makes use of four different suppliers for their Baseload Forward-contracts and one supplier for balancing (PV-player) the Spot part of the demand. This diminishes the exposure to one supplier and it also gives the possibility to compare the quotes of the different suppliers. In periods when there is a possibility of Spot prices going up, like we saw in March 2013, they try to hedge the Spot risk by purchasing an amount of Month-Forwards equal to the forecasted month average. At some days you have to buy an amount of Natural Gas at the Spot market, at other days you can sell an amount of Natural Gas on the Spot market. This should level each other out. See Figure 22 for visual support.

The supply risk of Electricity, as Tata Steel accounts for almost 2.5% (!) of the total Dutch Electricity consumption, is managed via a direct connection with a power plant from Nuon/Vattenfall next to the complex in IJmuiden. Nuon/Vattenfall makes on their turn use of abundant Cokes Gas from the plant of Tata Steel.

**Cargill.** The volumes and Energy cost price in the order portfolio of Cargill are hedged. As mentioned the Natural Gas-prices in whole Europe are conversed to TTF. The spread between TTF and for example GasPool or Zeebrugge is contractually determined. For the trading book Cargill uses daily-95%-VaR margins.
4.3 Purchasing Moment

How to determine the right moment to buy? The view on this topic is quite the same for the different buyers. In the end it is all about the fundamentals of supply and demand. What influences supply? Market supply comes from domestic European production, Natural Gas storage send-outs and supply from outside (Russia, Norway, Africa and LNG). Demand comes from domestic European demand and Natural Gas storage injections.

What influences the demand? Natural Gas demand is roughly coming from three different consumers: heating houses, industrial users and Electricity generation. The first one is especially influenced by temperature. The second one especially by economic conditions and Electricity is influenced by both economic conditions and weather. The market reacts on changes in these fundamentals.

On the short-term the most important factors are: weather and storage levels. The lower the temperature, the more demand for Natural Gas. So weather forecasts have influence on prompt-Futures.

On the long-term the influence of weather vanishes and the influence of Oil-prices comes into play due to Oil-indexed contracts.

Different buyers believe that the Spot-market has excessive influence on the Year-Forwards. An influence which should not be there that much, because of the seasonal factor in Spot prices. Heineken en Tata Steel both believe that prices of Year-Forwards are relatively cheaper during summer (when Spot prices are relatively low) compared to the winter.

The following information sources are used by the different buyers:

- Information from Suppliers.
- Montel (Tata Steel and Cargill).
- Heren LEBA (Cargill).
- Gasalys (Cargill).
- PointCarbon (part of Thomson Reuters) (De Heus).
- Thomson Reuters Eikon (Heineken and De Heus).
- Bloomberg (EnergieMakelaar)
- Met-office Weather News (Cargill).
- BP Year report (Cargill).
- International Energy Agency (Cargill).
- Argus - Platts (Cargill).
- McCloskey and MacQuarie for Coal (De Heus).
4.4 Recommendations

Next to insights I got in Purchasing Strategies, Risk Management, and the way the interviewed companies determine moments to buy, I noticed some other interesting points. I recommend to pay attention to these points:

- Further research about Supplier Risk. Is it wise to depend on one or two suppliers? Does FrieslandCampina get the best market quotes? How big is the physical delivery risk? Tata Steel uses four different Baseload suppliers. In the Netherlands physical delivery risk is likely to be low. But what about supply risk for FrieslandCampina’s factories in Eastern Europe? Heineken made back-up scenarios for Eastern Europe during the threat of an escalating dispute between Russia and Ukraine.

- Does benchmarking against the market average result in the Principal-Agent problem, with conflicting interests for buyer and company? Heineken and Tata Steel both do not benchmark their purchasing performance, because of possible conflicting interests. In Section 5.1.4 I will go into detail about the Principal-Agent Problem.

- Make the current view on the market a more rolling perspective instead of a year-on-year perspective.

- Investigate the possibilities to hedge the stochastic Profile part of FrieslandCampina’s demand with Month-products, as Tata Steel does. This can be a problem in accounting terms and might need hedge accounting, according to IFRS 9. Tata Steel already makes use of Futures instead of Forwards.

- In order to know if FrieslandCampina is ‘long’ or ‘short’ on Energy it can be interesting to investigate how the sales order portfolio of FrieslandCampina is built up. Do Business Groups make short-term contracts with their customers or long-term? From a hedging/risk perspective raw materials should not be bought (too far) ahead of the moment when contracts with customers are settled.

4.5 Conclusions

- **Purchasing Strategy.** The most important finding is what the drivers behind the different Strategies are. Different Strategies are used by the different companies and this is best described by the reasoning of Risk Management Director Hambling from Heineken: “The more certain and stable the demand is, the longer view on the market you can have”. FrieslandCampina is best compared with Heineken. FrieslandCampina does not need hedging like Tata Steel or Yara do. FrieslandCampina also does not have the resources for a sophisticated trading department like Cargill, nor the necessity if one compares trading volumes.

- **Risk Management.** The same counts for Risk Management, as counts for the Purchasing Strategy. Different Purchasing Strategies require also different ways of Risk Management. A company like Tata Steel is much more focused on Risk Management via hedging. This is less needed for a company like FrieslandCampina or Heineken, but still financial risks can be big. Heineken give themselves more space for opportunities on the long-term, but tightens their allowed open position, when reaching maturity. A rolling perspective, used by Cargill, Tata, Heineken, and Yara, can also be interesting for FrieslandCampina.
5 Purchasing Strategy FrieslandCampina

In this Chapter I analyse historical demand data of FrieslandCampina, and which Purchasing Strategy would be optimal on historical demand data.

5.1 Current Purchasing Strategy

5.1.1 Natural Gas Contracts

Before we look into historical demand data some background information about contracts FrieslandCampina buys from their supplier. As mentioned FrieslandCampina buys Forward-contracts priced on TTF. TTF Natural Gas Forward contracts are priced in MegaWatt (MW). If one agrees a 10 MW Year-Forward at price level $25/MW it means that FrieslandCampina will get every(!) hour during a year 10 MW gas. In total the buyer will receive $10 \times 8760 = 87,600$ MWh Natural Gas. The cost of this contract is $25 \times 87,600$ MWh = €2,190,000.

It can occur that at some hours during the year the 10 MW is not fully consumed. FrieslandCampina can level this out with other hours during the day. The average daily consumption should be 10 MW, or in others words the total daily consumption must be $10 \times 24 = 240$ MWh.

As the demand from all the factories is stochastic, the demand is in practice never exact the same amount as is purchased via Forward contracts. In fact two situations can occur: demand is higher than purchased via Forward contracts or demand is lower than purchased via Forward contracts.

Demand < Purchased via Forwards:

FrieslandCampina bought a 10 MW TTF Natural Gas Year-Forward for $25/MW. FrieslandCampina uses 200 MWh on day $x$. The contracted volume is 240 MWh. This means 40 MWh is not consumed. The supplier will sell 40 MWh on the Spot market at the Spot price. Assume the Spot price is $20/MW. FrieslandCampina pays $240MWh \cdot 25 = 6000$ and receives $40MWh \cdot 20 = 800$. So FrieslandCampina’s gas price is in the end: $5200/200MWh = 26$/MW. So it gives a financial risk when purchasing more than one uses.

Demand > Purchased via Forwards:

FrieslandCampina bought a 10 MW Year-Forward TTF Natural Gas Year-Forward for $25/MW. All of the factories are running on full capacity, there is a cold spell in Europe and therefore FrieslandCampina uses 340 MWh on day $x$. The contracted volume was 240 MWh. This means the supplier has to deliver an extra 100 MWh. The supplier will buy 100 MWh on the Spot market at the Spot price. Assume the Spot price is $30/MW. FrieslandCampina pays $240MWh \cdot 25 + 100MWh \cdot 30 = 9000$. $9000/340MWh = 26.5$/MW. As we see: it also gives a financial risk when purchasing not enough.

Accounting Rules:

According to IFRS 9 (Financial Instruments) a company has to apply hedge accounting when a company knows it will sell back to the market. With hedge accounting purchases have to be recognized in the financial statements and the value is adjusted by marking to market, which can create large swings in the profit and loss account. This is something FrieslandCampina does not want. The benefits will probably not outweigh these disadvantages.
5.1.2 Historical Natural Gas Demand

Figure 23 shows the average hourly demand in MW per month between 2012 and 2014. The demand has a seasonal pattern, due to lower temperatures in winter than in summer and also due to the supply of raw milk during the year. The winter period is typically a period of more raw milk supply to FrieslandCampina. Note that demand is expressed in MW or in other words the average hourly demand during a month.

![Average MW per Month 2012-2014](image)

Figure 23: Volume FrieslandCampina 2012-2014.

Table 1 (next page) shows the historical demand for 2013 and 2014 for FrieslandCampina. The third column displays the total usage during a certain month in MWh. The fourth column gives the average hourly amount of MW. The fifth and sixth column present how many MWh are bought via Forward contracts and how much MW on Spot. The Strategy of FrieslandCampina becomes visible by these numbers, as FrieslandCampina aims to not sell back to the market and has a short position during almost the whole year. On average 310 MW was bought via Forward contracts (Baseload) and 47 MW (13%) on Spot (Profile) in 2014.

On average the demand is significantly higher than the amount purchased via Forward contracts. As mentioned in the Section 5.1.1, supply has to meet demand and FrieslandCampina does not have a possibility to store Natural Gas. To know when demand meets supply we zoom further into the daily average supply and demand in 2014, see Figure 24.

We can see from Figure 24 not all demand can be covered with Forward contracts. The blue line is the average daily demand, the orange line is the amount of Forward-products FrieslandCampina bought. This is a combination of 260 MW Year-Forwards, complemented with Quarter-Forwards. In 2014 it happened six times demand was lower than the contracted amount of MW through Forward Year- and Quarter-contracts. The total volume sold back to the market was 28MW×24h=672 MWh, which is 0.02% of the total purchased volume. This can be interpreted as ‘safe’ and ‘risk-avoiding’, but an open position gives a financial risk as well. Therefore I show in the next Section an example at FrieslandCampina in the past, which clearly shows the risks of an open position.
5.1 Current Purchasing Strategy

![Daily Average MW - 2014](image)

**Figure 24:** Daily Volume FrieslandCampina 2014.

<table>
<thead>
<tr>
<th></th>
<th>2013 Days</th>
<th>Total Usage (MWh)</th>
<th>Average Usage (MW)</th>
<th>Forward (MW)</th>
<th>Spot (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>31</td>
<td>294,987</td>
<td>396</td>
<td>265</td>
<td>131</td>
</tr>
<tr>
<td>February</td>
<td>28</td>
<td>274,691</td>
<td>409</td>
<td>265</td>
<td>144</td>
</tr>
<tr>
<td>March</td>
<td>31</td>
<td>307,985</td>
<td>414</td>
<td>265</td>
<td>149</td>
</tr>
<tr>
<td>April</td>
<td>30</td>
<td>263,398</td>
<td>366</td>
<td>245</td>
<td>121</td>
</tr>
<tr>
<td>May</td>
<td>31</td>
<td>267,511</td>
<td>360</td>
<td>245</td>
<td>115</td>
</tr>
<tr>
<td>June</td>
<td>30</td>
<td>243,087</td>
<td>338</td>
<td>245</td>
<td>93</td>
</tr>
<tr>
<td>July</td>
<td>31</td>
<td>246,416</td>
<td>331</td>
<td>245</td>
<td>86</td>
</tr>
<tr>
<td>August</td>
<td>31</td>
<td>244,375</td>
<td>328</td>
<td>245</td>
<td>53</td>
</tr>
<tr>
<td>September</td>
<td>30</td>
<td>232,849</td>
<td>323</td>
<td>245</td>
<td>78</td>
</tr>
<tr>
<td>October</td>
<td>31</td>
<td>252,700</td>
<td>340</td>
<td>300</td>
<td>40</td>
</tr>
<tr>
<td>November</td>
<td>30</td>
<td>247,281</td>
<td>343</td>
<td>300</td>
<td>43</td>
</tr>
<tr>
<td>December</td>
<td>31</td>
<td>290,038</td>
<td>390</td>
<td>300</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td>365</td>
<td>3,165,320</td>
<td>362</td>
<td>300</td>
<td>62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2014 Days</th>
<th>Total Usage (MWh)</th>
<th>Average Usage (MW)</th>
<th>Forward (MW)</th>
<th>Spot (MW)</th>
<th>Δ(2014-2013) (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>31</td>
<td>284,365</td>
<td>382</td>
<td>340</td>
<td>42</td>
<td>-10,622</td>
</tr>
<tr>
<td>February</td>
<td>28</td>
<td>256,311</td>
<td>381</td>
<td>340</td>
<td>41</td>
<td>-18,380</td>
</tr>
<tr>
<td>March</td>
<td>31</td>
<td>282,592</td>
<td>380</td>
<td>340</td>
<td>40</td>
<td>-25,393</td>
</tr>
<tr>
<td>April</td>
<td>30</td>
<td>269,379</td>
<td>374</td>
<td>310</td>
<td>64</td>
<td>-5,981</td>
</tr>
<tr>
<td>May</td>
<td>31</td>
<td>272,358</td>
<td>366</td>
<td>310</td>
<td>56</td>
<td>4,847</td>
</tr>
<tr>
<td>June</td>
<td>30</td>
<td>254,809</td>
<td>354</td>
<td>310</td>
<td>44</td>
<td>11,722</td>
</tr>
<tr>
<td>July</td>
<td>31</td>
<td>252,375</td>
<td>339</td>
<td>280</td>
<td>59</td>
<td>5,959</td>
</tr>
<tr>
<td>August</td>
<td>31</td>
<td>250,417</td>
<td>337</td>
<td>280</td>
<td>57</td>
<td>6,042</td>
</tr>
<tr>
<td>September</td>
<td>30</td>
<td>239,519</td>
<td>333</td>
<td>280</td>
<td>53</td>
<td>6,670</td>
</tr>
<tr>
<td>October</td>
<td>31</td>
<td>249,900</td>
<td>336</td>
<td>310</td>
<td>26</td>
<td>-2,800</td>
</tr>
<tr>
<td>November</td>
<td>30</td>
<td>251,124</td>
<td>349</td>
<td>310</td>
<td>39</td>
<td>3,842</td>
</tr>
<tr>
<td>December</td>
<td>31</td>
<td>268,588</td>
<td>361</td>
<td>310</td>
<td>51</td>
<td>-21,450</td>
</tr>
<tr>
<td>Total</td>
<td>365</td>
<td>3,131,738</td>
<td>358</td>
<td>310</td>
<td>48</td>
<td>-33,582</td>
</tr>
</tbody>
</table>

