

# **Strategic repositioning of Safripol in the South African polymer industry**

**WA DU PLESSIS**

**11830697**

**Dissertation submitted in partial fulfilment of the requirements for  
the degree *Master of Engineering* at the Potchefstroom Campus of  
the North-West University, South Africa.**

**Supervisor: Prof PW Stoker**

**November 2010**

## **Abstract**

Safripol is a South African polymer company producing mainly high density polyethylene and polypropylene for the South African market. Safripol used to be part of a global chemical company Dow Chemicals. Dow Chemical's divested in South Africa in 2006 and Safripol lost all the advantages of being part of a global corporate enterprise.

The company is faced with a unique situation in that it is receiving monomer from Sasol, which is also its main competitor in the polymer market. The price of monomer and its low availability is putting pressure on Safripol's product margins, with a negative effect on the company's sustainability.

The above was also defined as the research problem that threatens to undermine the company's competitive edge in the polymer market.

It was clear from this research study that monomer and specifically propylene was the biggest burning point for Safripol regarding the price and availability thereof. Research into the South African polymer market has shown that Safripol will lose significant market share if the company is not showing additional growth in the market.

The research problem is investigated through interviews, monomer availability investigations, plant capacity increasing and potential technology partner's discussions. A specific scenario planning process was also followed to help Safripol identify potential present and future scenarios that the company can investigate.

The research problem was addressed by developing a strategy for Safripol to address the research objectives. Recommendations were done regarding the following:

- 1) Recommendations for additional propylene supply.
- 2) Recommendations to increase the polypropylene plant capacity.
- 3) Recommendations with regards to technology partners.
- 4) Recommendations regarding the scenario planning process.

## **Acknowledgement**

A special thank you goes to the Safripol GPS and Eagles team for their contributions towards the completion of this research project.

I also would like to acknowledge the role of the following Safripol individuals that assisted me in completing this dissertation: Charles van der Walt and Geoff Gaywood.

To my wife Tanya, and children; Janke and Wian, thank you for your support and commitment throughout the process of completing this dissertation.

Last but not least I would like to give recognition to Prof. Piet Stoker for his guidance and contributions to the success of this dissertation. Thank you very much Prof. Piet.

# TABLE of CONTENTS

<b><i>Abstract</i></b> .....	<b><i>ii</i></b>
<b><i>Acknowledgement</i></b> .....	<b><i>iii</i></b>
<b><i>List of tables</i></b> .....	<b><i>xi</i></b>
<b><i>List of figures</i></b> .....	<b><i>xii</i></b>
<b><i>List of abbreviations</i></b> .....	<b><i>xiii</i></b>
<b><i>Keywords</i></b> .....	<b><i>xiv</i></b>
<b><i>Chapter 1</i></b> .....	<b><i>1</i></b>
<b>1.1 Introduction</b> .....	<b>1</b>
<b>1.2 Polypropylene</b> .....	<b>1</b>
1.2.1 Polypropylene operations .....	2
<b>1.3 High-Density Polyethylene (HDPE)</b> .....	<b>2</b>
1.3.1 High-Density Polyethylene Operations .....	3
<b>1.4 Research problem</b> .....	<b>3</b>
<b>1.5 Research objectives</b> .....	<b>5</b>
<b>1.6 Chapter overview</b> .....	<b>5</b>

<b>Chapter 2 .....</b>	<b>7</b>
<b>2. Literature review .....</b>	<b>7</b>
<b>2.1 Introduction.....</b>	<b>7</b>
<b>2.2 History of Safripol.....</b>	<b>8</b>
<b>2.3 Global Polymer market.....</b>	<b>9</b>
<b>2.4 South African Polymer market .....</b>	<b>9</b>
<b>2.5 South African propylene availability .....</b>	<b>11</b>
2.5.1 PetroSA.....	13
2.5.2 Engen.....	13
2.5.3 SAPREF .....	13
2.5.4 NATREF .....	13
2.5.5 CHEVRON (Caltex).....	14
<b>2.6 South African ethylene availability .....</b>	<b>14</b>
<b>2.7 Green propylene .....</b>	<b>15</b>
2.7.1 Route via Bio-Ethanol (Fermentation, Dehydration, Dimerisation, and Metathesis).....	16
<b>2.8 Green Ethylene .....</b>	<b>17</b>
2.8.1 Ethanol to Ethylene Process.....	19
<b>2.9 Sugar production in South Africa .....</b>	<b>21</b>
2.9.1 Sugar milling and refining .....	21

2.9.2 World refined sugar price.....	22
<b>2.10 Technology partners .....</b>	<b>23</b>
<b>2.11 Scenario planning.....</b>	<b>24</b>
2.11.1 The history of scenario planning .....	25
2.11.2 A generic method of scenario planning.....	25
<b>2.12 Failure mode and effect analysis (FMEA) .....</b>	<b>27</b>
<b>2.13 Conclusion .....</b>	<b>28</b>
<b>Chapter 3.....</b>	<b>29</b>
<b>3. Empirical Investigation.....</b>	<b>29</b>
<b>3.1 Introduction.....</b>	<b>29</b>
<b>3.2 Interviews .....</b>	<b>30</b>
<b>3.3 Market survey: Monomer availability .....</b>	<b>30</b>
3.3.1 Propylene availability.....	31
3.3.2 SAPREF's splitter performance simulation test run.....	31
3.3.3 Ethylene availability .....	32
<b>3.4 Plant capacity and performance enhancement study .....</b>	<b>33</b>
<b>3.5 Technology support study.....</b>	<b>33</b>
<b>3.6 Scenario planning process.....</b>	<b>34</b>
3.6.1 Key drivers listing .....	34

3.6.2 Listing rules of the game.....	34
3.6.3 Listing uncertainties.....	35
3.6.4 SWOT analysis.....	35
3.6.5 Suggested recommendations for Safripol .....	35
<b>Chapter 4.....</b>	<b>36</b>
<b>4. Research findings.....</b>	<b>36</b>
<b>4.1 Interviews .....</b>	<b>36</b>
4.1.1 PetroSA.....	37
4.1.2 Engen.....	37
4.1.3 SAPREF .....	38
4.1.4 NATREF – Total .....	40
4.1.5 NATREF – Sasol.....	40
4.1.6 CHEVRON (Caltex) .....	40
<b>4.2 Market survey: Monomer availability .....</b>	<b>41</b>
4.2.1 Capacity study.....	41
4.2.2 Varying propylene purity study .....	43
4.2.3 SAPREF propylene trial test results.....	43
<b>4.3 Plant capacity and performance enhancement study .....</b>	<b>47</b>
4.3.1 Background .....	47

4.3.2 MAC definition .....	47
4.3.3 Method of conducting trial.....	47
4.3.4 Summary of trial results.....	48
4.3.5 Main throughput limitations per area.....	48
<b>4.4 Technology support study.....</b>	<b>50</b>
4.4.1 LyondellBasell .....	50
4.4.2 Grace Davison.....	51
4.4.3 BASF.....	51
4.4.4 The Dow Chemical Company .....	51
4.4.5 Sud-Chemie .....	51
4.4.6 Mitsui.....	51
<b>4.5 Scenario planning process.....</b>	<b>52</b>
4.5.1 Key drivers listing .....	52
4.5.2 Listing rules of the game.....	55
4.5.3 Listing uncertainties.....	56
4.5.4 SWOT analysis.....	58
4.5.5 Suggested recommendations for Safripol .....	61



<b>Chapter 5</b> .....	<b>63</b>
<b>5. Results discussion and interpretation</b> .....	<b>63</b>
<b>5.1 Introduction</b> .....	<b>63</b>
<b>5.2 Analysis of interviews</b> .....	<b>63</b>
5.2.1 PetroSA.....	63
5.2.2 Engen.....	64
5.2.3 SAPREF .....	64
5.2.4 NATREF – Total .....	64
5.2.5 NATREF – Sasol .....	65
5.2.6 CHEVRON (Caltex).....	65
<b>5.3 Market survey: Monomer availability study</b> .....	<b>66</b>
5.3.1 Safripol feedback.....	66
5.3.2 SAPREF feedback.....	67
<b>5.4 Plant capacity and performance enhancement study</b> .....	<b>68</b>
5.4.1 Polymerisation.....	68
5.4.2 Granulation.....	68
5.4.3 Utilities.....	69
<b>5.5 Technology support study</b> .....	<b>70</b>
<b>5.6 Scenario planning process</b> .....	<b>71</b>

5.7 Failure mode and effect analysis .....	74
5.8 FMEA results discussion .....	78
<b>Chapter 6 .....</b>	<b>79</b>
<b>6. Conclusions and recommendations.....</b>	<b>79</b>
<b>6.1 Conclusions .....</b>	<b>79</b>
6.1.1 Determine how the business support functions identified in the research problem contributes to the business success as a whole. ....	80
6.1.2 Identify and rank possible solutions to resolve Safripol's predicament. ....	81
6.1.3 Devise and recommend the implementation of viable solutions .....	82
6.1.4 Provide a summary of the approach that was followed to resolve the management challenges following divestment by a strategic stakeholder. ....	83
<b>6.2 Recommendations.....</b>	<b>85</b>
6.2.1 Additional propylene supply .....	85
6.2.2 Increase the Polypropylene plant capacity.....	86
6.2.3 Recommendations with regards to technology partners .....	87
6.2.4 Recommendations regarding the scenario planning process.....	88
<b>6.3 Areas for further research .....</b>	<b>89</b>
<b><i>Bibliography.....</i></b>	<b>90</b>