**Table 1:** Demand FrieslandCampina 2013 and 2014.
5.1.3 Risk on the Spot Market

To better understand financial risks in practice, I show what happened in March 2013. In January and February 2013 average temperature in N-W Europe was below normal levels. The lower than average temperatures resulted in higher demand for Natural Gas in Europe, which had in their case an upwards effect on the storage send-outs. Table 2 shows the average temperatures during the winter of 2013, normal temperatures and the prices of Natural Gas.

<table>
<thead>
<tr>
<th>Month</th>
<th>Average Temp (°C)</th>
<th>Normal Average (°C)</th>
<th>Spot (€)</th>
<th>Month-Forward (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December</td>
<td>5.0</td>
<td>3.7</td>
<td>27.33</td>
<td>27.35</td>
</tr>
<tr>
<td>January</td>
<td>2.0</td>
<td>3.1</td>
<td>26.53</td>
<td>27.40</td>
</tr>
<tr>
<td>February</td>
<td>1.7</td>
<td>3.3</td>
<td>26.31</td>
<td>26.59</td>
</tr>
</tbody>
</table>

Table 2: Temperatures and Natural Gas Prices — (Thomson Reuters Eikon, 2015).

Figures 25 and 26 show the aggregate storage levels in Germany, Belgium, France, and the Netherlands in 2011, 2012, 2013 (green line), 2014, and 2015 and the daily temperatures in the Netherlands in 2013 (orange line), 2014, and 2015. Storage levels in the four countries were comfortable the 1st of January, but the steep declining line shows the relative high send-outs. Figure 26 clearly shows the low temperatures in January, February and March 2013.

The question is which impact this had on the price of Natural Gas? In the months before March the average Spot price, opposed to what one should expect, declined from December to February, see Table 2. The Month-futures averages followed the same pattern. Averages from one-month to maturity till maturity of the corresponding Month-futures are displayed. For example: the price of December is the average of the December12-Future from 1st of November till the second last trading day of November. Both Spot-prices and month-futures were quite stable. The March13-Future was with an average (in February) of €25.75 even lower than the average Spot price in February (€26.31).

Conclusions which could have been derived in February: 1) storages were relatively empty, 2) March13-Future lies around Spot-price level, 3) weather forecast: chance of low temperatures.

FrieslandCampina covered 265 MW with Year- and Quarter-Forwards and decided to not take action. Figures 27 and 28 show what happened in March 2013. As we already could see in Figure
26, the temperatures continued to be low. The average temperature in March was 2.5°C, which is 3.7°C below normal March average of 6.2°C. Figure 28 displays the demand for Natural Gas at FrieslandCampina and the level of Natural Gas contracted via Forwards.

Figure 27: Prices Spot & Month Ahead Thomson Reuters Eikon (2015).

Figure 28: Demand vs. Forward-purchases.

There is a huge gap between actual demand (413 MW) and purchased amount via Forwards (265 MW). This gap had to be filled with Spot-purchases. What if FrieslandCampina had purchased in February a March13-Forward? The price of a March13-Forward was in February on average €25.75. Comparing this number with the actual Spot prices, gives us Table 3. It appears that Spot purchases cost FrieslandCampina €651,880 more than if around 150 MW March13-Forwards had been bought.

<table>
<thead>
<tr>
<th>Date</th>
<th>Demand (MW)</th>
<th>Forward (MW)</th>
<th>Spot (MW)</th>
<th>∆(S-F) (€)</th>
<th>Costs (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/03/2013</td>
<td>428</td>
<td>265</td>
<td>183</td>
<td>26.30</td>
<td>0.55</td>
</tr>
<tr>
<td>02/03/2013</td>
<td>414</td>
<td>265</td>
<td>149</td>
<td>26.60</td>
<td>0.85</td>
</tr>
<tr>
<td>03/03/2013</td>
<td>403</td>
<td>265</td>
<td>138</td>
<td>26.60</td>
<td>0.85</td>
</tr>
<tr>
<td>04/03/2013</td>
<td>421</td>
<td>265</td>
<td>156</td>
<td>26.60</td>
<td>0.85</td>
</tr>
<tr>
<td>05/03/2013</td>
<td>400</td>
<td>265</td>
<td>135</td>
<td>28.50</td>
<td>2.75</td>
</tr>
<tr>
<td>06/03/2013</td>
<td>376</td>
<td>265</td>
<td>111</td>
<td>27.30</td>
<td>1.55</td>
</tr>
<tr>
<td>07/03/2013</td>
<td>408</td>
<td>265</td>
<td>143</td>
<td>27.50</td>
<td>1.75</td>
</tr>
<tr>
<td>08/03/2013</td>
<td>408</td>
<td>265</td>
<td>143</td>
<td>27.20</td>
<td>1.45</td>
</tr>
<tr>
<td>09/03/2013</td>
<td>401</td>
<td>265</td>
<td>136</td>
<td>27.60</td>
<td>1.25</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>411</td>
<td>265</td>
<td>146</td>
<td>27.00</td>
<td>1.25</td>
</tr>
<tr>
<td>11/03/2013</td>
<td>424</td>
<td>265</td>
<td>159</td>
<td>27.00</td>
<td>1.25</td>
</tr>
<tr>
<td>12/03/2013</td>
<td>426</td>
<td>265</td>
<td>161</td>
<td>33.50</td>
<td>7.75</td>
</tr>
<tr>
<td>13/03/2013</td>
<td>444</td>
<td>265</td>
<td>179</td>
<td>36.20</td>
<td>10.45</td>
</tr>
<tr>
<td>14/03/2013</td>
<td>442</td>
<td>265</td>
<td>177</td>
<td>33.60</td>
<td>7.25</td>
</tr>
<tr>
<td>15/03/2013</td>
<td>445</td>
<td>265</td>
<td>180</td>
<td>29.40</td>
<td>3.65</td>
</tr>
<tr>
<td>16/03/2013</td>
<td>400</td>
<td>265</td>
<td>135</td>
<td>27.80</td>
<td>2.05</td>
</tr>
<tr>
<td>17/03/2013</td>
<td>395</td>
<td>265</td>
<td>130</td>
<td>27.80</td>
<td>2.05</td>
</tr>
<tr>
<td>18/03/2013</td>
<td>418</td>
<td>265</td>
<td>153</td>
<td>27.80</td>
<td>2.05</td>
</tr>
<tr>
<td>19/03/2013</td>
<td>400</td>
<td>265</td>
<td>135</td>
<td>30.20</td>
<td>4.45</td>
</tr>
<tr>
<td>20/03/2013</td>
<td>407</td>
<td>265</td>
<td>142</td>
<td>32.10</td>
<td>6.35</td>
</tr>
<tr>
<td>21/03/2013</td>
<td>417</td>
<td>265</td>
<td>152</td>
<td>34.60</td>
<td>8.85</td>
</tr>
<tr>
<td>22/03/2013</td>
<td>446</td>
<td>265</td>
<td>181</td>
<td>32.75</td>
<td>7.00</td>
</tr>
<tr>
<td>23/03/2013</td>
<td>433</td>
<td>265</td>
<td>168</td>
<td>36.30</td>
<td>10.75</td>
</tr>
<tr>
<td>24/03/2013</td>
<td>429</td>
<td>265</td>
<td>164</td>
<td>36.30</td>
<td>10.75</td>
</tr>
<tr>
<td>25/03/2013</td>
<td>430</td>
<td>265</td>
<td>165</td>
<td>36.30</td>
<td>10.75</td>
</tr>
<tr>
<td>26/03/2013</td>
<td>431</td>
<td>265</td>
<td>166</td>
<td>38.50</td>
<td>12.75</td>
</tr>
<tr>
<td>27/03/2013</td>
<td>412</td>
<td>265</td>
<td>147</td>
<td>38.45</td>
<td>12.70</td>
</tr>
<tr>
<td>28/03/2013</td>
<td>413</td>
<td>265</td>
<td>148</td>
<td>38.45</td>
<td>12.70</td>
</tr>
<tr>
<td>29/03/2013</td>
<td>411</td>
<td>265</td>
<td>146</td>
<td>36.55</td>
<td>10.80</td>
</tr>
<tr>
<td>30/03/2013</td>
<td>383</td>
<td>265</td>
<td>118</td>
<td>36.55</td>
<td>10.80</td>
</tr>
<tr>
<td>31/03/2013</td>
<td>364</td>
<td>265</td>
<td>99</td>
<td>36.55</td>
<td>10.80</td>
</tr>
</tbody>
</table>

Table 3: Costs Spot vs. Forward March 2013.
5.1.4 Principal-Agent Problem

Conflicts of interest and moral hazard can occur when a principal hires an agent to perform specific tasks that are in interest of the principal, but may be not in the best interests of the agent. This problem arises when the principal develops an environment where the agent has incentives to pursue its own interests (Rees, 1985).

In the situation the performance of a buyer is measured against a certain market benchmark and the buyer gets a reward when performing better than the market, a kind of Principal-Agent problem can occur. For example: Schröder is benchmarked against the average market price of the Forward-price from 3 years to maturity to maturity. 3 years before maturity a third of the benchmark is already determined. As an example: the average price of Natural Gas was €25 in the first year. If the current price is €24 and no volume was bought yet, the buyer can buy ‘without risk’ already a third of the total volume, because he knows: €24 < €25 and a third of the benchmark will never be lower than the achieved purchase price. The buyer sees the fundamentals of the market and thinks that the market will be lower, but as his goal is to perform better than benchmark he decides to buy, so he can lock in his own reward.

Afterwards the price drops to €20 in April, a perfect price to lock in the whole volume. But the problem for the buyer is: if the price gets even lower, his performance can be lower than the benchmark and his performance can be bad. So he decides to not buy more than the ‘Strategy’, which means: (365 days of the first year + 90 days of the second year)/(365x3) = 42 % of the volume.

The €20 appeared to be a perfect market moment and prices rise again to €25. The buyer only bought 10 % of the total volume at €20. In the remaining time the market price fluctuates between €25 and €26 and the buyer can lock in the rest of the 58 % of the volume for €25.20. The buyer is satisfied with €25.20, as it is lower than the average market price. The average market price was in the end €25.30 and the achieved purchased price €24.35. The buyer is happy, because he performed better than benchmark.

Figure 29: Cumulative Purchases Cal 2016.

Figure 29 shows FrieslandCampina’s cumulative purchases for Cal 2016. The cumulative amount is always a bit under ‘Strategy’. It seems the Principal-Agent problem is a side-effect of benchmarking Schröder’s performance, and is present at FrieslandCampina.
5.2 Risk Profile FrieslandCampina

To understand the Risk-profile of FrieslandCampina I have interviewed Corporate Head of Treasury Klaas Springer, Controller Procurement Dirk van Breen, and Director Finance Butter & Milkpowder Simon Molenaar.

Springer explains why FrieslandCampina does not want to buy Futures on ICE Ender. Futures need margin-settlements and this is settled over the Profit & Loss account. “We cannot sell a loss of €10,000,000 to our farmers due to margin settlement of Futures, because the Natural Gas prices declined with €3 - €4.”

Van Breen explains FrieslandCampina can be roughly divided into Business-to-Consumer (BG Consumer Products and part of BG Cheese and Butter) and Business-to-Business (BG Ingredients and BG Milkpowder). Contracts in B2C are characterized by longer term contracts. Higher Energy costs are probably hard to offset in customer prices. Contracts in B2B have shorter term length and higher Energy costs are easier to offset in customer prices.