## List of tables

<b>Table</b>	<b>Page</b>
2.1 Current Crop Estimates for South Africa	22
4.1 Design data for SAPREF PPS.	39
4.2 Design rates for SAPREF PPS	42
4.3 Table of railcar propylene purity	43
4.4 Throughput limitations per area	49
4.5 Technology partners	52
5.1 Summary of technology partners	70
5.2 Failure mode and effect analysis (FMEA)	76/77
6.1 Business function versus associated study or process.	80
6.2 FMEA actions and action owners	82

## List of figures

<b>Figure</b>	<b>Page</b>
2.1 PP Market in South Africa	12
2.2 HDPE Market in South Africa	14
2.3 Worldwide ethanol production for 2006	18
2.4 Worldwide growth in ethanol production	19
2.5 Polymer grade ethylene from ethanol	20
2.6 World refined sugar price	23
4.1 SAPREF propylene supplies	42
4.2 SAPREF splitter	44
4.3 Trend of propane and propylene purity in plant	45
4.4 Trend of catalyst mileage over 7 days trial period	46
4.5 Rules of the game	55
4.6 Key uncertainties	56
4.7 Vision for 2020	57
5.1 Expansion capacities versus required capacities	69

## List of abbreviations

PP:	Polypropylene
HDPE:	High-density polyethylene
FMEA:	Failure Modes and Effects Analysis
C3:	Propylene
C2:	Ethylene
MAC:	Maximum asset capability
MT:	Metric tons
Kt/a:	Kilo tons per annum
SWOT:	Strengths, weaknesses, opportunities and threats
RPN:	Risk priority number
LPG:	Liquid petroleum gas
LDPE:	Low-density polyethylene
LLDPE:	Linear low-density polyethylene
SADC:	Southern Africa Development Community
GPS:	Game Plan to Success

## **Keywords**

Monomer

Propylene

Ethylene

Spheripol

Polypropylene

High-density polyethylene

Technology partners

Scenario planning process

Six Sigma

# Chapter 1

## 1.1 Introduction

Safripol is an independent South African company operating in its current form since December 2006; Safripol was first established in 1972 as a joint venture between Hoechst SA and Sentrachem Ltd (*Safripol, 2010*). In 1997 the business was purchased by The Dow Chemical Company and in 2006 sold to a consortium consisting of ABSA Capital, Thebe investments and the company's management team (*Safripol, 2010*).

Safripol produces approximately two thirds of the high-density polyethylene (HDPE) and more than a third of the polypropylene (PP) consumed in South Africa using the most advanced technology and manufacturing processes that meet international best practice standards (*Safripol, 2010*). HDPE and PP are used in various types of packaging, automotive components, building materials and a multitude of other polymer applications (*Safripol, 2010*).

Safripol buys raw materials derived from oil and coal and converts them to HDPE and PP. Its customers in turn transform or convert these materials into finished products. The company produces a variety of different types known as grades, which are specialised for different applications.

Safripol is one of South Africa's leading plastics manufacturers. Following is a short description of both technologies that Safripol are utilising.

## 1.2 Polypropylene

The polypropylene plant has a name plate capacity of 120 KT/a and was commissioned in 1997. Polypropylene products are supplied to customers or converters that manufacture a wide range of polymer products for the South African market and with limited exports (*Safripol, 2010*).

Polypropylene is a lightweight and versatile plastic with high stiffness and impact properties. Polypropylene is produced from a monomer called propylene and has three main product families; homopolymer, random copolymer and high impact copolymer produced with ethylene as a co-monomer (*Safripol, 2010*).

Customers or converters use PP to manufacture a wide range of products ranging from injection-molded articles, blow-molded containers, pipe and sheet to textile fibers. Application and usage for PP products are both indoors and outdoors. For outdoor applications PP will only be UV resistant if appropriately stabilised (*Safripol, 2010*). Another advantage of PP is good resistance to fatigue and therefore ideal for usage on flip-top bottles as a living hinge (*Safripol, 2010*).

### **1.2.1 Polypropylene operations**

The technology of the plant named the Spheripol technology was derived from the unique ability of the catalyst used in the process to produce uniform polymer spheres known as “Spheriform”. This process takes place in the polymerisation reactors (*Safripol, 2010*).

The Spheripol process involves the following sections:

- 1) Catalyst feeding.
- 2) Polymerisation:
  - a) Bulk polymerisation (homopolymer or random copolymer)
  - b) Gas phase polymerisation (heterophasic impact copolymer)
  - c) Finishing (*Montell, 1996*)

### **1.3 High-Density Polyethylene (HDPE)**

Safripol utilises the Hoechst slurry polymerisation technology. This technology was originally derived from Hostalen <sup>TM</sup> (*Safripol, 2010*). Safripol has a technology agreement with The Dow Chemical Company in place that will allow the company to implement further updates of



the technology enabling Safripol to stay on the forefront of the market as required (*Safripol, 2010*).

Ethylene is used as a monomer for the polymerisation process, producing a polymer with excellent mechanical properties like stiffness and environmental stress crack resistance (*Safripol, 2010*).

The main application of HDPE ranges from crates, pipe, blow-moulded containers, blown film and drums (*Safripol, 2010*). One of the most important and growing products for the HDPE plant is carbon-black-filled grades for the pipe industry. The Safripol HDPE products are suitable for food contact applications (*Safripol, 2010*).

### **1.3.1 High-Density Polyethylene Operations**

Safripol's high-density polyethylene plant production units consist of three polyethylene plants with a hydrocarbon distillation facility and an extruder plant consisting of five extruders (*Safripol, 2010*).

## **1.4 Research problem**

The South African chemical industry is a R270 billion market enterprise producing more than 300 different products (*Laing, 2006*).

South Africa's annual plastics industry represents 9% of the total size of the SA Chemical industry. It contributes 5% to the SA Gross Domestic Product (GDP) and has an annual growth rate of 7% (*Laing, 2006*). The South African polymer industry has current sales of ± R23 billion per annum with very limited exports (*Plastic Federation SA, 2010*).

Safripol is also doing business in this chemical environment with an annual turnover of ± R3.0 billion or 1% of the South African chemical industry (*Schoch, 2010*).

Safripol used to be part of a global chemical company, Dow Chemical's since 1998. Being part of Dow presented the company with all the advantages of a global corporate enterprise. Safripol also had access to the following vital business support functions and processes:

- 1) Monomer supply contract negotiation and leveraging
- 2) Technology partner
- 3) Technology support
- 4) Technology centre support
- 5) Product development
- 6) Proven most effective technology
- 7) International codes and standards
- 8) Work processes
- 9) Human relations support
- 10) Networking

Not being part of a global company anymore and as a consequence of the disinvestment by Dow Chemicals in Safripol, the company no longer has access to the above vital business support functions. It threatens to undermine the company's competitive edge in the South African polymer industry and marketplace. Safripol's position is further compromised by the fact that it is competing in the polymer market with the same company that is supplying its raw materials, namely propylene and ethylene.

**Therefore research is required to determine how the above predicament in which Safripol finds itself in the market can be turned around, using specific strategy and technology as a means to stabilise the situation and establish a firm basis for building a prosperous and long term future for the company.**

## **1.5 Research objectives**

The objective of this research will be to find ways of positioning Safripol and specifically the polypropylene plant in the South African polymer environment helping Safripol to be competitive and sustainable in the long term.

The research problem will be approached according to the following research objectives:

- 1) Determine how the business support functions identified in the research problem contributes to the business success as a whole.
- 2) Identify and rank possible solutions to resolve Safripol's predicament.
- 3) Devise and recommend the implementation of viable solutions.
- 4) Provide a summary of the approach that was followed to resolve the management challenges following divestment by a strategic stakeholder.

## **1.6 Chapter overview**

It can be seen that Safripol is a well established player in the South African polymer market with a significant customer basis. The two businesses at its premises in Safripol were discussed; HDPE and PP. The main product families that the two businesses produce were elaborated upon; high-density polyethylene and polypropylene.

The situation Safripol is in with regards to being an independent company and not linked to a technical parent company anymore has given the company an opportunity to gain access to a number of vital business support processes or functions.

Contributing even more to Safripol's uniqueness in the polymer marketplace is the fact that it is competing in the market with the same company that is supplying its raw materials.

Therefore the reason has arisen why research is required to determine how Safripol will be able to strategically reposition itself in the South African polymer industry.

The objective of this research will be to find ways of positioning Safripol and in particular focusing on the polypropylene plant in the South African polymer environment helping Safripol to be competitive and sustainable in the long term.

Research objectives were listed that will help with the approach of solving the research problem. As indicated in the research problem Safripol lost access to a number of technologies and vital business processes.

## Chapter 2

### 2. Literature review

#### 2.1 Introduction

The chemical industry is vital for the Global economy to grow and exist, converting raw materials (oil, natural gas, air, water, metals, and minerals) into more than 80,000 different products (*Britannica, 2010*).

Chemicals are used to produce almost every type of consumer goods, as well as products that are essential for the agriculture, manufacturing, construction, and service industries. Major industrial customers include rubber and plastic products, textiles, apparel, petroleum refining, pulp and paper, and primary metals (*Laing, 2006*).