According to Molenaar milkpowder is the product with the highest percentage of Energy costs in the cost price. This is still not more than 5% of the total cost price. “Energy has no influence on the price of milkpowder”, Molenaar says. The price of milkpowder is determined by the price of raw milk. In his eyes Utilities Procurement should aim for a low purchasing price, instead of the risk-averse current Strategy.

Summarizing, there seems no real need from BGs for hedging and a risk-averse Strategy. The business asks to aim for low Energy prices. As Energy is such a low percentage of the cost-price, with a maximum of 5% in milkpowder, BGs will not be faced with much higher cost-prices and unmarketable products when Energy prices are a bit higher than expected. Having covered the biggest part of the demand before budget determination already gives a certain degree of certitude about Energy-prices.
5.3 Backtests of Purchasing Strategies - Baseload

5.3.1 Optimization Model

As explained in the introduction, FrieslandCampina’s current Strategy is purchasing Natural Gas 3 years ahead.

How did FrieslandCampina perform compared to the market? To have a fair comparison I take the average Futures prices from 3 years to maturity to maturity and give them the weighted average 25-25-35%. Achieved purchase prices are obtained from historical data from FrieslandCampina. The historical prices of the TTF Futures prices are obtained via Thomson Reuters Eikon (2015). These TTF-prices are the End-of-Day Settlement prices of ICE Endex for 2013-2015 and for 2011-2012 the daily prices are the Thomson Reuters estimated End-of-Day Settlement prices of the OTC Forward market, as more data are not available from ICE Endex.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fr.Camp.</th>
<th>Market</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>24.40</td>
<td>25.55</td>
<td>1.23%</td>
</tr>
<tr>
<td>2014</td>
<td>26.40</td>
<td>26.83</td>
<td>1.50%</td>
</tr>
<tr>
<td>2013</td>
<td>26.60</td>
<td>25.48</td>
<td>-4.40%</td>
</tr>
<tr>
<td>2012</td>
<td>25.45</td>
<td>23.81</td>
<td>-6.90%</td>
</tr>
<tr>
<td>2011</td>
<td>20.51</td>
<td>23.54</td>
<td>12.86%</td>
</tr>
</tbody>
</table>

Table 4: FrieslandCampina Procurement.

The purchasing performance is quite diverse if we compare it to the market. The last 3 years FrieslandCampina ‘beat’ the market by more than 1%, but the 3 years before the average purchase price of FrieslandCampina is above the market average. In 2011 it seems that FrieslandCampina Procurement did a very good job, ‘beating’ the market with 12%. How could these differences occur? The first observation made is that the Strategy is not followed at all! Figure 30 displays the history of Year-Forward purchases of FrieslandCampina the last 5 years. Older data are not available. The line represents the historical price pattern of the representing Forward. The histograms show the purchases with their corresponding amount and date. For
example, for 2015 the blue line is the TTF Cal 2015 Forward price from 1st of January 2012 to the 31th of December 2014. It is clear from the Figures that the Strategy has not been followed. For example for 2011, everything (!) was bought in the second half of 2010. If we look to the historical price pattern of the Cal 2011-Forward, it was in terms of a good price a good decision not to buy in 2008 and wait for 2010. But the Strategy has not been followed. The Figures show that after the appointment of Schröder in July 2013 the amount of purchases increases and Strategy is followed.

Figure 30: Purchase history FrieslandCampina.
What if the Strategy had been followed, which results could have been found? I set up a L.P.-problem to see what the optimal purchase prices could have been when buying exactly at the right moment, the right amount of Natural Gas, given the bandwidth set by FrieslandCampina. To do so we have to define the right constraints. Two questions can be answered with these calculations: which Strategy performed well the last 5 years and how much potential is lost by a tight bandwidth? I split the last year before maturity into two periods. One period before budget is determined (before October 1st) and one period after budget determination. Therefore I will talk from now on in terms of 7-7-7-7% bandwidth.

Parameters:

\[ B \quad \text{Batch size of one TTF Forward, } B=5 \]
\[ P_t \quad \text{number of purchased batches of TTF Forwards at day } t \]
\[ S_1 \quad \text{Strategy at } Y+3 \]
\[ S_2 \quad \text{Strategy at } Y+2 \]
\[ S_3 \quad \text{Strategy at } Y+1 \]
\[ M_1 \quad \text{Margin at } Y+3 \]
\[ M_2 \quad \text{Margin at } Y+2 \]
\[ M_3 \quad \text{Margin at } Y+1, \text{ from 1-1 to 30-9} \]
\[ M_4 \quad \text{Margin at } Y+1, \text{ from 1-10 to 31-12 (after budget determination)} \]

Decision variable:

\[ X_t \quad \text{number of purchased batches of TTF Forwards at day } t \]

\[
\begin{align*}
\text{min } Z &= B \sum_{t=1}^{T} X_t \cdot P_t \\
\text{s.t.} & \quad B \cdot X_t \leq 20 \quad \forall t \in T \\
& \quad B \cdot \sum_{t=1}^{7T/8} X_t = 300 \quad \forall t \in T \\
& \quad B \cdot \sum_{t=7T/8}^{7T} X_t \geq (S_1 \cdot \left(\frac{1}{t}\right)) \cdot D \quad \forall t \in [t = 1, \ldots, 257] \\
& \quad B \cdot \sum_{t=7T/8}^{7T} X_t \geq (S_1 + S_2 + (S_3 \cdot \left(\frac{1}{t-514}\right))) \cdot M_3 \cdot D \quad \forall t \in [t = 515, \ldots, 705] \\
& \quad B \cdot \sum_{t=7T/8}^{7T} X_t \geq (S_1 + S_2 + (S_3 \cdot \left(\frac{1}{t-514}\right))) \cdot M_4 \cdot D \quad \forall t \in [t = 706, \ldots, 771] \\
& \quad B \cdot \sum_{t=7T/8}^{7T} X_t \leq (S_1 \cdot \left(\frac{1}{t}\right)) + M_1 \cdot D \quad \forall t \in [t = 1, \ldots, 257] \\
& \quad B \cdot \sum_{t=7T/8}^{7T} X_t \leq (S_1 + S_2 + (S_3 \cdot \left(\frac{1}{t-514}\right))) \cdot M_3 \cdot D \quad \forall t \in [t = 515, \ldots, 705] \\
& \quad B \cdot \sum_{t=7T/8}^{7T} X_t \leq (S_1 + S_2 + (S_3 \cdot \left(\frac{1}{t-514}\right))) \cdot M_4 \cdot D \quad \forall t \in [t = 706, \ldots, 771] \\
& \quad X_t \geq 0 \quad \forall t \in T \\
& \quad X_t = \text{integer}
\end{align*}
\]

The L.P.-problem is programmed in Microsoft Excel (OptimizationBaseload.xlsx) and can be found in Appendix B. To understand what the Linear Problem does, two scenarios for 2015 are given. Optimal solutions are calculated for Scenario 1) Strategy: 25-25-35%, Margin: 7-7-7-7%,

---

60 THESIS - J.R.WILLEMINCK
Year: 2015 and Scenario 2) Strategy: 25-25-35%, Margin: 25-25-25-15%, Year: 2015. The optimal price for the first scenario is €24.35 and for the second it is €23.58. FrieslandCampina bought on average TTF 2015 Forwards for €25.24. A Δ of €1 means: 350 MW x 8760 hours x €1 = €3,066,000. So in this example FrieslandCampina misses an opportunity of €24.35 - €23.58 = €0.77, or €2,360,820 because of the tight bandwidth.

Figure 31 gives visual insight in the optimal solution. The first two graphs are the price pattern of the TTF Cal 15 and the purchases. The blue histogram displays the purchases of FrieslandCampina and the orange histogram displays the purchases in the optimal solution. The lowest two graphs show the cumulative purchases in time. The two outer dotted lines are the boundaries given by the bandwidth. The middle dotted line is the rolling ‘Strategy’. The thick blue line is the cumulative amount of purchases. Every time the blue line hits the lower boundary it means the optimal solution is forced to buy an amount of Natural Gas. Every time the blue line hits the upper boundary the optimal solution is bound to a maximum amount of purchasing. The more often the optimal solution hits the boundaries, the more ‘opportunity’ is given away by the Strategy and bandwidth. As can be seen, the optimal solution for the 7-7-7-7% bandwidth hits the boundary more often than the optimal solution of the 25-25-25-15% bandwidth. This is a simple explanation where the difference of €0.77 comes from.

Figure 31: Scenarios for Cal 2015.
5.3.2 Results Optimization Model

To start I compare the purchases of FrieslandCampina with the optimal purchases given the Strategy and bandwidth. Table 5 shows the optimal solution for the current Strategy vs. FrieslandCampina’s prices. This comparison is not totally fair, as the Strategy is not followed between 2011 and July 2013.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fr. Camp. (€)</th>
<th>Optimal (€)</th>
<th>Difference (€)</th>
<th>Difference (%)</th>
<th>Total Difference (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>25.24</td>
<td>24.35</td>
<td>-0.89</td>
<td>-3.67%</td>
<td>-2,741,004</td>
</tr>
<tr>
<td>2014</td>
<td>26.40</td>
<td>25.62</td>
<td>-0.78</td>
<td>-3.05%</td>
<td>-2,397,612</td>
</tr>
<tr>
<td>2013</td>
<td>26.60</td>
<td>23.68</td>
<td>-2.92</td>
<td>-12.32%</td>
<td>-8,946,077</td>
</tr>
<tr>
<td>2012</td>
<td>25.45</td>
<td>21.45</td>
<td>-4.00</td>
<td>-18.64%</td>
<td>-12,263,304</td>
</tr>
<tr>
<td>2011</td>
<td>20.51</td>
<td>19.86</td>
<td>-0.65</td>
<td>-3.27%</td>
<td>-1,992,714</td>
</tr>
</tbody>
</table>

Table 5: Optimal results 25-25-35 % Strategy.

The current Strategy has room for improvement. But more interesting is how other Strategies perform and how much opportunity is given away by the tightness of the 7-7-7-7% bandwidth. Solutions are defined for a set of Strategies, bandwidths and years. We test 7 different Strategies and 6 different bandwidths on 5 different years. This gives a set of 7x6x5=210 prices.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Bandwidth</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-25-35 %</td>
<td>7-7-7-7 %</td>
<td>2015</td>
</tr>
<tr>
<td>5-30-50 %</td>
<td>25-15-7-7 %</td>
<td>2011</td>
</tr>
<tr>
<td>0-35-50 %</td>
<td>50-25-15-7 %</td>
<td></td>
</tr>
<tr>
<td>0-0-85 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Parameters.

Table 7 show the results of the optimality runs. The Strategy is on the vertical axis, the different bandwidths are on the horizontal axis. I compare the optimal purchases prices calculated with the average market price. The number given in Table 7 is \((\text{market price}) - (\text{optimal solution})\). A number of 1.2 means that in the optimal case, given the Strategy and bandwidths, the purchase price can be €1.2 / MW under the market average.
### Backtests of Purchasing Strategies - Baseload