The global production of chemicals is worth almost \$3.5 trillion on an annual basis and the United States of America's chemical industry is the world's largest producer. Instrumental in the changing structure of the global chemical industry has been the growth in China and the Middle East.

The South African chemical industry is a \$36 billion enterprise producing more than 300 different products (*Laing, 2006*).

South Africa's annual plastics industry represents 9% of the total size of the SA Chemical industry and contributes 5% to the SA Gross Domestic Product (GDP) and has an annual growth rate of 7%. The South African polymer industry has current sales of ± US\$ 3.3 billion per annum with very limited exports (*Plastic Federation SA, 2010*).

Safripol is also doing business in this chemical environment with an annual turnover of ± \$0.4 billion or 1% of the South African chemical industry (*Laing, 2006*).

The research headings in the rest of the chapter are all relevant to Safripol's unique situation. The structure of the research chapter will be as follows:

- 2.2 History of Safripol
- 2.3 Global polymer market
- 2.4 South African Polymer market
- 2.5 South African propylene availability
- 2.6 South African ethylene availability
- 2.7 Green propylene
- 2.8 Green ethylene
- 2.9 Sugar production in South Africa
- 2.10 Technology partners
- 2.11 Scenario planning
- 2.12 Failure mode and effect analysis (FMEA)

## **2.2 History of Safripol**

Safripol (Pty) Ltd is an independent plastics manufacturing company that supplies polypropylene and high-density polyethylene to the converting industry, for the manufacture of a wide range of packaging and industrial end uses. The plant now has an estimated polyolefin's manufacturing capacity of 280 000 tpa. Ethylene and propylene for the polymerisation process is sourced mainly from Sasol.

Safripol was originally established as a joint venture between Hoechst SA and Sentrachem in 1969. Shortly before the turn of the century it was purchased by The Dow Chemical Company and operated as Dow Plastics SA. By late 2006 Dow's strategy with regard to emerging markets had changed, and the company was sold to a South African consortium comprising ABSA Capital, the investment arm of South Africa's largest banking group, Thebe Investments and the management team led by Joaquin Schoch. The name Safripol was once again restored.

The company's approximately 270 employees are based between its offices in Bryanston, Johannesburg, Durban and its manufacturing plant at Sasolburg. In addition to supplying

larger local converters directly it also uses a local distributor to service smaller customers (*Safripol GPS program, 2009*).

## 2.3 Global Polymer market

The global polymer market is divided into five regions with the main concentration in three regions. Below is a breakdown of the different polymer market segments in percentage (*Laing, 2006*):

Market segment	Percentage
Asia Pacific:	42%
North America	21%
Europe	23%
Africa and Middle East	6%
South America	8%

China and India has a significant influence on the global polymer market and Asia Pacific is a major role player that needs to be taken notice of.

The annual global polymer market is  $\pm$  200 million MT. South Africa's polymer market size is 1.3 million MT with limited exports (*Plastic Federation SA, 2010*).

## 2.4 South African Polymer market

Safripol's site annual polymer production capacity is 280 000 MT in total. The main product family's annual production capacities are (*Safripol, 2010*):

- 1) HDPE: 160 000 MT
- 2) PP: 120 000 MT

The repositioning of Safripol in the global and South African polymer industry is critical compared by the relative sizes of each. This also indicates that Safripol will have to be

competitive to survive in the global polymer industry. Safripol represent about 22% of the local polymer industry (*Laing, 2006*).

The chemical industry has been defined as a priority industry in all government plans. Although the polymer industries total contribution is relatively small, the multiplier effect is considered very big and essential. As an example; in the polymer industry there is approximately 3 000 converters and the job creation multiplier effect is approximately 10. This equates in 30 000 people being employed within the polymer industry (*Schoch, 2010*).

Polymers are used in all sectors of the industry and each and every South African consumer is dependent on polymer products (*Plastic Federation SA, 2010*).

South Africa is producing HDPE and PP and has plants in Sasolburg (Sasol and Safripol) and Secunda (Sasol). One of Safripol's main competitors in South Africa is Sasol. The following points show Sasol's annual polymer producing capabilities (*Sasol, 2010*):

- 1) HDPE: Sasol does not have an HDPE production facility.
- 2) They do have the following PE plants:

<b>Plant</b>	<b>Capacity</b>
Poly 2 LLDPE	154 000 MT
Poly 3 LDPE	220 000 MT
<b>Total</b>	<b>374 000 MT</b>

- 3) Sasol has the following Polypropylene plants.

<b>Plant</b>	<b>Capacity</b>
PP1	225 000 MT
PP2	300 000 MT
<b>Total</b>	<b>525 000 MT</b>

Sasol is a major role player in the South African polymer industry. Sasol is also Safripol's major supplier of monomer and main competitor in the polypropylene market.



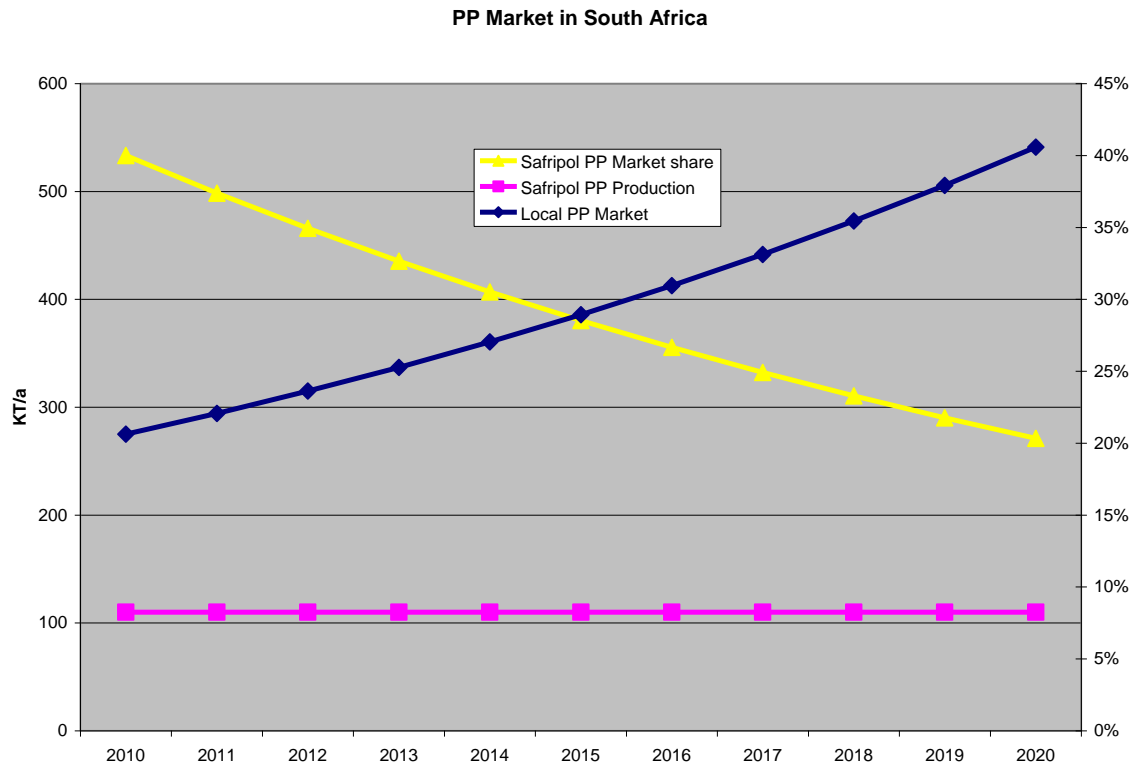
## **2.5 South African propylene availability**

Safripol has only one propylene supply contract in place with Sasol for 55 KT/a. SAPREF's refinery in Durban supplies Safripol with 20 KT/a propylene via rail cars and wants to engage into a 20 KT/a propylene supply contract with Safripol.

Sasol has a tier 1 and tier 2 supply pricing formula in place with Safripol. The tier 1 price formula is applicable up to 45 KT/a and with higher volumes supplied to Safripol the tier 2 price is applied. Sasol is supplying the company with propylene in excess of 45 KT/a at a tier 2 price that is a higher price than the tier 1 price.

With the PP plant having a 120 KT/a production capacity there is 75 KT/a propylene presently unsecured.

Figure 2.1 is showing Safripol's polypropylene market share that is declining from 40% in 2010 to 20% in 2020 if the PP plant is not showing any significant growth. This is assuming that the local PP market will grow with 7% on an annual basis:



**Figure 2.1: PP Market in South Africa**

Safripol is receiving more than the 45 KT/a propylene from Sasol and is therefore short falling on cheaper propylene or propylene at a tier 1 price with Sasol. According to Andre Potgieter SAPREF is also experiencing regular propylene supply short falls.

Research of the South African petroleum industry was done with six potential monomer suppliers identified. The following criteria were used as a guideline during research:

- 1) Identify potential suppliers of propylene.
- 2) Propylene availability. Safripol's PP plant has an availability of 95%. (*Safripol, 2010*).
- 3) Propylene quality.
- 4) Propylene quantity.
- 5) Feed options of propylene to Safripol.

### **2.5.1 PetroSA**

PetroSA was formed in January 2002 from the merger of three previous entities, i.e. Mossgas (Pty) Limited, Soekor (Pty) Limited, and parts of the Strategic Fuel Fund Association (*PetroSA, 2010*).