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>BANDWIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y+3</td>
</tr>
<tr>
<td></td>
<td>Y+2</td>
</tr>
<tr>
<td></td>
<td>Y+1</td>
</tr>
<tr>
<td>Oct.</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Y+3</td>
</tr>
<tr>
<td></td>
<td>Y+2</td>
</tr>
<tr>
<td></td>
<td>Y+1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 1</th>
<th>avg.</th>
<th>2.0</th>
<th>2.9</th>
<th>3.0</th>
<th>3.8</th>
<th>3.4</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>2015</td>
<td>1.3</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Y+2</td>
<td>2014</td>
<td>1.2</td>
<td>1.5</td>
<td>1.5</td>
<td>1.8</td>
<td>1.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Y+1</td>
<td>2013</td>
<td>1.5</td>
<td>2.3</td>
<td>2.3</td>
<td>3.1</td>
<td>3.1</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>2.1</td>
<td>3.3</td>
<td>3.7</td>
<td>4.9</td>
<td>4.7</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>4.1</td>
<td>5.5</td>
<td>5.5</td>
<td>6.9</td>
<td>5.8</td>
<td>7.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 2</th>
<th>avg.</th>
<th>2.1</th>
<th>2.8</th>
<th>3.0</th>
<th>3.8</th>
<th>3.4</th>
<th>4.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>2015</td>
<td>1.5</td>
<td>1.7</td>
<td>1.9</td>
<td>2.1</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Y+2</td>
<td>2014</td>
<td>1.2</td>
<td>1.4</td>
<td>1.4</td>
<td>1.7</td>
<td>1.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Y+1</td>
<td>2013</td>
<td>1.2</td>
<td>1.9</td>
<td>1.9</td>
<td>2.8</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>2.0</td>
<td>3.3</td>
<td>3.3</td>
<td>4.4</td>
<td>4.3</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>4.6</td>
<td>5.8</td>
<td>5.8</td>
<td>7.2</td>
<td>6.2</td>
<td>7.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 3</th>
<th>avg.</th>
<th>2.1</th>
<th>2.8</th>
<th>2.9</th>
<th>3.6</th>
<th>3.4</th>
<th>4.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>2015</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Y+2</td>
<td>2014</td>
<td>1.1</td>
<td>1.4</td>
<td>1.4</td>
<td>1.7</td>
<td>1.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Y+1</td>
<td>2013</td>
<td>0.9</td>
<td>1.8</td>
<td>1.8</td>
<td>2.6</td>
<td>2.6</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1.7</td>
<td>2.8</td>
<td>3.1</td>
<td>4.0</td>
<td>3.8</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>4.9</td>
<td>6.1</td>
<td>6.2</td>
<td>7.4</td>
<td>6.3</td>
<td>7.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 4</th>
<th>avg.</th>
<th>2.0</th>
<th>2.8</th>
<th>2.9</th>
<th>3.6</th>
<th>3.2</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>2015</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Y+2</td>
<td>2014</td>
<td>1.1</td>
<td>1.3</td>
<td>1.3</td>
<td>1.6</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Y+1</td>
<td>2013</td>
<td>0.5</td>
<td>1.4</td>
<td>1.4</td>
<td>2.5</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1.7</td>
<td>2.6</td>
<td>2.8</td>
<td>3.8</td>
<td>3.7</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>5.1</td>
<td>6.2</td>
<td>6.2</td>
<td>7.4</td>
<td>6.5</td>
<td>7.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 5</th>
<th>avg.</th>
<th>2.0</th>
<th>2.7</th>
<th>2.7</th>
<th>3.5</th>
<th>3.2</th>
<th>4.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>2015</td>
<td>1.5</td>
<td>1.8</td>
<td>1.9</td>
<td>2.2</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Y+2</td>
<td>2014</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.6</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Y+1</td>
<td>2013</td>
<td>0.3</td>
<td>1.3</td>
<td>1.3</td>
<td>2.3</td>
<td>2.3</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1.5</td>
<td>2.3</td>
<td>2.5</td>
<td>3.5</td>
<td>3.5</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>5.2</td>
<td>6.1</td>
<td>6.2</td>
<td>7.4</td>
<td>6.4</td>
<td>7.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 6</th>
<th>avg.</th>
<th>1.9</th>
<th>2.6</th>
<th>2.7</th>
<th>3.4</th>
<th>3.1</th>
<th>4.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>2015</td>
<td>2.2</td>
<td>2.4</td>
<td>2.5</td>
<td>2.7</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Y+2</td>
<td>2014</td>
<td>0.7</td>
<td>1.1</td>
<td>1.1</td>
<td>1.4</td>
<td>1.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Y+1</td>
<td>2013</td>
<td>0.0</td>
<td>0.9</td>
<td>0.9</td>
<td>1.8</td>
<td>1.9</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>-0.6</td>
<td>0.5</td>
<td>0.5</td>
<td>1.5</td>
<td>1.4</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>5.3</td>
<td>6.3</td>
<td>6.3</td>
<td>6.8</td>
<td>6.6</td>
<td>8.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRATEGY 7</th>
<th>avg.</th>
<th>1.5</th>
<th>2.2</th>
<th>2.3</th>
<th>2.9</th>
<th>2.7</th>
<th>4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE</td>
<td>1.9</td>
<td>2.7</td>
<td>2.8</td>
<td>3.5</td>
<td>3.2</td>
<td>4.4</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Optimal Results Scenarios
I draw the following conclusions from Table 7:

- **When keeping the bandwidth constant**, the different Strategies give *on average* quite the same results. However, the outliers in different years become bigger when the center of gravity in a strategy shifts more to a specific year. Strategy 1 divides the purchases over the years and the outliers are 1.2 and 3.7. Strategy 6 gives on average almost the same result as Strategy 1 (2.0 vs. 1.9), but the outliers lay further away from each other: 0.3 and 5.2. Conclusion: on average the Strategies give over 5 years almost the same results, but Strategy 1 gives the most stable results. **Therefore I recommend Strategy 1.**

- **When keeping the Strategy constant** and change the bandwidth, we begin to see the influence of the tight bandwidth. The tight bandwidth of 7-7-7-7% performs in the optimal solution on average 1.9 better than the market. Whereas the bandwidth 50-25-15-7% could beat the market with an average of 4.4. This difference (4.4-1.9=2.5) gives away €7,665,000 of potential savings. **Therefore I recommend more flexibility in the bandwidth.**

Figure 32 explains the difference. This figure gives the optimal purchasing pattern for Strategy 1 with bandwidth 50-20-15-7%. This bandwidth gives the opportunity to buy huge amounts when the market is low, even if the time to maturity is more than 2 years. At the end of the winter, begin of spring 2010, TTF Natural Gas Forward prices were relatively low. The TTF Cal 2012 price reached a level under €17/MW. This was the opportunity to take advantage of low market prices. The optimal purchase price that could be reached is: €17.1, where the optimal price with the tight bandwidth was €21.5. The difference: 4.4 x 350 MW x 8760 hours = €13,490,400.

**Figure 32:** Strategy 1, Margin 50-25-15-7%.

**Conclusion Backtest of Purchasing Strategies - Baseload:** Summarizing the analysis we can see a lot of space for opportunities is given away because of the tight bandwidth. The tight bandwidth are set to ‘manage risks’. But risk is not managed by setting a tight bandwidth and ‘monkey buying’. If 1 year before maturity 175 MW is covered (50%) it is perceived as ‘risk-neutral’ by FrieslandCampina. But this is *not* the case. When you have an open position (175 MW), you still have financial risk.
Therefore I recommend the 25-25-35% Strategy with a bandwidth of 50-25-15-7%, to have much more space for opportunities to be able to make use of the right market moments. The longer away from maturity, the more space I advise. On the short-term, 3 months before maturity of the Year-Forwards, FrieslandCampina’s budget is determined. Afterwards I should tighten the bandwidth and be sure the purchase price will not fluctuate that much anymore.

**Limitations Backtest of Purchasing Strategies - Baseload:** I only have looked to downside potential. When increasing the bandwidth the upside potential will also get bigger. Therefore I advise for the recommended Strategy definitely more active Risk Management and constantly thorough market analysis.

The optimal result is a theoretical result. It is close to impossible to reach the exact right market moments. Moreover it is questionable if it possible in practice to buy volumes of more than 100 MW in one day (as the optimization model does), without disturbing the market or facing higher Ask-prices due to low volumes. On the other hand, Figure 33 zooms into the price pattern of TTF Natural Gas 2 Years Ahead-Forward. The price is for 12 trading days under a level of €17. This should give enough time to buy the volume in portions and not disturbing the market.

![Figure 33: TTF Natural Gas 2 Year Ahead (Thomson Reuters Eikon, 2015).](image-url)
5.4 Backtest of Purchasing Strategies - Total Demand

The focus of FrieslandCampina always have been on procurement of Baseload. Only the purchasing-performance of Baseload-Forwards is benchmarked and the Profile part of the forecasted demand is almost neglected. The prevailing thought was: “We have to buy 85% of our forecasted demand with Forward-products and the last 15% of the forecasted demand we have to buy on the Spot market”. In 5.1.3 I already showed the financial risk of an open Spot position. Therefore I also investigated how the Total Demand can be fulfilled optimally. Below I show the results of the optimization.

As demand is fluctuating each day it is inevitable to buy (or sell) on the Spot market. At this moment FrieslandCampina standard buys a substantial amount on the Spot market. Is it optimal? The last 3 years demand was fulfilled as shown in Table 8.

<table>
<thead>
<tr>
<th>Year</th>
<th>Quarter</th>
<th>Spot</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Q1</td>
<td>245</td>
<td>26.6</td>
</tr>
<tr>
<td></td>
<td>Q2</td>
<td>245</td>
<td>26.6</td>
</tr>
<tr>
<td></td>
<td>Q3</td>
<td>245</td>
<td>26.6</td>
</tr>
<tr>
<td></td>
<td>Q4</td>
<td>245</td>
<td>26.6</td>
</tr>
<tr>
<td>AVG</td>
<td></td>
<td>245</td>
<td>37.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Quarter</th>
<th>Spot</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Q1</td>
<td>260</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>Q3</td>
<td>260</td>
<td>26.4</td>
</tr>
<tr>
<td></td>
<td>Q4</td>
<td>260</td>
<td>26.4</td>
</tr>
<tr>
<td>AVG</td>
<td></td>
<td>260</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 8: Demand fulfilling FrieslandCampina 2013 & 2014.

The first observation is that also in terms of purchased amount of Year-Forwards the Strategy is not followed. Especially in 2013 huge amounts where bought on the Spot market, which was in hindsight not optimal and gave huge financial risks, we also saw from the March 2013 case. After 2013 it probably has been decided that FrieslandCampina should not take that much risk on the Spot market. The amounts bought on the Spot market in 2014 were about twice as low as in 2013. But what is optimal? Another LP-problem is formulated to determine optimal purchasing amounts.

The exact L.P.-problem formulation can be found in the attached Microsoft Excel file OptimizationTotalDemand.xlsx in Appendix B. The L.P.-problem minimizes total costs. Daily historical demand data between 2011-2014 is used. To understand what the optimization problem does I take a random day as an example. During this day demand was on average 400 MW. This can be bought via Year-, Quarter-, or Month-Forwards or on Spot Market. The amount purchased via Forwards is determined before the day, and this random day the following had been bought:

Year 300 MW €25 || Quarter 20 MW €24.50 || Month 40 MW €24

This automatically means 40 MW will be bought on Spot Market. If the price at the Spot mar-
ket was €23/MW, it would have been optimal to buy on Spot. Table 9 shows which restrictions are used in the L.P.-problem. I will variate within these restrictions to show the dynamics. Given these restrictions the model will search for the optimal allocation of products. The prices used in this model are average TTF prices. For example the Year - Y+1 - price is the average TTF Forward Cal 1 Year Ahead price from 1 year to maturity to maturity. It becomes too complex to use daily prices, the assumption I make is that average prices will show the dynamics in the optimal solution as well. The model optimizes the purchases over the last 4 years, more daily historical demand data from FrieslandCampina is not available.

<table>
<thead>
<tr>
<th>Description</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy Baseload</td>
<td>25%-25%-35%</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>7 %</td>
</tr>
<tr>
<td>Minimum Amount of Year-Forwards</td>
<td>295 MW</td>
</tr>
<tr>
<td>Maximum Amount of Year-Forwards</td>
<td>320 MW</td>
</tr>
<tr>
<td>Maximum Amount of Quarter-Forwards</td>
<td>100 MW</td>
</tr>
<tr>
<td>Maximum Amount of Month-Forwards</td>
<td>80 MW</td>
</tr>
<tr>
<td>Maximum Amount of Spot on a random Day</td>
<td>150 MW</td>
</tr>
<tr>
<td>Minimum Amount of Spot on a random Day</td>
<td>-40 MW</td>
</tr>
<tr>
<td>Minimum Amount of Spot per Day on Average per Month</td>
<td>10 MW</td>
</tr>
<tr>
<td>Maximum Amount of Spot per Day on Average per Month</td>
<td>100 MW</td>
</tr>
<tr>
<td>Minimum Amount of Spot per Day on Average per Year</td>
<td>20 MW</td>
</tr>
<tr>
<td>Minimum Amount of Y-, Q- or M-Forwards</td>
<td>0 MW</td>
</tr>
</tbody>
</table>

**Table 9:** Constraints Optimization Model Total Demand.

To give an impression of the dynamics I show the optimal solution for 2014 in Table 10. The solution is bound to the constraints given in Table 9. Looking to the Spot prices, it was especially in the first half of 2014 optimal to buy as much on Spot as possible. The constraint ‘Maximum amount of Spot per day’ withholds the optimal solution to purchase more on Spot. And as the constraint ‘Minimum amount of Year-Forward’ bounds us to 295 MW, there is only limited space for opportunities on the Spot market. The total spend (€81.1 million) is even higher than the realized spend of FrieslandCampina in 2014 (80.2 million), mainly because the realized purchases of FrieslandCampina do not fit the constraints.

<table>
<thead>
<tr>
<th>Year</th>
<th>Spend (€)</th>
<th>Price (€)</th>
<th>Y (MW)</th>
<th>Q (MW)</th>
<th>Month</th>
<th>M (MW)</th>
<th>SPOT (MW)</th>
<th>TOTAL (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>81,078,358</td>
<td>25.89</td>
<td>296</td>
<td>26.85</td>
<td>Q4</td>
<td>0</td>
<td>0.00</td>
<td>Dec-14</td>
</tr>
<tr>
<td>Y+1</td>
<td></td>
<td></td>
<td>119</td>
<td>26.59</td>
<td></td>
<td></td>
<td></td>
<td>Nov-14</td>
</tr>
<tr>
<td>Y+2</td>
<td></td>
<td></td>
<td>115</td>
<td>26.98</td>
<td></td>
<td></td>
<td></td>
<td>Oct-14</td>
</tr>
<tr>
<td>Y+3</td>
<td></td>
<td></td>
<td>64</td>
<td>27.09</td>
<td>Q3</td>
<td>0</td>
<td>0.00</td>
<td>Sep-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aug-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jul-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jun-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>May-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apr-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mar-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feb-14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jan-14</td>
</tr>
<tr>
<td>AVG.</td>
<td></td>
<td>26.7</td>
<td>0</td>
<td>0</td>
<td>35</td>
<td>21.9</td>
<td>56</td>
<td>20.9</td>
</tr>
</tbody>
</table>

**Table 10:** 2014 - Current Strategy.
5 PURCHASING STRATEGY FRIESLANDCAMPINA

It is interesting to see what influence the constraints and Strategy have on the optimal Purchasing Strategy.