PetroSA is a pioneer in Gas-to-Liquids (GTL) technology; PetroSA owns and operates one of the world's largest GTL refineries and is situated in Mosselbay.

### **2.5.2 Engen**

Engen supplies fuel to the South African market, affiliates in Lesotho, Botswana and Swaziland, and half of Namibian operation's needs. The Engen Refinery (Enref) is in Durban on the east coast of South Africa (*Engen, 2010*).

### **2.5.3 SAPREF**

SAPREF is an oil refinery situated in Durban supplying propylene to Safripol via a propylene and propane splitter on their site. The splitter is on Safripol's asset list and is operated and maintained by SAPREF personnel.

The splitter has excess capacity according to the design criteria and will therefore be investigated in detail regarding propylene supply improvement opportunities (*P.P. Splitter FWSA Contract 25145 Volume 2 Book A*).

### **2.5.4 NATREF**

Natref (National Petroleum Refiners of South Africa) is an inland refinery at Sasolburg with a capacity of 108 500 barrels oil per day. The Natref refinery is a joint venture between Sasol mining (Pty) Ltd and TOTAL South Africa (Pty) Ltd. Sasol has a 63.64 percent share in Natref and TOTAL 36.36 percent (*TOTAL, 2010*).

### 2.5.5 CHEVRON (Caltex)

Chevron's Cape Town refinery is a 110 000 barrels a day oil refining capacity (Chevron, 2010). The refinery is situated in Milnerton, Cape Town and produces gasoline, diesel and aviation fuel, kerosene, fuel oil, and other products.

### 2.6 South African ethylene availability

Safripol is 100% dependant on Sasol for its ethylene supply. Sasol also approved a R2bn ethylene purification unit for 48 KT/a that will be built in Midlands, Sasolburg (Sasol, 2010).

Figure 2.2 below shows Safripol's high density polyethylene market share declining from 70% in 2010 to 36% in 2020. That is also if the HDPE plant is not showing any significant growth. This is assuming that the local HDPE market will grow with 7% on an annual basis.

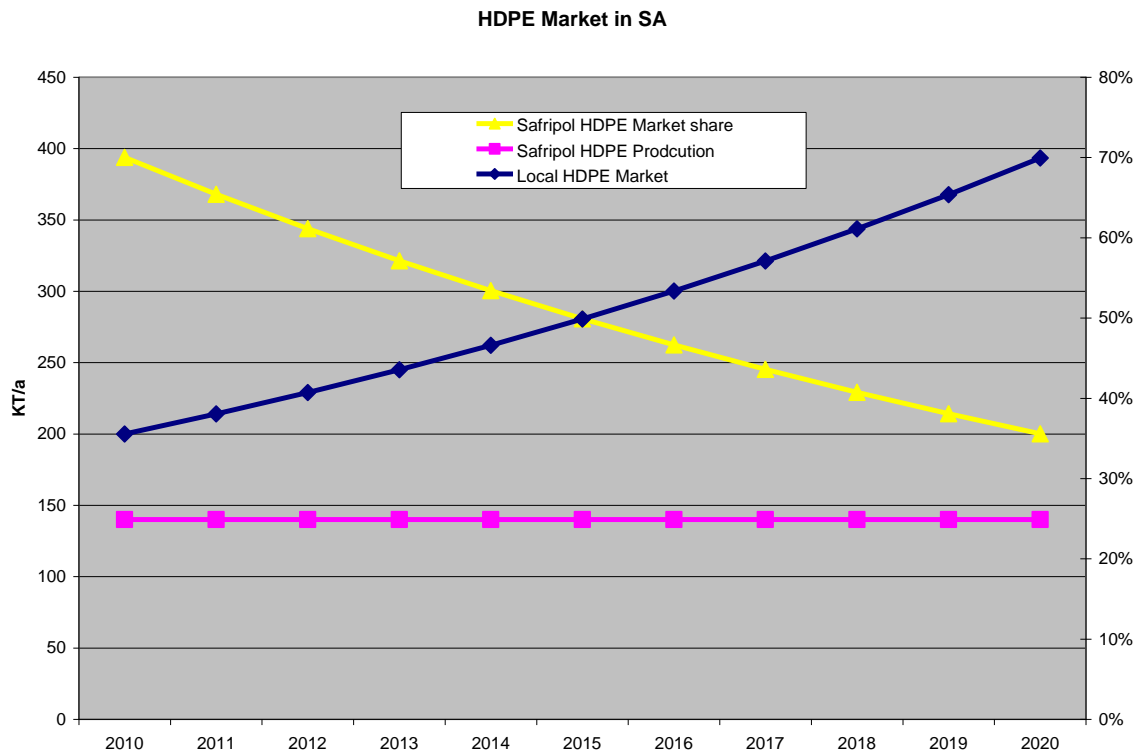


Figure 2.2: HDPE market in South Africa

## 2.7 Green propylene

Green propylene is researched exclusively for the purpose of giving Safripol a competitive advantage over its competitors in the market if the research shows that 'green' propylene can be competitively produced.

The question needs to be asked but why "green" propylene and what will be the influence on the polymer industry and in particular Safripol's operations? The answers will be:

- 1) Manage the carbon footprint of 120 KT polypropylene produced every year by Safripol.
- 2) The quest for sustainability in reducing Safripol's dependence on fossil fuels.
- 3) The world is asking for renewable, sustainable options.

Though propylene demand is only about half of ethylene, the world is heading to a shortage of propylene from fossil fuels. Technology is there to produce propylene and ethylene from renewable sources such as biomass and therefore propylene that is generated from biomass is called green propylene.

According to the research company Chemsystems, several cases are considered herein for the production of green (or sustainable) propylene. These include the following five cases (*Chemsystems, 2010*):

- 1) Fermentation of sugars to produce bio-ethanol and then dehydrated to bio-ethylene. Some of the ethylene is then dimerised and normal butenes are produced. A reaction then takes place between the bio-butenes and the remaining bio-ethylene via metathesis and green propylene is produced.
- 2) Butanol can be produced by fermentation of sugars or gasification of biomass. Bio-butanol is dehydrated to produce bio-butene and the bio-butene is then reacted with bio-ethylene.
- 3) Bio-propane is produced as a by-product of biodiesel. Bio-propane is then dehydrogenated to produce green propylene.

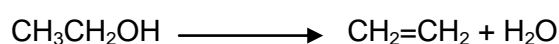
- 4) Vegetable oil is fed to an enhanced fluid catalytic cracker (FCC) unit and green propylene is produced.
- 5) Syngas is produced by the gasification process of biomass. This process is then followed by synthesis of bio-methanol. The methanol-to-olefins technology is used to produce green propylene.

### **2.7.1 Route via Bio-Ethanol (Fermentation, Dehydration, Dimerisation, and Metathesis)**

The production of green propylene includes fermentation of sugars where after bio-ethanol is produced. The dehydration process follows after the bio-ethanol process that produces ethylene. Ethylene is then partially dimerised and normal butenes is produced.

The remaining ethylene is then reacted with the butenes via the metathesis reaction to produce green propylene.

The chemical reaction of ethylene production via dehydration of ethanol can be represented as follows:



Activated alumina catalyst is used for the dehydration reaction that is taking place at temperatures ranging from 315 - 425°C. The yield of the ethylene from ethanol process ranges at approximately 96 percent.

Ethanol produced from biomass contains impurities that will contaminate the ethylene that is produced by the dehydration reaction. These impurities will have a negative impact on the metathesis catalyst downstream (*Chematur,2010*).

Lummus Technology Inc. is currently the license holder of the technology for the production of normal butenes by the olefin dimerisation process that was invented by Phillips Petroleum

Company. Olefin metathesis, or disproportionation, has given an opportunity for olefin interchange ability (CBI Lummus' *Olefin Conversion Technology*, 2010).

## **2.8 Green Ethylene**

Once again and for the same reasons as the research being done for green propylene, green ethylene is researched exclusively for the purpose of giving Safrinol a competitive advantage over its competitors in the market if the research shows that 'green' ethylene can be competitively produced.

The production of ethylene from ethanol is already a proven production process. The technology for the production of ethylene from ethanol has been modernised and uses modern and technology advanced catalysts.

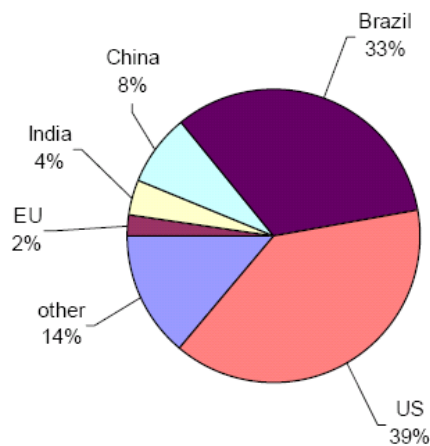
These processes are well documented and continuously improved and have therefore considerable importance regarding the feedstock available for ethylene production. This is of significant importance particularly in petroleum poor and agriculturally rich economies (*Chematur*, 2010).

Ethanol has received the most interest among the many bio-derived feedstocks that are available. Reason is that the technology is a simple process of fermentation of agricultural products such as corn and sugar cane.

A fully commercial production plant of ethanol to ethylene glycols as an alternative to petroleum based feedstock ethylene to glycols was developed by Scientific Design Company Inc. (SD).

The first commercial plant using this technology was started up in India in 1989. Scientific Design Company together with Chematur Engineering AB also offers a non-integrated ethanol to ethylene production process.

In Brazil, more than 30 products were derived from ethanol, several with installed capacities above 100 000 tons/year during this period (*Scientific Design Company, Inc, 2010*). Figure 2.3 shows worldwide ethanol production for 2006 (51 Billion litres)



**Figure 2.3 Worldwide ethanol production for 2006**

*Source: Scientific Design Company Inc, 2010*

Due to this renewed interest in ethanol the worldwide production of ethanol is projected to more than double over the next 15 years to over 120 000 million litres by 2020 as shown in figure 2.4 below:



Worldwide Growth in Ethanol Production [2]

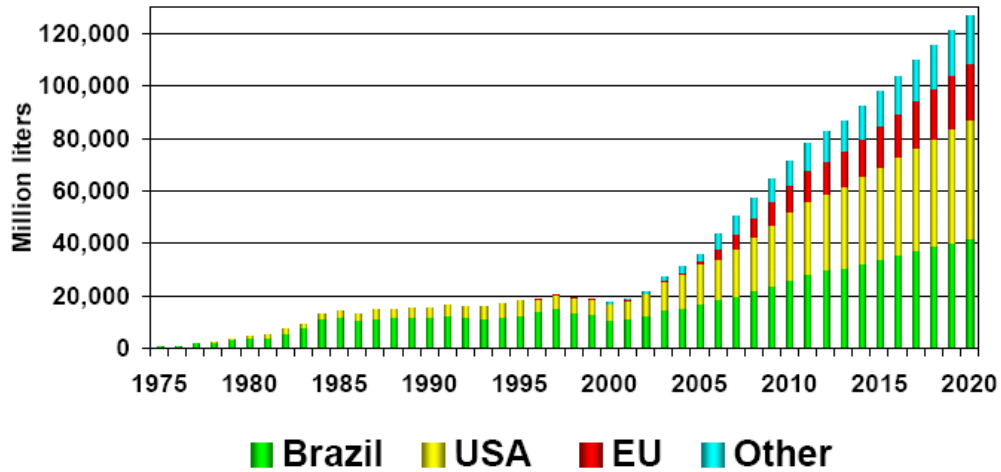


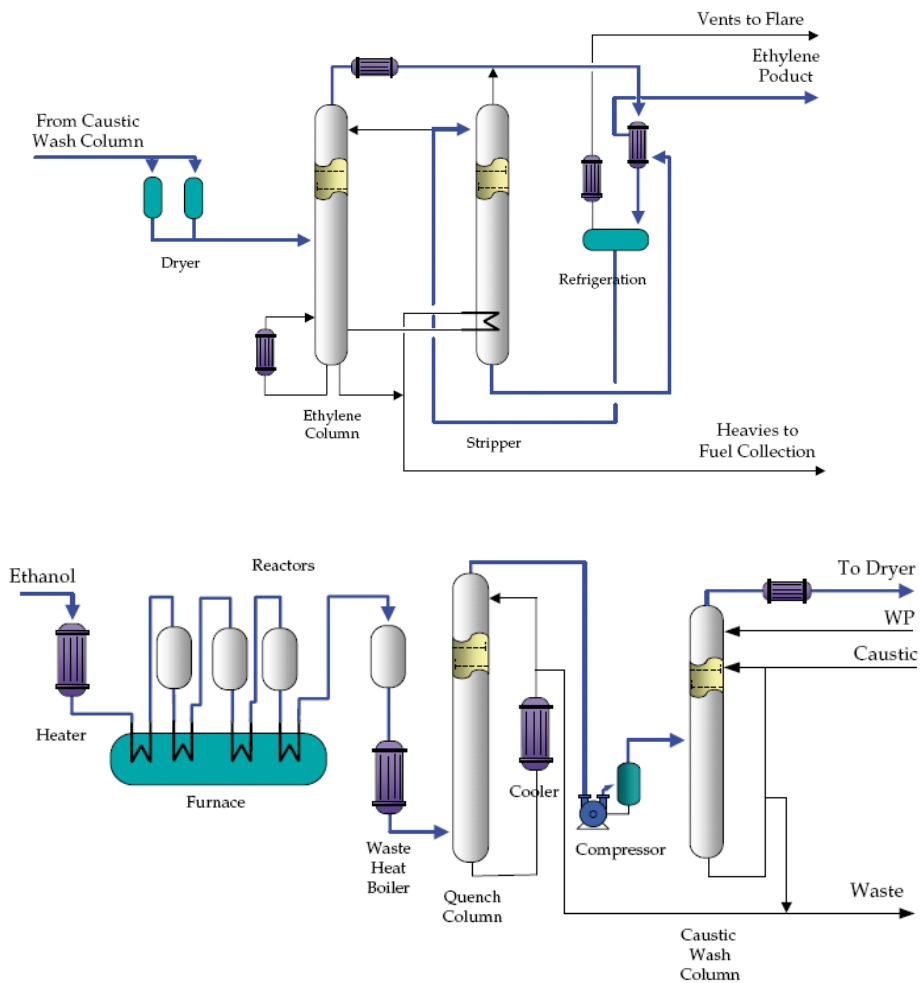
Figure 2.4: Worldwide Growth in ethanol production.

Source: Scientific Design Company Inc, 2010

### 2.8.1 Ethanol to Ethylene Process

Two types of reactors are used for the production of ethanol from ethylene. Fixed bed or fluidised bed reactors are used and the ethylene from ethanol to reaction takes place in the vapour phase of these reactors.

The reaction is either isothermal or adiabatic when fixed bed reactors are being utilised. Therefore the basis of the following ethylene from ethanol process description will be the adiabatic, fixed bed reactor process from SD/Chematur. A schematic of the process is shown below in figure 2.5:



**Figure 2.5: Polymer grade ethylene from ethanol**

*Source: Chematur Engineering AB*

Ethanol is vaporised and superheated by means of a fired heater. The superheated ethanol is then fed to a series of dehydration reactors. Reheating is required between the reactors due to the endothermic dehydration to drive the reaction to a 99.0% yield of ethylene conversion.

The dehydrator effluent stream is first cooled and then compressed. The ethylene stream is then caustic washed and dried. The ethylene stream then goes through an ethylene column

and stripper to purify the stream by reducing the CO levels up to parts per million (ppm) levels in the final ethylene gas stream.

One way to reduce the current pricing disadvantage of ethanol-derived ethylene when compared to petroleum derived ethylene would be to take advantage of the benefits of building a fully integrated chemical processing unit which would go from sugar to downstream ethylene derivatives such as high density polyethylene (HDPE).

## **2.9 Sugar production in South Africa**

South Africa's sugar industry is a leading producer of high quality sugar at competitive prices.

The industry produces an estimated average of 2.5 million tons of sugar per season. About 50% of this sugar is marketed in the Southern Africa Custom's Union (SACU). The remainder is exported to numerous markets in Africa, the Middle East, North America and Asia (*South Africa Sugar Association, 2010*).

According to Sasa executive director Trix Trikam, South Africa exports on average about 800 000 t/a of sugar after it has satisfied the regional demand.

### **2.9.1 Sugar milling and refining**

Sugar will be the main raw material used for the production of ethanol and subsequently ethylene. An in depth research is done regarding the availability of sugar in Southern Africa and the global price trends of sugar.

The sugar industry is employing more than 11 000 people in its sugar mills across South Africa. There are 14 sugar mills in South Africa and the sugar companies have central administration offices in KwaZulu-Natal and Mpumalanga. Following is a breakdown of the mills:

- 1) Six mills are owned by Illovo Sugar Ltd.
- 2) Four mills are owned by Tongaat Hulett Sugar Ltd.
- 3) Two mills are owned by Transvaal Sugar Ltd located in Mpumalanga province and KwaZulu-Natal province (*Tongaat Hulett, 2010*).
- 4) Five of the mills produce their own refined sugar known as white end sugar.
- 5) Transvaal Sugar is producing raw sugar that is exported via the sugar terminal in Maputo.

The raw sugar that is produced at the rest of the sugar mills is routed to Durban where it is either stored at the Sugar Association sugar terminal for export purposes or further refined at the central refinery of Tongaat Hulett (*Tongaat Hulett, 2010*).

Table 2.1 below shows the current crop estimates for South Africa for the July 2010/11 season:

<b>Estimates (tons)</b>	<b>July 2010/11 Season</b>
Sugarcane crush	17 531 000 ton
Saleable sugar production	2 065 000 ton

**Table 2.1: Current Crop Estimates for South Africa**

*Source: Tongaat Hulett*

## **2.9.2 World refined sugar price**

The world refined sugar prices are seasonable sensitive and therefore cycling. Below is a graph showing the world sugar prices per ton from January 2009 up to July 2010.



**Figure 2.6: World refined sugar price**

Source: London International Financial Futures and Options Exchange (LIFFE).

## 2.10 Technology partners

The purpose of a technology partner is researched to show in the first place the importance of having a technology partner for the Spheripol technology and secondly listing the technology partners that will be suitable for Safripol.

A technology partner in the polymer industry can be either a licensee supplier of the polymer manufacturing plant technology or a catalyst supplier that has access to the technology. In Safripol's case the specific technology that is used to produce polypropylene is the Spheripol process licensed by LyondellBasell (*LyondellBasell, 2010*).