I let the bandwidth and constraints vary in the amount of certain products (Y-, Q- or M-products). The variations and optimal results are presented in Table 11. The columns at the right side of the table show the optimal purchase price given the constraints for the years 2011, 2012, 2013 and 2014. The numbers in the header row are the average purchase prices of FrieslandCampina. Note, for 2011 and 2012 these numbers are the average purchase price of the Year-Forwards. No data are available of Spot amounts per day. For 2013 and 2014 the numbers (26.85 and 25.61) are the real average purchase prices including all the different products. In the last column a $\Delta$ is given. This $\Delta$ is the average ‘possible saving’ in a year. This saving is calculated by using the average prices of 2013 and 2014.

For example: $((26.85 - 24.78) + (25.61 - 25.34))/2 \cdot 8760 h \cdot 358 MW = \text{€}3.70 million$

\[( FC_{2013} - \text{Optimal}_{2013} ) + ( FC_{2014} - \text{Optimal}_{2014} ) / 2 \cdot 8760 \cdot (\text{Avg.Demand}) \]

<table>
<thead>
<tr>
<th>Strategy Margin</th>
<th>Min Year</th>
<th>Max Year</th>
<th>Min Month</th>
<th>Max Month</th>
<th>Min Spot /D</th>
<th>Max Spot /D</th>
<th>Min Spot /M</th>
<th>Max Spot /M</th>
<th>Min Spot /Y</th>
<th>Max Spot /Y</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-25-35%</td>
<td>25%</td>
<td>267</td>
<td>100</td>
<td>100</td>
<td>-40</td>
<td>15</td>
<td>100</td>
<td>15</td>
<td>20.46</td>
<td>25.06</td>
<td>24.78</td>
<td>25.34</td>
<td>3.70 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>7%</td>
<td>295</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>22.51</td>
<td>25.53</td>
<td>25.50</td>
<td>25.82</td>
<td>1.81 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>7%</td>
<td>267</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>22.44</td>
<td>25.08</td>
<td>25.47</td>
<td>25.36</td>
<td>2.57 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>7%</td>
<td>249</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>22.44</td>
<td>24.87</td>
<td>25.47</td>
<td>25.15</td>
<td>2.99 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>15%</td>
<td>267</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>21.54</td>
<td>24.89</td>
<td>25.15</td>
<td>25.32</td>
<td>3.14 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>7%</td>
<td>295</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>21.54</td>
<td>24.78</td>
<td>25.14</td>
<td>25.06</td>
<td>3.57 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>15%</td>
<td>267</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>20.51</td>
<td>24.44</td>
<td>24.81</td>
<td>25.73</td>
<td>3.04 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>25%</td>
<td>295</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>20.43</td>
<td>24.39</td>
<td>24.78</td>
<td>25.27</td>
<td>3.81 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>25%</td>
<td>267</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>20.43</td>
<td>24.32</td>
<td>24.73</td>
<td>25.61</td>
<td>4.24 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>25%</td>
<td>249</td>
<td>80</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>20.43</td>
<td>24.32</td>
<td>24.73</td>
<td>24.60</td>
<td>4.95 M</td>
<td></td>
</tr>
<tr>
<td>25-25-35%</td>
<td>25%</td>
<td>213</td>
<td>100</td>
<td>150</td>
<td>-40</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>20.43</td>
<td>24.32</td>
<td>24.73</td>
<td>24.60</td>
<td>4.95 M</td>
<td></td>
</tr>
</tbody>
</table>

Table 11: Optimality run

The more space is given, the better the optimal solution. Especially good results are seen when the minimum amount of purchased Year-Forwards is lower. Note that we make use of average prices and do not take into account the possibility to make use of the right market moments. The Strategy bound by the two horizontal lines in Table 11 scores best with a possible saving amount of €5.11 million per year, so I will further highlight this Strategy. This Strategy gives a nice performance and is still conservative from a risk point of view.

<table>
<thead>
<tr>
<th>Strategy Margin</th>
<th>Min Year</th>
<th>Max Year</th>
<th>Min Month</th>
<th>Max Month</th>
<th>Min Spot /D</th>
<th>Max Spot /D</th>
<th>Min Spot /M</th>
<th>Max Spot /M</th>
<th>Min Spot /Y</th>
<th>Max Spot /Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-25-35%</td>
<td>25%</td>
<td>267</td>
<td>320</td>
<td>100</td>
<td>100</td>
<td>15</td>
<td>100</td>
<td>15</td>
<td>20.46</td>
<td>25.06</td>
</tr>
</tbody>
</table>

Table 12: Optimal Strategy

Table 27 in Appendix A shows the dynamics for this Total Demand Strategy in terms of numbers, Figure 34 displays it visually. The visual presentation gives a better feeling about the dynamics.
What I want to show here is that the optimal way of purchasing Natural Gas is purchasing a mixture of different products and that it is especially unwise to leave a position of 15% open to the Spot market. The possibility to fulfill the forecasted average monthly demand with Month-products and thereby leveling out days of buying extra on the Spot market with days of selling on the Spot market must be further researched, as it can involve other (hedge) accounting rules.

- **2011** is an example of a year when buying on Spot market was not optimal. The results here show a low number of Spot purchases, but also not the maximum amount of Year-products. It was optimal to fulfill part of the demand with Quarter-products.

- In **2012** it was optimal to buy as much as possible Year-products, complemented with Month-products during periods with higher demand.

- **2013** has everything in it. Low Year-products, in some months high Spot-purchases and in the first 3 quarters a high amount of Quarter-products.

- In **2014** Spot prices went down and it was therefore optimal to buy as much as possible on the Spot market.

![DISTRIBUTION OF PRODUCTS](image)

**Figure 34:** Distribution
Conclusion Backtest of Purchasing Strategies - Total Demand: What I have shown here is that only looking to Baseload is too simplistic. In an optimal solution FrieslandCampina makes use of the Spot-Market and Year-, Quarter-, and Month-products. In some cases it might be smart from a Risk Management perspective to buy Quarter- or Month-products. In other cases it can be an opportunity to make use of market moments and fix the position for a low price.

I recommend to give more attention to the Profile part and to Demand Forecast. First steps are made during this project, but extra attention is needed, especially now extra milk supply is expected, after ending of the Milk Quotum the 1st of April 2015. Extra milk will be mainly processed into cheese and milkpowder, both relatively big Energy users. It can result in (big) financial risks if demand for Natural Gas is tens of MWs higher than forecasted. Note that it probably requires extra resources to actively manage risks in the Profile part.
5.5 Risk Management Dashboard in Microsoft Excel

To have more insight in open positions, actual budget prices, and support in making buy-decisions, a Risk Management Dashboard has been made with real-time connection to market prices from Thomson Reuters Eikon. The Dashboard needs connection with Thomson Reuters Eikon and is therefore not attached to this report.

Figure 35 shows a screenshot of the Dashboard made. In this Dashboard Risk Management, the Purchasing Strategy, and Purchasing Decision Support Tool come together in one overview. The Purchasing Decision Support Tool is explained in the next Chapter.

Figure 35: Risk Management Dashboard in Microsoft Excel.
5.6 Conclusions

Purchase Strategy for Baseload. The Purchase Strategy for Baseload consists of two parts. Part I: number of years to look ahead and the percentage bought in a year. The current 3-years ahead (25%-25%-35%) Strategy gave the best results of the scenarios tested. Therefore I recommend to maintain this part of the Strategy.

<table>
<thead>
<tr>
<th>Year</th>
<th>Strategy</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y+3</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>Y+2</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Y+1</td>
<td>35%</td>
<td>15%</td>
</tr>
<tr>
<td>&gt; Oct.</td>
<td></td>
<td>7%</td>
</tr>
</tbody>
</table>

Table 13: Recommended Strategy.

The optimization model showed that FrieslandCampina misses opportunities because of the tight 7% bandwidth. The 7% bandwidth is perceived to be risk-averse, but I have explained why this is not the case. I recommend to give more space further ahead from maturity and tighten the bandwidth closer to maturity. 3 months before a certain year the Budget is determined at FrieslandCampina. At that moment the business is going to use Energy prices in cost price calculations. So after October I recommend to tighten the bandwidth again to 7%, to reduce the chance of (big) fluctuations in the realized purchase price compared to the budget price. I recommend the Strategy given in Table 13. In Figure 36 this is visualized.

Purchase Strategy for Total Demand. More attention is needed for the Profile part (15%) of the demand. In an optimal solution FrieslandCampina makes use of the Spot-Market and Year-, Quarter-, and Month-products. In some cases it might be smart from a Risk Management perspective to buy Quarter- or Month-products. In other cases it can be an opportunity to make use of market moments and fix the position for a low price. But as mentioned, this probably requires extra resources.

Benchmark. It appears the Principal-Agent problem is present at FrieslandCampina. I recommend to review the way Schröder’s performance is measured/benchmarked.
6 Purchasing Decision Support Tool

In this Chapter I present a Purchasing Decision Support Tool (PDST) which helps to recognize local minima of a price pattern, to support the purchasing decision whether or not to buy Year-products. As the name already explains, the aim of this tool is to support in decision making and it is not meant to rely only on the decision tool. The tool is developed as Schröder asked for support in determining right moments to buy. I evaluate three different Technical Analysis indicators: the Relative Strength Index (RSI), the Moving Average Convergence/Divergence (MACD) and the Moving Average Relative Strength Index (MA RSI). These indicators are used in the Purchasing Decision Support Tool.

6.1 Technical Analysis Indicators

6.1.1 Introduction to Technical Analysis

Technical Analysis can be seen as the counterpart of Fundamental Analysis. Where Fundamental Analysis focuses on Supply and Demand, Technical Analysis aims to search for historical price patterns, trends or any other clues which can be an indicator of future price movements. According to (Chong, 2008) it has become increasingly popular over recent years. Technical analysis has been controversial for a long time, as the question is whether it really can help investors earn higher profits. If this is true, it implies the Efficient Market Hypothesis (EMH) does not hold. The EMH states the market price always includes all public information available.

6.1.2 Relative Strength Index

In 1978 J. W. Wilder, Jr. introduced in his book “New Concepts in Technical Trading Systems” the Relative Strength Index (Wilder, 1978). The RSI is a momentum oscillator which measures speed and change of price movements. An oscillator is a technical analysis tool that is bounded within two extreme values and meant to discover short-term overbought and oversold markets. When a price moves up very quickly, it is considered to be ‘overbought’. When a price declines very quickly, it is considered to be ‘oversold’. It is believed that a reaction or reversal is imminent in this situation.

The RSI is one of the tools used in ‘Technical Analysis’. Wilder (1978) explains that three problems with (technical) oscillators are tackled when using the Relative Strength Index: 1) incorrect erratic price movements are eliminated by the averaging technique. An increase in the average close UP is automatically responded by a decrease in the average close DOWN and vice versa. 2) As the RSI must fall between 0 and 100 the question ‘how high is high’ is eliminated and different commodities are comparable. Most volatile commodities are those where the RSI is showing the greatest vertical movement. 3) The third problem Wilder describes is that normal oscillators include a lot of data, the RSI is calculated easily. This last problem is not an issue anymore.

The Relative Strength Index indicates:

- **Tops and bottoms:** Tops and bottoms are indicated when the Index is above 70 or below 30. The RSI mostly tops or bottoms out before the actual market reaches the top or bottom and therefore gives an indication a reversal or at least a reaction is at hand.
- **Failure swings**: Failure swings above 70 or below 30 are very strong indications of a market reversal.

- **Other technical indicators**: Furthermore the RSI can help with investigating typical technical indicators like support and resistance. Also the divergence between price action and the RSI is a strong indicator of a market turning point.

The Formula for the Relative Strength Index is:

\[
\text{Relative Strength Index} = 100 - \left[ \frac{100}{1 + \text{Relative Strength}} \right]. \tag{9}
\]

where:

\[
\text{Relative Strength} = \frac{\text{Average of 14 days' closes UP}}{\text{Average of 14 days' closes DOWN}}.
\]

An ‘up close’ is when the price at day \( t > \) price at day \( t - 1 \). For example: price at day \( t - 1 = \€25.00 \), at day \( t \) the price is \( \€25.50 \). Up close = \( \€25.50 - \€25.00 = \€0.50 \). A ‘down close’ is the other way around. The first calculation of the RSI needs the previous 14 days’ close prices. Afterwards only RSI data of previous days is needed. The first step is to sum up all the up closes for the last 14 days and divide it by 14, which is the average of 14 days’ closes up. Second step is to sum up all the down closes for the last 14 days and divide it by 14: the average of 14 days’ closes down. After dividing the average up by the average down, we get the Relative Strength. Add up 1.00 to the RS and divide the result by 100. Subtract this result from 100 and the first RSI is calculated. From this point the next RSI is simply calculated by multiplying the previous average up closes by 13, adding today’s up close, and divide by 14. For the down average the same applies. When the today’s close is down, zero is added to average up closes.

### 6.1.3 Moving Average Relative Strength Index

The Moving Average RSI is a simple moving average of the RSI. Therefore it is slower to react to price changes with less ‘noise’ than the original RSI. I use the recommended 14-day Moving Average (Chong, 2008). The formula for the MA RSI:

\[
MARSI(t) = \frac{1}{14} \sum_{i=1}^{14} RSI(t - i). \tag{10}
\]

The RSI has a 14 day average in itself, I also use a 14-day average to smooth the RSI. The MA RSI can be used as an indicator by itself, but it can also be used in combination with the RSI. If the RSI is under 30, which is a buy signal, you could wait for the RSI to move back upwards and cross the MA RSI. I test both the MA RSI as a single indicator and RSI and MA RSI in combination with each other.

### 6.1.4 Moving Average Convergence/Divergence

The MACD is (as well) a trend-following momentum indicator, which shows the relationship between two exponential moving average prices (Appel, 2005). It shows the difference between
the ‘fast’ and the ‘slow’ Exponential Moving Average (EMA) of closing prices. MACD at day \( t \) is calculated by subtracting the 26-day EMA at day \( t \) from the 12-day EMA at day \( t \).

\[
MACD(t) = 12-day \text{EMA}(t) - 26-day \text{EMA}(t),
\]

\[\text{(11)}\]

\[n-day \text{EMA}(t) = \text{closing price } (t) \cdot k + n-day \text{EMA}(t-1) \cdot (1 - k),\]

\[\text{(12)}\]

where, \( k = 2/(n + 1) \), and \( n \) represents the number of days for which the EMA is calculated. So \( k = 2/13 \) and \( n = 12 \) for 12-day EMA, and \( k = 2/27 \) and \( n = 26 \) for 26-day EMA.

A ‘signal line’ is plotted on top of the MACD. The signal line is the 9-day EMA of the MACD. This signal lines is the trigger for buy and sell signals. Equation 13 shows how the 9-day EMA of the MACD is calculated, where \( k = 2/10 \) and \( n = 9 \).

\[
9-day \text{EMA-MACD}(t) = MACD \cdot k + 9-day \text{EMA-MACD}(t-1) \cdot (1 - k).
\]

\[\text{(13)}\]

When the MACD crosses the signal line in upward direction, it is a buy signal. When the MACD crosses the signal line in downward direction it is a sell signal. The standard periods were recommended by the originator of the formula, Appel (2005).

6.2 The Purchasing Decision Support Tool

As the aim of technical analysis is to observe momentum, it might be a useful tool to determine buy-moments. I developed Purchasing Decision Support Tool which automatically buys an ‘open volume’ when an indicator reaches a certain level. The open volume is determined by the amount of MWs already purchased and the moment in time. In 3 years we have to buy 300 MW. I let the maximum purchased volume grow linearly in time. So after 1 year the maximum amount of MWs purchased is 100 MW. If after a year 60 MW is covered, the open position is 40 MW. If then the indicator comes under a certain level, 40 MW will be bought. After a number of days the threshold level of the indicator is raised. See Figure 37 for an example of the cumulative purchase amount for Cal 2015 by the Moving Average RSI PDST. The thick blue line is the cumulative amount of purchases Natural Gas in MW. The dotted line is the maximum purchased volume through time.
6.2.1 RSI - and Moving Average RSI - PDST

To give an introduction to the PDST I give an example to show the dynamics of the PDST (Moving Average RSI), see Figure 38. After this visual example the PDST is explained in mathematical terms. This visual example displays the TTF Cal 2015 (blue line) price from 1 January 2012 till end of maturity at the end of December 2014. The price of the TTF Cal 2015 Future is on the left axis. The thick orange line is the Moving Average Relative Strength Index, units of the MA RSI are on the right vertical axis. The buy-threshold line is displayed with the orange dotted line. Buy moments are those moments that the thick orange line crosses the dotted line. The vertical orange lines emphasize these moments.

In this particular example we see that the PDST recognizes (local) low levels. Of course, the optimal moment to buy was at the end of 2014. But when having a 3-year Strategy in mind, this example gives nice results. The results in this example:

<table>
<thead>
<tr>
<th>Price (€)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market average:</td>
<td>€25.72</td>
</tr>
<tr>
<td>FrieslandCampina:</td>
<td>€25.24</td>
</tr>
<tr>
<td>Algorithm:</td>
<td>€24.19</td>
</tr>
</tbody>
</table>

Table 14: Results.
As every € difference gives a difference of around €3,000,000 in expenditures, determining the right moment to buy can generate huge savings. Here the market average is taken as the baseline. FrieslandCampina already purchased €0.48 better than the market average. The PDST beats the market with €1.53, which means a reduction in costs of €4,754,883.

### 6.2.2 Combination RSI and Moving Average RSI - Algorithm

The PDST works a bit differently when using a combination of the RSI and the Moving Average RSI. The RSI is the indicator triggering the PDST. First the RSI has to reach a level (in this case RSI=30). If this happens the PDST waits for the RSI to cross the Moving Average RSI. The purchasing moment is when RSI crosses MA RSI. See Figure 39 for the explanation. The orange line is the RSI, the dark blue line is the Moving Average RSI. When the two cross each other the purchase is done (yellow vertical line). The Moving Average RSI is always lagging behind the RSI, therefore the two will cross each other when the RSI comes in an upward trend again. Because the Moving Average RSI is always lagging behind, the RSI will always cross the Moving Average RSI from a lower position when the Purchasing Decision Support Tool is triggered. When the RSI remains in a constant downtrend, the two will not cross. In that case the volume remains open and the open volume has to be executed on the last trading day before maturity.

![Figure 39: MA RSI - RSI.](image)

Results for the Combination RSI and Moving Average RSI are treated in Section 6.3.
6.2.3 MACD - Algorithm

When the signal line crosses the MACD it is a buy signal. To not generate too much buy-signals I lowered the threshold line when the MACD can be triggered. The threshold is set on a MACD level of -0.30. So when the MACD (orange line) comes below -0.30 the PDST is triggered. It then waits until the signal line (dark blue) crosses the MACD. In this example we see that the two already cross a bit too late.

The same problem occurs as described for the Combination RSI and Moving Average RSI. It can happen the tool is triggered by the MACD-line, but the MACD does not cross the MACD-EMA. In that case open volume is bought at the last trading day before maturity.

Results for the MACD are treated in Section 6.3.
6.2.4 Mathematical Formulation

The ‘basics’ of the PDST are explained below. Later on we will see small adjustments for the different indicators. The basic PDST is made for the Relative Strength Index. The model is also programmed in Microsoft Excel: PurchasingDecisionSupportTool.xlsx, see Appendix B.

The formula:

**Data:**

\[ p_t \quad \text{Price of Natural Gas Year-product at day } t \]
\[ RSI_t \quad \text{Relative Strength Index at day } t \]
\[ TV_y \quad \text{Total Volume of Natural Gas in MW to purchase in Year } y \]

**Variables:**

\[ V_t \quad \text{Maximum purchased volume of Natural Gas in MW at day } t \]
\[ PV_t \quad \text{Total Cumulative Purchased volume of Natural Gas in MW at day } t \]
\[ OV_t \quad \text{Open Volume of Natural Gas in MW at day } t \]
\[ B_t \quad \text{Volume of Natural Gas (MW) to BUY at day } t \]
\[ T_t \quad \text{Threshold level at day } t, \text{ determining whether or not to buy} \]
\[ D_t \quad \text{Number of days ago when last purchase took place} \]

\[
V_t = V_{t-1} + \frac{1}{750} \cdot TV_y \\
PV_t = PV_{t-1} + B_t \\
OV_t = V_t - PV_t
\]

\[
D_t = \begin{cases} B_{t-1} > 0 & D_t = 0 \\ B_{t-1} = 0 & D_t = D_{t-1} \end{cases}
\]

\[
T_t = \begin{cases} D_t \leq 50 & T_t = 20 \\ D_t \leq 125 & T_t = 25 \\ D_t > 125 & T_t = 25 \end{cases}
\]

\[
B_t = \begin{cases} RSI_t \leq T_t & B_t = OV_t \\ RSI_t > T_t & B_t = 0 \end{cases}
\]

\[
TV_y = \begin{cases} y = 2011 - 2015 & 300 \text{ MW} \\ y = 2016 & 186 \text{ MW} \\ y = 2017 & 88 \text{ MW} \end{cases}
\]

The achieved purchase price:

\[
\frac{1}{TV_y} \sum_{t=1}^{750} B_t \cdot p_t
\]
Moving Average RSI. For the Moving Average RSI small adjustments have to be made. An extra data set is used, namely MA RSI figures from 2011 to 2017. Furthermore the threshold level for MA RSI is set on 30 and after 50 days 34. Because the MA RSI is a moving average it has lower peaks and higher minimums. Therefore the threshold level is set higher.

\[ MARSIT_t \quad \text{Moving Average of Relative Strength Index at day } t \]

\[
T_t = \begin{cases} 
D_t \leq 50 & T_t = 30 \\
D_t \leq 125 & T_t = 34 \\
D_t > 125 & T_t = 34 
\end{cases}
\]

Combination RSI and Moving Average RSI. For the combination RSI and Moving Average RSI we need an extra variable. Namely decision variable \( X_t \). This decision variable is the trigger that the PDST can make purchases. First \( RSI_t \) has to reach a certain level to activate \( X_t \). \( X \) has to remain active \( (X_t = 1) \), until a purchase \( (B_t) \) is done. The purchase is done when the MA RSI crosses the RSI: \( RSI_t > MARSIT_t \). \( MARSIT_t \) is always a bit behind \( RSI_t \), because it is a moving average.

The way how the value of variable \( X_t \) is determined in mathematical terms is made clear below. It depends first on the status of \( X_{t-1} \). If \( X_{t-1} = 1 \), then it depends on whether there was a purchase at \( t - 1 \). If yes \( (B_{t-1} > 0) \), then if \( RSI_t \leq T_t \), \( X_t = 1 \), else \( X_t = 0 \). If \( B_{t-1} = 0 \) and \( X_{t-1} = 1 \), \( X_t \) will remain 1. The logic is, when \( X_t = 1 \), \( B_t \) can be triggered, decision variable \( X \) will remain 1 until \( B > 0 \).

If \( X_{t-1} = 0 \), then it can \( X_t \) can become 1 if \( RSI_t \leq T_t \).

\( X_t \quad \text{Extra decision variable at day } t \)

\[
X_t = \begin{cases} 
X_{t-1} = 1 & \{ \begin{align*} 
RSI_t & \leq T_t \quad X_t = 1 \\
RSI_t & > T_t \quad X_t = 0
\end{align*} \} \\
X_{t-1} = 0 & \{ \begin{align*} 
RSI_t & \leq T_t \quad X_t = 1 \\
RSI_t & > T_t \quad X_t = 0
\end{align*} \}
\end{cases}
\]

\( B_t \) depends on \( X_t \). \( B_t \) can only by non-zero if \( X_t = 1 \). If \( X_t = 1 \) the PDST waits before \( RSI_t > MARSIT_t \). If this is the case \( B_t = OV_t \), else \( B_t = 0 \).
\[ B_t = \begin{cases} X_t = 1 & \text{RSI}_t > M \text{ARSI}_t \quad \text{B}_t = O \text{V}_t \\ X_t = 0 & \text{RSI}_t \leq M \text{ARSI}_t \quad \text{B}_t = 0 \end{cases} \]

**MACD.** The MACD follows a similar logic as the combination between the RSI and the MA RSI. The PDST is first triggered if the MACD line comes under a certain level. When afterwards the MACD line crosses the signal line, a purchasing signal is given.

\[ MACD_t \quad \text{The MACD at day} \ t \\
SIG_t \quad \text{The MACD-signal line at day} \ t \\
X_t \quad \text{Extra decision variable at day} \ t \\
T_t \quad -0.25 \]

\[ X_t = \begin{cases} X_{t-1} = 1 & \begin{cases} B_{t-1} = 0 \\
MACD_t \leq T_t \\
MACD_t > T_t \end{cases} \quad X_t = 1 \\
B_{t-1} > 0 & X_t = 0 \end{cases} \]

\[ X_{t-1} = 0 & \begin{cases} MACD_t \leq T_t \\
MACD_t > T_t \end{cases} \quad X_t = 0 \]

\[ B_t \quad \text{depends on} \ X_t. \ B_t \text{ can only by non-zero if} \ X_t = 1. \ \text{If} \ X_t = 1 \text{ the PDST waits before} \ MACD_t > SIG_t. \ \text{If this is the case} \ B_t = O \text{V}_t, \ \text{else} \ B_t = 0. \]

\[ B_t = \begin{cases} X_t = 1 & \begin{cases} \text{RSI}_t > M \text{ARSI}_t \\
\text{RSI}_t \leq M \text{ARSI}_t \end{cases} \quad \text{B}_t = O \text{V}_t \\
X_t = 0 & \text{B}_t = 0 \end{cases} \]
6.3 Backtesting the Algorithm

6.3.1 Performance of the Algorithm

The most interesting part, how does the PDST perform in practice and through the years? I have backtested the PDST on the years 2011-2017. I also ‘backtested’ for 2016 and 2017, because already a part of the volume is bought by FrieslandCampina, due to the 3-year Strategy. The problem is programmed in Microsoft Excel. Market price data, RSI, MA RSI, MACD and MACD signal numbers are obtained from Thomson Reuters Eikon (2015). The results are compared with the average purchase price of FrieslandCampina and the average market price.