Safripol is currently engaged into a technology agreement contract with LyondellBasell that will be expiring in 2011. This contract makes provision for the following:

- 1) Any new product developments on the market.
- 2) Plant safety improvements.
- 3) Plant technology improvements.
- 4) Plant technology support.
- 5) Plant catalyst support.
- 6) Plant product quality support.
- 7) Benchmarking.

Research done regarding technology partners that are available revealed the following list:

- 1) LyondellBasell (*LyondellBasell, 2010*)
- 2) Grace Davison (*Grace Davison, 2010*)
- 3) BASF (*BASF, 2010*)
- 4) The Dow Chemical Company (*Dow, 2010*)
- 5) Sud-Chemie (*Sud-Chemie, 2010*)
- 6) Mitsui (*Mitsui, 2010*)

## **2.11 Scenario planning**

Safripol is using scenario planning because it enhances strategic thinking by helping the company to better anticipate and plan for the future to reposition itself according to future trends.

Scenario planning is a discipline for rediscovering the original entrepreneurial power of creative foresight in contexts of accelerated change, greater complexity, and genuine uncertainty (*Pierre Wack, Royal Dutch/Shell, 1984*).

Peter Schwartz described scenario planning technique in his book: *The Art of the Long View* (New York: Currency Doubleday, 1996).

According to Schwartz scenario planning is a strategic process that develops a view into the future. It identifies and assesses potential strategic risks and opportunities characterised by great uncertainty (*Juergen and Daum, 2010*).

Scenario planning is the process in which future scenarios are created in order to take away the surprise element. The purpose of scenario planning is not to define the future, but to understand the future and events that could be materialised or triggered.

### **2.11.1 The history of scenario planning**

According to Peter Schwartz (*Juergen and Daum, 2010*) scenario planning first emerged in the United States Military during World War II for strategic planning. Military think tanks such as the RAND Corporation have been using scenario type thinking and simulated war games of military strategy for decades (*Peter Lauburn, 2010*).

In business scenario planning started in the 1970's with the experience of Royal Dutch Shell planning directors Pierre Wack and Ted Newland. Pierre Wack is considered as one of the greatest teachers of scenario planning and the first widely documented and recognised success story of scenarios (*Peter Lauburn, 2010*).

### **2.11.2 A generic method of scenario planning**

Peter Schwartz process of building scenarios starts with considering what is changing in the current world. Thinking out of the box is essential to create scenarios and it can range from technological to environmental changes. Once a list has been developed the key driving forces that are fundamentally shaping the industry in the future needs to be identified (*Peter Lauburn, 2010*).

Once the driving forces are listed they need to be differentiated into:

- 1) Those driving forces that have some certainty such as demographics are called rules of the game.
- 2) Those driving forces where there is no certainty or it is just too unclear to make judgment are called key uncertainties.

These uncertainties need to be assessed in terms of:

- 1) Their potential impact.
- 2) Risk uncertainty.

The uncertainties that will be used in developing scenarios are the two with both high probability and high impact should they materialise.

Plotting the two uncertainties as the 'x' and 'y' axis, a simple matrix is constructed with the two extreme possible outcomes of each uncertainty at the end of each axis.

For example:

X axis = Global stagnation with biofuels versus global stagnation with fossil fuels.

Y axis = Rapid economic growth in Africa with foreign investments versus Rapid economic growth in Africa without foreign investments.

The possible scenarios are now based on the different possibilities from each of the two critical uncertainties in the industry:

- 1) Global stagnation with biofuels.
- 2) Global stagnation with fossil fuels.
- 3) Rapid economic growth in Africa through foreign investments.
- 4) Rapid economic growth in Africa without foreign investments.



For each scenario the world of that scenario 5 - 10 years from now needs to be considered.

Once these scenarios have been developed a SWOT analysis can be developed. Threats and opportunities are identified and then the organisation's weaknesses and strengths. Future scenarios can then be listed with recommended suggestions for further investigation.

Scenario planning enhances strategic thinking by helping companies to better anticipate and plan for the future.

## **2.12 Failure mode and effect analysis (FMEA)**

Failure mode and effect analysis will help Safripol identify processes that need to be focused on because they have the most critical influence on Safripol's business support functions.

FMEA is an acronym for Failure Modes and Effects Analysis. FMEA is defined as a systematic method of identifying and preventing product and process problems before they occur (*McDermott, Mikulak, Beauregard 1996:4*).

FMEA is also a tool used in the Six Sigma methodology process. The FMEA identify an outcome (effect) and quantify it based on its level of severity. The FMEA is used to prioritise development of processes by means of identifying the level of severity by using an ordinal scale from one to ten. (*The Black Belt Memory Jogger 2002:211-215*).

An effect is normally the result of a chain of events; sequence of root cause to failure mode to effect. The likelihood that the effect will realise depends on how often the chain of events is started, when it starts, versus how often the chain of events is stopped.

Description of the frequency of occurrence term is how often the chain of events is initiated by a root cause. Detectability is the ability to halt the chain of events. The risk priority number (RPN) is the overall evaluation of the risk and is the product of the severity of the effect, frequency of occurrence and detectability.

The failure mode is most of the times also the root cause-failure-effect chain in the process that is easily defined. Failure modes are the parts of the process that project team's need to focus on because they have the most critical influence on the processes and in Safripol's case this will be the business support functions.

## **2.13 Conclusion**

Research was done over the entire value chain that Safripol is involved in. Safripol is a well established and respected player in the South African polymer environment and industry.

It is also indicated that there is significant growth worldwide regarding polymer production and consumption, specifically in South Africa. Therefore it is even more important that research is done due to the fact that Safripol cannot take advantage of the growing polymer market and is losing its competitive edge and market share in the South African polymer industry.

Monomer availability is highlighted by the number of monomer suppliers that are available in South Africa and research was done regarding the opportunities that are available regarding additional supplies of monomer.

The different technologies that are available for green propylene and ethylene were also investigated. Research regarding the availability and pricing of sugar was done with the possibility to produce ethanol from sugar.

Technology partners that are relevant to Safripol's technology were listed.

The history of scenario planning was discussed and in the next chapter the process of Safripol's scenario planning will be outlined in detail.

Failure mode and effect analysis is a tool that is used with Six Sigma problem solving techniques in order to rate solutions and effects. This process was investigated regarding the relevance and assistance of it being used in solving the research problem.

## Chapter 3

### 3. Empirical Investigation

#### 3.1 Introduction

Empirical Investigation is a factual enquiry carried out by simply recording what is observed or discovered (*Archaeology Dictionary, 2003*).

This chapter presents the process that was followed for the empirical investigation of the research problem.

After the literature review chapter it is postulated that a need exists to find ways of repositioning Safripol in the South African polymer industry.

Following are the different approaches regarding the empirical investigations that were done with specific goals of each that were discussed in the rest of the chapter:

3.1. Interviews:

The function of interviews and written communication is to gather information regarding potential monomer suppliers.

3.2. Market survey: Monomer availability study:

Market surveys are performed to gather information for support of the most feasible options available for additional propylene and ethylene.

3.3. Plant capacity and performance enhancement study:

A plant capacity test run on the polypropylene plant is done to focus on specific areas in the plant for debottlenecking purposes. A logical approach to identify these areas is discussed. The polypropylene plant's capacity is increased to maximum to identify potential limitations.

#### 3.4. Technology support study:

The purpose of the study is to identify the technology partners that can give various support functions to Safripol. The companies are listed and the evaluation approach is discussed.

#### 3.5. Scenario planning process:

Structural approach and investigation regarding the scenario planning process is described.

### **3.2 Interviews**

Interviews with written communication were conducted with key people in order to collect data regarding monomer availability.

These interviews are used as a guideline regarding what is important to focus on with respect to the research problem and possible solutions.

Interviews and written communication was conducted with:

- 1) Geoff Gaywood – Chief Operating Officer Safripol
- 2) Peter Raine – Independent researcher

### **3.3 Market survey: Monomer availability**

A market survey was conducted in South Africa to identify existing and potential monomer suppliers. The following criteria were the basis of the study:

- 1) Availability of monomer at various suppliers.
- 2) Quality of available monomer.
- 3) Capacity of additional monomer that is available.
- 4) Potential capacity increase.

### **3.3.1 Propylene availability**

In an ongoing effort to increase the monomer supply for the Safripol Polypropylene plant, Safripol investigated all the possibilities regarding the six available propylene suppliers with respect to the following:

- 1) Propylene availability.
- 2) Propylene quality.
- 3) Propylene quantity.
- 4) Feed options of propylene to Safripol.

### **3.3.2 SAPREF's splitter performance simulation test run**

A splitter performance simulation test run was conducted by SAPREF according to the following studies:

- 1) Varying propylene purity study.
- 2) Capacity study.

#### **3.3.2.1 Varying propylene purity study**

A varying propylene purity study or test run was performed by SAPREF on its splitter unit in accordance with the following Safripol specifications and requirements:

- 1) Propylene purity specification shall be varied between 98% and 99.2% with the balance propane and no other components.
- 2) The simulation test run shall be done with 280 MT of propylene or eight full rail tankers with almost 33 MT of propylene in each.
- 3) Catalyst performance evaluation with high propane concentration in the Polypropylene plant.
- 4) Verifying if 98% propylene is feasible to produce at SAPREF.
- 5) Verifying the feasibility of processing 98% propylene at Safripol.

The existing purity specifications for the product stream of SAPREF's splitter loaded into the rail tankers are:

- 1) 99.2% propylene
- 2) 0.8% propane

### **3.3.2.2 Capacity study**

SAPREF agreed with Safripol to perform a capacity study on SAPREF's propylene and propylene splitter to verify the following:

- 1) Existing capacity versus design capacity of the SAPREF's splitter.
- 2) The simulation test run will be done to determine if there is potential propylene supply increase due to the varying propylene purity.

This capacity run was done in conjunction with Safripol's operations personnel.

### **3.3.3 Ethylene availability**

Sasol approved the construction of a 48 KT/a ethylene purification unit that will be built in Midlands at Sasol 1 site in Sasolburg.

The ethylene supply contract between Safripol and Sasol stipulates that Sasol needs to share with Safripol any new ethylene production that comes available according to a fixed ratio. The options that are available for Safripol to increase ethylene availability and feed were investigated.

### **3.4 Plant capacity and performance enhancement study**

The Safripol Polypropylene plant has the capability to be expanded from the current 120 kt/a capacity to 140 kt/a. A detail engineering study was done with a technology supplier to determine the following:

- 1) Expansion options per area of the Polypropylene plant.
- 2) Rough cost estimate for the expansions.
- 3) Engineering study agreement with LyondellBasell.
- 4) Investigate the influence of the expansions on the license agreement with LyondellBasell and costs thereof.

A capacity run was conducted during a period where there was an excess amount of propylene available to identify throughput limitations with specific equipment and polymer grades on the plant.

This capacity run ensures that focus can be given to the following specific predetermined key areas on the plant that needs to debottleneck:

- 1) Polymerisation section
- 2) Extruder section
- 3) Packaging machines

### **3.5 Technology support study**

In the polymer industry the catalyst supplier is normally also doing the technology support for a plant. In Safripol's situation LyondellBasell is giving plant technical support and Grace Davison catalyst technology support. The following companies were listed and perused with engaging into new technology agreement contracts with Safripol:

- 1) LyondellBasell
- 2) Grace Davison

- 3) BASF
- 4) Dow Chemicals
- 5) Sud-Chemie
- 6) Mitsui

The companies were investigated regarding the type of technology support that they will be able to offer Safripol. Therefore a matrix was created showing the kind of technology support each company can offer.

Safripol needs to ensure that a new technology agreement with one of the listed companies above cover all the topics that the existing agreement with LyondellBasell has in place.

### **3.6 Scenario planning process**

A few key employees of Safripol were identified that came together with Pete Laburn as facilitator to follow the scenario planning process for the company in the polymer industry.

This process is fitting in perfectly with this research problem of repositioning Safripol in the South African polymer industry. Following is the process that Safripol followed with Pete Laburn for the scenario planning:

#### **3.6.1 Key drivers listing**

Key driving forces that are fundamentally shaping the industry in the future were identified by the Safripol team.

#### **3.6.2 Listing rules of the game**

Once the driving forces were listed the Safripol team differentiated them into those that were certain and they are therefore called rules of the game. The rules of the game were rated according to their impact and probability.



### **3.6.3 Listing uncertainties**

Uncertainties are those driving forces where there is no certainty or it is just too unclear to make any judgment. Uncertainties were listed by the Safripol team and they are called key uncertainties. Their potential impact and risk uncertainty was also plotted.

The uncertainties that were used in developing scenarios for Safripol are the two with both high probability and high impact should they materialise.

The possible scenarios are then based on the different possibilities from each of the two critical uncertainties in the industry.

### **3.6.4 SWOT analysis**

A SWOT analysis was developed according to an analysis performed on Safripol. Firstly threats and opportunities of Safripol in the current polymer industry were identified and then the organisations weaknesses and strengths.

### **3.6.5 Suggested recommendations for Safripol**

Once the SWOT analysis was completed future scenarios were listed with recommended suggestions to be investigated further.

Recommendations were made regarding focus areas of Safripol to be concentrated on. The results and analysis thereof forms the basis for the recommendations.

## Chapter 4

### 4. Research findings

#### 4.1 Interviews

Presented below are the findings from the interview and written communication sessions conducted with some key players used for this research.

i) *Peter Raine – Independent researcher.*

According to the above;

Safripol made contact through Peter Raine with key representatives of various suppliers of propylene for the following reasons:

- 1) Identify potential suppliers of propylene.
- 2) Propylene availability. Safripol's PP plant has an availability of 95%.
- 3) Propylene quality.
- 4) Propylene quantity.
- 5) Feed options of propylene to Safripol.

Each propylene supplier was investigated in detail by Peter Raine and below is a summary of each of the possible supplier's regarding the following:

- 1) Volume potential.
- 2) Capex and type required.
- 3) Supplier's alternative value propositions.
- 4) Clean fuels and biofuels impacts are also reflected.

### **4.1.1 PetroSA**

A hydrocarbon stream of predominantly olefin material of 85% composition is separated with butane being driven by demand to either LPG or transportation fuel. In the latter instance it is routed to the COD (conversion of olefins to distillate) unit.

A rich propylene and propane stream is routed to both the COD and LAD (low aromatic distillate unit). The total amount of propylene and propane available is 150 KT/a with the split being roughly 50% to the COD and 50% to the LAD units.

With 85% olefin content the total amount of propylene potentially available is 127 KT/a but half is already committed to the LAD unit.

There are currently two projects at the pre-feasibility stage with all process engineering work having been completed:

- 1) Expansion of the LAD to absorb the full 150 KT/a propylene that is currently available.
- 2) Utilising the propylene and propane currently consigned to the COD unit in order to produce chemical grade propylene.

Polymer grade propylene purity is 99.2% (*Basell, 2010*) and PetroSA has used the same purity of 99.8% in a 1997 study on propylene production.

### **4.1.2 Engen**

Engen has the potential to supply between 23 and 29 KT/a of propylene subject to three key provisos:

- 1) That the despatching logistics can be easily overcome.
- 2) That capacity on the splitter at SAPREF can be found.
- 3) That SAPREF is supportive of the project.

Engen is flexible to switch between propylene and fuel service at variable rates at its refinery. This is however subject to acceptable economic returns being met. Engen's alternative value for propylene is petrol or LPG and in Engen's case this is the same value.

### 4.1.3 SAPREF

SAPREF is an oil refinery situated in Durban supplying propylene to Safripol via a propylene and propane splitter on their site. The splitter is on Safripol's asset list and is operated and maintained by SAPREF personnel.

Following in table 4.1 are a few key points regarding the SAPREF splitter design data (*P.P. Splitter FWSA Contract 25145 Volume 2 Book A*):

<b>1) The PP splitter comprises:</b>
a) Feed surge drum
b) Fractionating column split into 3 due to height restrictions. Dimension of each tower; ID = 2 060 mm and Length between tangent lines = 44 500 mm
c) Reboiler
d) Overhead condensing system and drum
e) Reflux
f) Hot water system to provide heat for Reboiler
g) Bleed to fuel gas of light contaminants
h) Feed and product draw-off's
<b>2) Operating hours:</b>
a) 8000 hours/a
<b>3) The unit is designed for the following feed rates:</b>
a) Maximum: 150 tons/day
b) Normal: 100 tons/day
c) Minimum: 80 tons/day

<b>4) The feed composition:</b>
a) Propylene: 75.0 vol %
b) Propane: 24.45 vol %
<b>5) The product rate (propylene yield at 74.4% and 8 000 hrs year availability):</b>
a) Maximum: 111.6 tons/day = 37 200 tpa
b) Normal: 74.4 tons/day = 24 800 tpa
c) Minimum: 59.5 tons/day = 19 840 tpa
<b>6) The product composition is:</b>
a) Propylene: 99.5 vol%
b) Water: 10 ppm v/v

**Table 4.1: Design data for SAPREF PPS.**

*Source: Safripol*

SAPREF has no catalytic condensation or ‘cat poly’ plant at its refinery and only an alkylation unit. The management of the propylene in the propane and butane stream from the cat cracker is therefore dependent on the Safripol splitter.

The following points are critical for Sapref’s strategy regarding propylene production and supply to Safripol:

- 1) Propylene and propane production is linked with the contract to supply butane to Isegen.
- 2) The LPG shortage in RSA will always drive SAPREF to seek the maximum feed it can get.
- 3) SAPREF is not averse to processing Engen feed.
- 4) Based on a 30 – 35 KT/a maximum capacity for the splitter the ability is there to process around 10 KT/a from Engen.
- 5) Propylene volumes of 22.5 KT/a is the contractual volume that should be supplied annually by SAPREF to Safripol.

- 6) Propylene from SAPREF is currently delivered to Safripol with rail cars and logistically rail tank cars in shuttle mode offered the best transportation option from Sapref in Durban to Safripol in Sasolburg.

#### **4.1.4 NATREF – Total**

Natref is operating a propylene and propane splitter on their site which is owned by Sasol polymers. This unit supplies propylene to Safripol with a pipeline.

The following points highlight the flow diagram which clearly reflects the path of Total's olefin stream from the catalytic cracker:

- 1) The propane and propylene stream is diverted to the alkylation unit as opposed to Sasol's molecules which are routed to the Sasol polymer owned splitter.
- 2) At the time of the investment from Sasol Polymers, Total was offered participation in the splitter.
- 3) The estimated volume of propylene that would be available is between 10 and 12 kt/annum.