**Average market price:** the average market price is the average of the TTF Cal Endex End-of-Day settlement prices from 3 years before maturity till maturity.

**Average purchase price of FrieslandCampina:** the average purchase price of FrieslandCampina is the average price of the purchased Year-products related to a certain year. It does not take into account Quarter-, Month- or Spot-purchases.

The standard parameter settings I used are given below in Table 23. These settings are determined by trial-and-error.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>$D_t &lt; 50$</th>
<th>$50 &lt; D_t &lt; 125$</th>
<th>$D_t &gt; 125$</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSI</td>
<td>20</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>MA RSI</td>
<td>30</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>MACD</td>
<td>-0.3</td>
<td>-0.3</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

**Table 15:** Parameter Settings PDST.

Table 16 shows the achieved purchase prices of the PDST. Columns 2-5 present the purchase price of the different variations of the PDST. The last two columns display the FrieslandCampina average purchase price and the market average. Figures in green are best performances, figures in red are worst performances. Only in two years the buyer of FrieslandCampina performs better than any of the PDSTs. The best performing variations of the PDST are the Moving Average RSI and the RSI. This can of course also depend on the parameter settings, sensitivity

<table>
<thead>
<tr>
<th>Year</th>
<th>RSI (€)</th>
<th>Moving Average RSI (€)</th>
<th>Combi RSI &amp; MA RSI (€)</th>
<th>MACD (€)</th>
<th>Friesland Campina (€)</th>
<th>Market average (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>23.41</td>
<td>23.67</td>
<td>23.66</td>
<td>24.93</td>
<td>20.51</td>
<td>24.36</td>
</tr>
<tr>
<td>2012</td>
<td>22.78</td>
<td>23.00</td>
<td>22.47</td>
<td>23.52</td>
<td>25.45</td>
<td>23.69</td>
</tr>
<tr>
<td>2013</td>
<td>25.42</td>
<td>25.27</td>
<td>25.85</td>
<td>25.33</td>
<td>25.60</td>
<td>25.47</td>
</tr>
<tr>
<td>2016</td>
<td>23.56</td>
<td>23.65</td>
<td>23.87</td>
<td>23.47</td>
<td>24.48</td>
<td>24.73</td>
</tr>
<tr>
<td>2017</td>
<td>23.29</td>
<td>23.26</td>
<td>23.37</td>
<td>23.13</td>
<td>24.01</td>
<td>24.03</td>
</tr>
</tbody>
</table>


**Table 16:** Results Purchasing Decision Support Tool.
6.3 Backtesting the Algorithm

of the parameters are discussed later on. As the RSI is also the trigger for the combination RSI and Moving Average RSI parameter settings can also have influence on the performance of this indicator. The MACD is clearly another indicator than RSI or Moving Average RSI. The first four years the MACD performs worse than the Moving Average RSI, but the last three years the performance of the MACD is better. On average Relative Strength Index gives the best results with with the given parameter settings.

What does this mean for the total spend during a year? The impact on total spend is given below in Table 17. The figure given is Total Spend in Reality by FrieslandCampina - Total Spend Algorithm. The first figure -8,983,283 means that the total spend when buying with the PDST would be €8,983,283 higher than the total spend in reality achieved by the buyer of FrieslandCampina.

<table>
<thead>
<tr>
<th>Year</th>
<th>RSI (€)</th>
<th>MA RSI (€)</th>
<th>Combi (€)</th>
<th>MACD (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>-8,983,283</td>
<td>-9,794,967</td>
<td>-9,772,233</td>
<td>-13,689,083</td>
</tr>
<tr>
<td>2012</td>
<td>8,268,217</td>
<td>7,592,933</td>
<td>9,227,150</td>
<td>5,975,767</td>
</tr>
<tr>
<td>2013</td>
<td>3,660,583</td>
<td>4,137,983</td>
<td>2,311,567</td>
<td>3,934,417</td>
</tr>
<tr>
<td>2014</td>
<td>-1,452,350</td>
<td>-665,777</td>
<td>-1,554,753</td>
<td>-989,055</td>
</tr>
<tr>
<td>2015</td>
<td>4,272,833</td>
<td>3,251,693</td>
<td>2,589,275</td>
<td>3,424,932</td>
</tr>
<tr>
<td>2016</td>
<td>2,855,426</td>
<td>2,574,468</td>
<td>1,883,087</td>
<td>3,133,529</td>
</tr>
<tr>
<td>2017</td>
<td>2,235,444</td>
<td>2,340,500</td>
<td>1,989,167</td>
<td>2,743,500</td>
</tr>
</tbody>
</table>

Table 17: Results PDST vs. FrieslandCampina.

As mentioned, the (huge) differences are explained later on. Comparing the PDST with the achieved purchase price of FrieslandCampina is not really fair, because FrieslandCampina did not follow the 3-year Strategy, where the PDST has to. Therefore to have a better understanding of the performance of the PDST I compare it with average market prices. The impact it has on total expenditures is shown in Table 18.

<table>
<thead>
<tr>
<th>Year</th>
<th>RSI (€)</th>
<th>MA RSI (€)</th>
<th>Combi (€)</th>
<th>MACD (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>2,952,750</td>
<td>2,141,067</td>
<td>2,163,800</td>
<td>-1,753,050</td>
</tr>
<tr>
<td>2012</td>
<td>2,806,017</td>
<td>2,130,733</td>
<td>3,764,950</td>
<td>513,567</td>
</tr>
<tr>
<td>2013</td>
<td>151,073</td>
<td>628,473</td>
<td>-1,197,943</td>
<td>424,907</td>
</tr>
<tr>
<td>2014</td>
<td>52,597</td>
<td>839,170</td>
<td>-49,807</td>
<td>515,892</td>
</tr>
<tr>
<td>2015</td>
<td>5,776,023</td>
<td>4,754,883</td>
<td>4,092,465</td>
<td>4,928,122</td>
</tr>
<tr>
<td>2016</td>
<td>3,630,426</td>
<td>3,349,468</td>
<td>2,658,087</td>
<td>3,908,529</td>
</tr>
<tr>
<td>2017</td>
<td>2,297,444</td>
<td>2,402,500</td>
<td>2,051,167</td>
<td>2,805,500</td>
</tr>
<tr>
<td>Avg.</td>
<td>2,523,762</td>
<td>2,320,899</td>
<td>1,926,103</td>
<td>1,620,495</td>
</tr>
</tbody>
</table>

Table 18: Results PDST vs. Market Average.

This follows the same logic as in Table 17. We now see that the RSI and the Moving Average RSI give the best results and outperform the market in all the years backtested. The years 2013 and 2014 are the ‘hardest’ years for the PDST, it does outperform the market (except for the combination MA RSI - RSI), but with a small difference. On average the RSI performs best,
but the Moving Average RSI has the ‘best’ worst performances in 2013 and 2014 and gives the most stable results.

6.3.2 Limitations and Under-Performance of the Algorithm

2011. The most notable under-performance figured are in 2011. In the best case (RSI) the Algorithm buys €2.90 / MW worse than FrieslandCampina. This huge difference can be explained: the buyer of FrieslandCampina did not follow the 3-year Strategy and bought everything in the last half year, which can easily be seen in Figure 41. The orange vertical lines are the PDST purchases, the blue vertical lines are the purchases from FrieslandCampina. As can be seen, everything is bought in the last half year. Therefore this is not a fair comparison.

![Figure 41: Cal 2011 - FrieslandCampina vs. Moving Average RSI.](image)

2013 and 2014. The markets for the Calendar Years 2013 and 2014 seem to be difficult markets for the PDST. The combination between RSI and MA RSI performs worse than the market. The other indicators perform, compared to performances in other years, as well not that good. If we compare 2014 with the performance of FrieslandCampina the PDST buys worse in all the four cases.

Why does this happen? Compared to FrieslandCampina: FrieslandCampina began to buy after 1.5 years at market levels under €26 and bought the biggest part of the volume from May 2013 until August 2013. As can be seen from the Figure 42 the market was at that time stable between €26 - €26.50. When markets are relatively stable and therefore volatility is low, the RSI will stay closer to 50. So an open volume of 90 MW had to be bought at the last trading day by the PDST. As prices went up a little the last month the PDST had to buy the remaining open volume for a price of €27.00.

Compared to the market: the market starts around €24 - €25 and begins to raise afterwards. In a raising market RSI > 50. In October 2011 the PDST recognizes the low point. In the first quarter of 2013 the PDST recognizes another local minimum, but this minimum is above market
average. For Cal 2013 the same holds. The market starts 3 years before maturity around €20, declines to €18 and then begins to raise €29 1.5 years before maturity. Afterwards the market remains relatively stable between €26 and €28.

6.3.3 Sensitivity of the Parameters

The PDST works well with the parameters chosen, but how sensitive is the PDST for these parameters? What if we decrease or increase the threshold level? Tables 19 and 20 show the sensitivity of the threshold level $T_t$ for the Relative Strength Index and the Moving Average RSI. The numbers given in the Tables are the average purchase prices of the PDST for 2011-2017. The results show that the lower the threshold, the better the PDST performs.

<table>
<thead>
<tr>
<th>$D_t$</th>
<th>20</th>
<th>23</th>
<th>25</th>
<th>28</th>
<th>30</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>23.44</td>
<td>24.01</td>
<td>24.17</td>
<td>24.48</td>
<td>24.53</td>
<td>24.53</td>
</tr>
<tr>
<td>20</td>
<td>24.05</td>
<td>24.21</td>
<td>24.52</td>
<td>24.53</td>
<td>24.56</td>
<td>24.56</td>
</tr>
<tr>
<td>28</td>
<td>24.53</td>
<td>24.56</td>
<td>24.59</td>
<td>24.65</td>
<td>24.68</td>
<td>24.70</td>
</tr>
</tbody>
</table>

Table 19: Sensitivity $T_t$ for Relative Strength Index.

The same holds for the MACD (Table 21). The lower the threshold level is set, the better the PDST performs. This has a logical reason. The lower value the Relative Strength Index or the MACD has, the more oversold the market is. So very low levels of these indicators are preceded by steep declines of the market. A steep decline results in a local minimum, but is not per se a low level in the whole price pattern.

Table 22 shows the sensitivity of the numbers of days where after the threshold level is raised. The standard setting is after 50 trading days the threshold level is raised. It seems that the
Table 20: Sensitivity \( T_t \) for Moving Average RSI.

<table>
<thead>
<tr>
<th>( D_t &lt; 50 )</th>
<th>25</th>
<th>28</th>
<th>30</th>
<th>32</th>
<th>34</th>
<th>36</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D_t \leq 5 )</td>
<td>25</td>
<td>22.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>23.25</td>
<td>23.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>23.49</td>
<td>23.51</td>
<td>23.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>23.72</td>
<td>23.73</td>
<td>23.75</td>
<td>23.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>24.22</td>
<td>24.21</td>
<td>24.24</td>
<td>24.25</td>
<td>24.25</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>24.41</td>
<td>24.42</td>
<td>24.45</td>
<td>24.47</td>
<td>24.47</td>
<td>24.49</td>
</tr>
</tbody>
</table>

Table 21: Sensitivity of MACD. Table 22: Sensitivity of number of days.

PDST is not that sensitive to changing this feature.

So why not lower the threshold levels? I use the parameter settings given in Table 23. To understand what happens we look at the number of purchases done by the PDST in a certain year. Table 24 shows the number of purchases done by the PDST when using the standard parameter settings. We see here that in the years 2013 and 2014 the number of purchases is already quite low. In 2014 the RSI and the combination RSI & Moving Average RSI only makes two purchases. This means one purchase during the three years and one purchase at the last trading day. With such low number of purchases the factor ‘chance’ becomes bigger.

If we lower the threshold level to the levels shown in Table 23 the number of purchases decrease to the level displayed in Table 25. In 2014 and 2015 only one purchase is done, at the last trading day. For 2015 this means a bad level (€27), but for 2015 counts that the market declined from an average of €25 - €26 to a level of €21.

Also the standard deviation per year becomes much bigger, see Table 26. In some years the PDST performs way better than the market, which results in a reduction of more than €10 million. But in some years it also means a negative result compared to the market average. The outliers (2015 and 2016) are caused by a steep decline of the market at the end of 2014. This is also the case for 2017, but it can only be found back in the performance of the Moving Average RSI.
### 6.3 Backtesting the Algorithm

#### Table 24: # Purchases - Standard $T_t$.

<table>
<thead>
<tr>
<th>Year</th>
<th>RSI</th>
<th>Moving Average RSI</th>
<th>Combi RSI &amp; MA RSI</th>
<th>MACD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>8</td>
<td>14</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>2012</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>2013</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2014</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2015</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2016</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>2017</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Table 25: # Purchases - Low $T_t$.

<table>
<thead>
<tr>
<th>Year</th>
<th>RSI</th>
<th>Moving Average RSI</th>
<th>Combi RSI &amp; MA RSI</th>
<th>MACD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>2012</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>2013</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2014</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2015</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2016</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>2017</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

The biggest outlier, Moving Average RSI Cal 2011, gives us a very good argument to make use of the right market moments. After a decline from €40/MW the market reached a minimum of €17/MW. The Moving Average RSI reaches the threshold level 25 at that moment and buys 200 MW. This exactly shows the enormous impact of buying at the right moment.

#### Table 26: Results Low Threshold vs. Market Average.

<table>
<thead>
<tr>
<th>Year</th>
<th>RSI  (€)</th>
<th>MA RSI  (€)</th>
<th>Combi  (€)</th>
<th>MACD  (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>4,370,483</td>
<td>15,492,767</td>
<td>2,568,867</td>
<td>-3,505,067</td>
</tr>
<tr>
<td>2012</td>
<td>4,108,533</td>
<td>642,217</td>
<td>3,764,950</td>
<td>1,668,317</td>
</tr>
<tr>
<td>2013</td>
<td>-546,427</td>
<td>-564,510</td>
<td>-1,475,393</td>
<td>-756,710</td>
</tr>
<tr>
<td>2014</td>
<td>-345,753</td>
<td>-345,753</td>
<td>-345,753</td>
<td>241,180</td>
</tr>
<tr>
<td>2015</td>
<td>14,396,090</td>
<td>14,396,090</td>
<td>11,094,590</td>
<td>14,396,090</td>
</tr>
<tr>
<td>2016</td>
<td>9,247,300</td>
<td>12,190,668</td>
<td>11,425,050</td>
<td>14,611,687</td>
</tr>
<tr>
<td>2017</td>
<td>2,338,778</td>
<td>7,260,889</td>
<td>1,699,833</td>
<td>10,932,667</td>
</tr>
</tbody>
</table>

Avg. 4,795,572 7,010,338 4,104,592 5,369,738
6.4 Discussion

The Purchasing Decision Support Tool raises some discussion points, which I will treat here.

At first the market prices used for backtesting are questionable. The prices used are TTF Natural Gas Endex End-of-Day Settlement Prices. The E-o-D Settlement Price is composed of a weighted average of Average Trade Prices and Average Mid Order Prices, executed in the last 15 minutes of the trading day. The Average Mid Order Price is the average of the best Bid- and best Ask-prices. When no trades are executed in these last 15 minutes, the settlement price is only composed of Average Mid Order Prices (ICE Endex, 2015a). Purchases have to be done during the day and the question is if we can reach the same price-level as in the backtests. Because the price fluctuates through the day, and as the Ask-price has to be paid by Friesland-Campina, and not a Mid Order price.

In some cases the Open Volume mounts up to more than 100 MW or even more than 200 MW. In the backtests I assume more than 100 MW can be bought without any problems in one day. In reality it is questionable if such amounts can be bought without disturbing the market. Traded volumes are low for Year-products and Ask-prices can therefore rise easily €0-0.50 (Thomson Reuters Eikon, 2015). On the other hand, I showed in Section 5.6 low moments do not vanish in one day and purchases can be spread out over several days.

What happens when other market players are going to use the same Purchasing Decision Support Tool? It will probably have a self-fulfilling prophecy effect (Gao & Li, 2011). When a significant amount of market players starts buying after a decline, demand raises and market prices will go up. This is also described by Menkhoff (1997), he concludes that Technical Currency Analysis should be interpreted not as either a marginal phenomenon or second-best strategy, but possibly as a kind of self-fulfilling prophecy.

The Purchasing Decision Support Tool works on historical data and parameters are chosen to fit on these historical figures. Bos and Kooiman (2015) reported about the default of hedge fund Arete Caerus. This Dutch hedge fund developed an algorithm which should recognize the right market moments and trades automatically. Their algorithm also worked well on historical data, but after going ‘live’ they faced in one of the first months a loss of 7%. After one and a half year they declared bankruptcy. This example can be kept in mind, as past performance is no guarantee of future results.

6.5 Conclusions

The historical performance of the Purchasing Decision Support Tool is quite nice. Both Relative Strength Index and Moving Average RSI beat the market average every backtested year. The two most important conclusions:

- Making use of the right market moments makes sense and can save millions of euros on a yearly basis. This is also an argument for more space for opportunities in the Purchasing Strategy.

- The Purchasing Decision Support Tool can be a useful tool to support in determining if a market is oversold and to support the ‘buy-or-wait’ decisions.
7 Conclusions and Recommendations

In this Chapter I give an answer to the Research Questions and make recommendations.

7.1 Conclusions

1. Which Purchasing Strategy fits with the risk-profile of FrieslandCampina?

To answer this question the risk-profile needs to be determined. From the products FrieslandCampina makes, Milkpowder has with 5% the highest amount of energy in the cost-price. Therefore Business Groups will not face unmarketable products when energy prices unexpectedly rise, and it can be concluded FrieslandCampina does not need a hedging Strategy. To be sure about budget prices, large part of the forecasted demand should be purchased before budget prices are determined.

Before budget prices are determined a larger bandwidth gives much more space for opportunities. Every euro the achieved purchase price is lower, saves around €3,000,000 on total spend of Natural Gas. Therefore it makes sense to make use of right market moments. This report shows that FrieslandCampina misses an opportunity of around €7,500,000 on average per year by having a tight bandwidth of 7%-7%-7%-7% compared to 50%-25%-15%-7%.

Theory about the Spot-Forward relationship for a storable commodity shows the current Forward price is not the expected Spot price of the future, but a combination of financing costs, storage costs and convenience yield. Geman (2005) also shows for Oil prices that Futures prices are rather poor in predicting the Spot price of Oil in the future. This pleads for making use of right market moments.

Furthermore we found from research at other companies the more certain the future demand is, the longer view on the market companies have. From the companies interviewed, FrieslandCampina can be best compared with Heineken, as both companies have quite a certain and stable demand. Heineken also has a three years ahead view, but leaves more space open for opportunities.

2. How should Risk Management be applied to Procurement of Natural Gas at FrieslandCampina?

Chapter 5 “Purchasing Strategy FrieslandCampina” shows that especially on the stochastic part of the forecasted demand (Profile-15%) financial risks are present. In the current situation no attention is paid to these financial risks. March 2013 showed us when not having covered the right amount of Natural Gas and leaving a (huge) position open to the Spot market, it can cost FrieslandCampina €651,800 in only one month. Backtests in the period 2011-2015 show it is optimal to have a mix between Year-, Quarter-, Month- and Spot-Purchases when fulfilling the total forecasted demand and it is not optimal always leaving a position of 15% open to the Spot market.

Risks are visualized in the developed Risk Management Dashboard in Microsoft Excel. The Risk Management Dashboard has real-time connection to market prices via Thomson Reuters Eikon and gives insights in open positions. Moreover the best estimate of the Budget Price updates automatically.
3. Which models or factors influencing the market can be applied to predict price-development of Energy prices?
The literature shows that for a better understanding of commodity prices we should aim for the fundamental models. A fundamental model derives commodity prices as the equilibrium result of basis Supply and Demand factors. The Theory of Storage states that commodity storages generate a certain stream of benefits, the convenience yield. Price of a commodity and its volatility are positively correlated, as both are negatively related to storage level.

When looking to Supply and Demand Market Dynamics in the Natural Gas Market in Europe, we see a shift is taking place from Oil-indexed pricing to pricing via Exchange markets. This has introduced very interesting dynamics between Oil-indexed supply (Russia), Oil-indexed demand (Asian LNG), and supply on exchange-prices (Norway, the Netherlands, UK, and free LNG). The Dutch TTF has nowadays become the benchmark of Natural Gas in Continental Europe and is in strong correlation with NBP in United Kingdom, due to pipelines via Zeebrugge-Bacton (IUK) and Balgzand-Bacton (BBL). Current low Oil-prices show the influence of Oil-prices as a ceiling on the Natural Gas Market in Europe and demonstrate the mentioned Market Dynamics. Expected 200 bcm extra LNG regasification capacity in mainly Australia and the United States can possibly have strong influence on the European Natural Gas Market the coming years. Does the European market become the battlefield between (declining) domestic production, Russian pipeline supply and world LNG?

4. How can the Purchasing Decisions be supported, taking into account the Purchasing Strategy and forecasted price development?
The developed Purchasing Decision Support Tool can support in the daily decision to buy an amount of Natural Gas or to wait for a better market moment. The tool recognizes low market moments in historical market data and saves on average €2,523,762 per year compared to market average, backtested on the period 2011-2017. The Purchasing Decision Support Tool outperforms FrieslandCampina’s average purchase prices as well. From the four Technical Analysis indicators tested, The Moving Average RSI gives the most stable results over the years. The Purchasing Decision Support Tool in combination with the Risk Management Dashboard built in Microsoft Excel gives support in Purchasing Decisions, taken into account the Purchasing Strategy and (technical) price developments. Fundamental price developments can only be recognized by extensive analysis of the market.
7.2 Recommendations

At the end of each Chapter extensive Discussions, Conclusions, and/or Recommendations can be found. Here I will highlight the most important recommendations.

- It is not clear how much supplier risk FrieslandCampina has with only two suppliers GDF Suez and GasTerra. Does FrieslandCampina always get the best possible market price? With a portfolio of 3,100,000 MWh a difference of €0.10 is already a big number. I recommend to investigate the need for more suppliers. Furthermore I recommend to further investigate physical supply risk in Eastern Europe.

- The role of the Principal-Agent problem at FrieslandCampina has not been researched into detail. The Principal-Agent problem can also be present at other departments of FrieslandCampina. I recommend to further investigate this phenomenon.

- The backtests of both Baseload and Total Demand are totally focused on opportunities we miss. Further research should focus also more on the upside risks of a broader bandwidth. When taking more space for opportunities, it also implies more risk. Therefore I strongly recommend only more space for opportunities when resources are available to give attention to the Profile part of the demand and to thoroughly follow market developments. Otherwise it can generate huge risks instead of risk management.

- Further research would be valuable for the Purchasing Decision Support Tool. Some questions remain unanswered at the moment. It is a nice tool, but I recommend it only as a tool to support the buy-decisions. One should not rely only on the Purchasing Decision Support Tool.
References


# A Results Optimal Strategy Total Demand

<table>
<thead>
<tr>
<th>Year</th>
<th>Spend (€)</th>
<th>Price (€)</th>
<th>Y (MW)</th>
<th>Q (MW)</th>
<th>Month</th>
<th>M (MW)</th>
<th>SPOT (MW)</th>
<th>TOTAL (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>79,378,232</td>
<td>25.35</td>
<td>267</td>
<td>26.72</td>
<td>Q4</td>
<td>0</td>
<td>0.00</td>
<td>Dec-14</td>
</tr>
<tr>
<td></td>
<td>178</td>
<td>26.59</td>
<td>0</td>
<td>27.09</td>
<td>Q3</td>
<td>0</td>
<td>0.00</td>
<td>Nov-14</td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>26.98</td>
<td>0</td>
<td>27.09</td>
<td>Q2</td>
<td>0</td>
<td>0.00</td>
<td>Oct-14</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>27.09</td>
<td>0</td>
<td>27.09</td>
<td>Q1</td>
<td>0</td>
<td>0.00</td>
<td>Sep-14</td>
</tr>
<tr>
<td>2013</td>
<td>78,506,532</td>
<td>24.78</td>
<td>267</td>
<td>24.19</td>
<td>Q4</td>
<td>0</td>
<td>0.00</td>
<td>Aug-13</td>
</tr>
<tr>
<td></td>
<td>62</td>
<td>26.94</td>
<td>0</td>
<td>27.05</td>
<td>Q3</td>
<td>0</td>
<td>0.00</td>
<td>Jul-13</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>25.72</td>
<td>0</td>
<td>25.72</td>
<td>Q2</td>
<td>53</td>
<td>25.11</td>
<td>Jun-13</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>27.05</td>
<td>0</td>
<td>27.05</td>
<td>Q1</td>
<td>32</td>
<td>27.42</td>
<td>May-13</td>
</tr>
<tr>
<td>2012</td>
<td>72,537,696</td>
<td>22.90</td>
<td>301</td>
<td>22.67</td>
<td>Q4</td>
<td>0</td>
<td>0.00</td>
<td>Apr-12</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>21.70</td>
<td>0</td>
<td>21.70</td>
<td>Q2</td>
<td>30</td>
<td>18.43</td>
<td>Mar-12</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>19.85</td>
<td>0</td>
<td>19.85</td>
<td>Q1</td>
<td>60</td>
<td>16.49</td>
<td>Feb-12</td>
</tr>
</tbody>
</table>

**Table 27:** Results Optimal Strategy Total Demand
B Microsoft Excel-files

The following files are available on the attached DVD.

- OptimizationBaseload.xlsx
- OptimizationTotalDemand.xlsx
- PurchasingDecisionSupportTool.xlsx