#### **4.1.5 NATREF – Sasol**

The volumetric information relative to Natref's propylene production indicates that approximately 20 – 30 kt/annum of propylene is available.

#### **4.1.6 CHEVRON (Caltex)**

Chevron's Cape Town refinery operates two cat poly units and no alkylation unit and therefore there is in consequence no splitting of propane and propylene. Cat poly output is directed to LPG and petrol.

If propylene production was to contemplate separation of propylene and propylene, it would be necessitated first followed by olefin and saturates separation.

ii) *Geoff Gaywood – COO Safripol.*

According to the above;

- 1) The initiative regarding Engen supplying Safripol with propylene via the SAPREF PPS is still viable. The capacity of the SAPREF PPS needs to be verified.
- 2) Resolution of conflict between Sasol and Safripol with the monomer supply contract at this stage is priority before any further investigations can be done.
- 3) Therefore any initiatives regarding propylene and ethylene availability with Sasol will be on hold.
- 4) Ethylene from Ethanol project was thoroughly investigated by a delegation from Safripol and it was found not to be economically feasible.
- 5) PetroSA future regarding feedstock availability prevents them from going into a contractual agreement regarding propylene supplies.

## **4.2 Market survey: Monomer availability**

The simulation test run conducted by SAPREF was done according to the following studies:

- 1) Capacity study
- 2) Varying propylene purity study

### **4.2.1 Capacity study**

Safripol performed a capacity trial with SAPREF in order to verify the capacity of the SAPREF PPS plant. According to the design data the design rates of the SAPREF PPS are shown in table 4.1 below:

	<b>Tons/day</b>	<b>Tons per annum</b>
Maximum	111.6 tons/day	37 200 tpa
Normal	74.4 tons/day	24 800 tpa
Minimum	59.5 tons/day	19 840 tpa

**Table 4.2: Design rates for SAPREF PPS.**

*Source: Safripol*

According to figure 4.1 below the propylene volumes received from SAPREF steadily declined from 20 KT/a in 2005 to 15 KT/a in 2008.



**Figure 4.1: SAPREF propylene supplies**

*Source: Safripol*



## 4.2.2 Varying propylene purity study

SAPREF analysed the propane and propylene content of the PPS rundown stream on a weekly basis and the following results were obtained:

- 1) Propylene: 15 % vol. This propylene rich stream will be the source of the extra propylene that will be available for the 98% propylene test run.
- 2) Propane: 75 % vol.
- 3) Balance is butane.

SAPREF has done a 98% propylene purity simulation showing that the potential capacity increase will be 10 tons/day propylene.

## 4.2.3 SAPREF propylene trial test results

The propylene trial consisted out of 280 KT propylene or eight railcars that were delivered to Safripol via rail. The target propylene purity for the trial was 98% and the railcar numbers and propylene purity is shown in table 4.2:

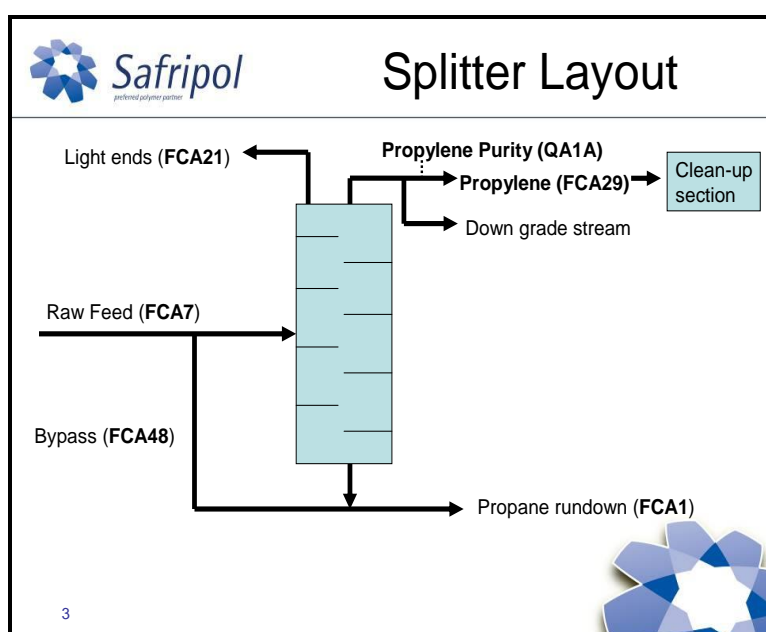
<b>Railcar number</b>	<b>Purity</b>
46015175	98.3 %
46016260	98.3 %
46016341	98.5 %
46016023	98.3 %
46016244	97.8 %
46016600	98.6 %

**Table 4.3: Table of railcar propylene purity.**

*Source: Safripol*

A schematic drawing of the SAPREF PPS with all the relevant inlet and outlet streams of the unit is shown in figure 4.2. Propylene and propane enters the splitter at the raw feed stream with a propane rich stream leaving the bottom of the splitter. This stream is fed to the liquid petroleum gas storage vessel supplying the local market of LPG.

Propylene product supplied to Safripol exits the top of the splitter and is fed through a cleanup section, removing sulphur compounds and scrubbing the propylene from impurities. This propylene stream's purity was adjusted for the 98% propylene trial.

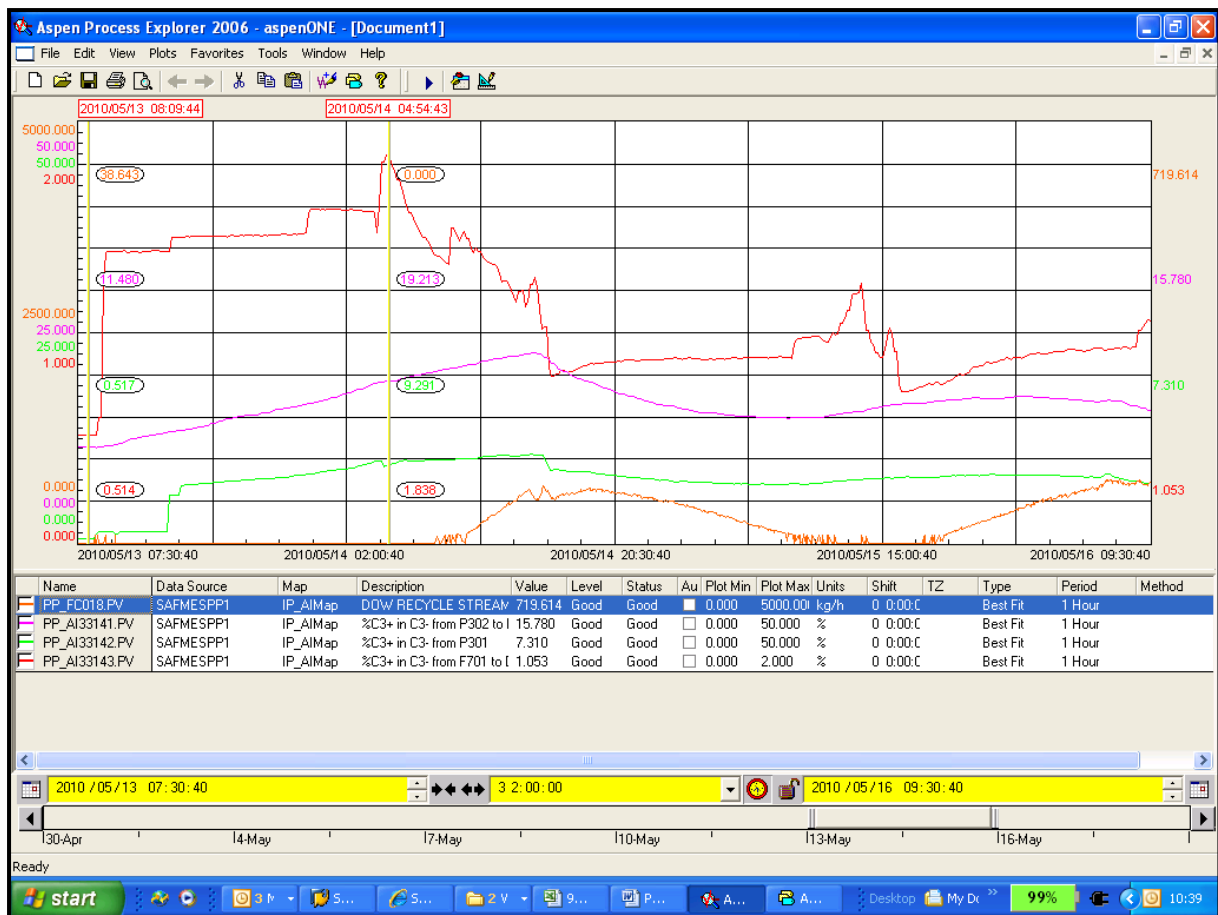


**Figure 4.2: SAPREF splitter**

*Source: Safripol*

During the trial period only SAPREF propylene was fed to the plant and the propylene supply stream from Sasol was cut back completely.

The propane concentration steadily increased in the plant during the trial, reaching a maximum of 22.5 %. At the same time the feed to the plant from the propylene storage vessels reached a maximum concentration of 10.5% propane. The purple line in figure 4.3 indicates the increase of propane in the plant to 22.5% over a 20 hour period.



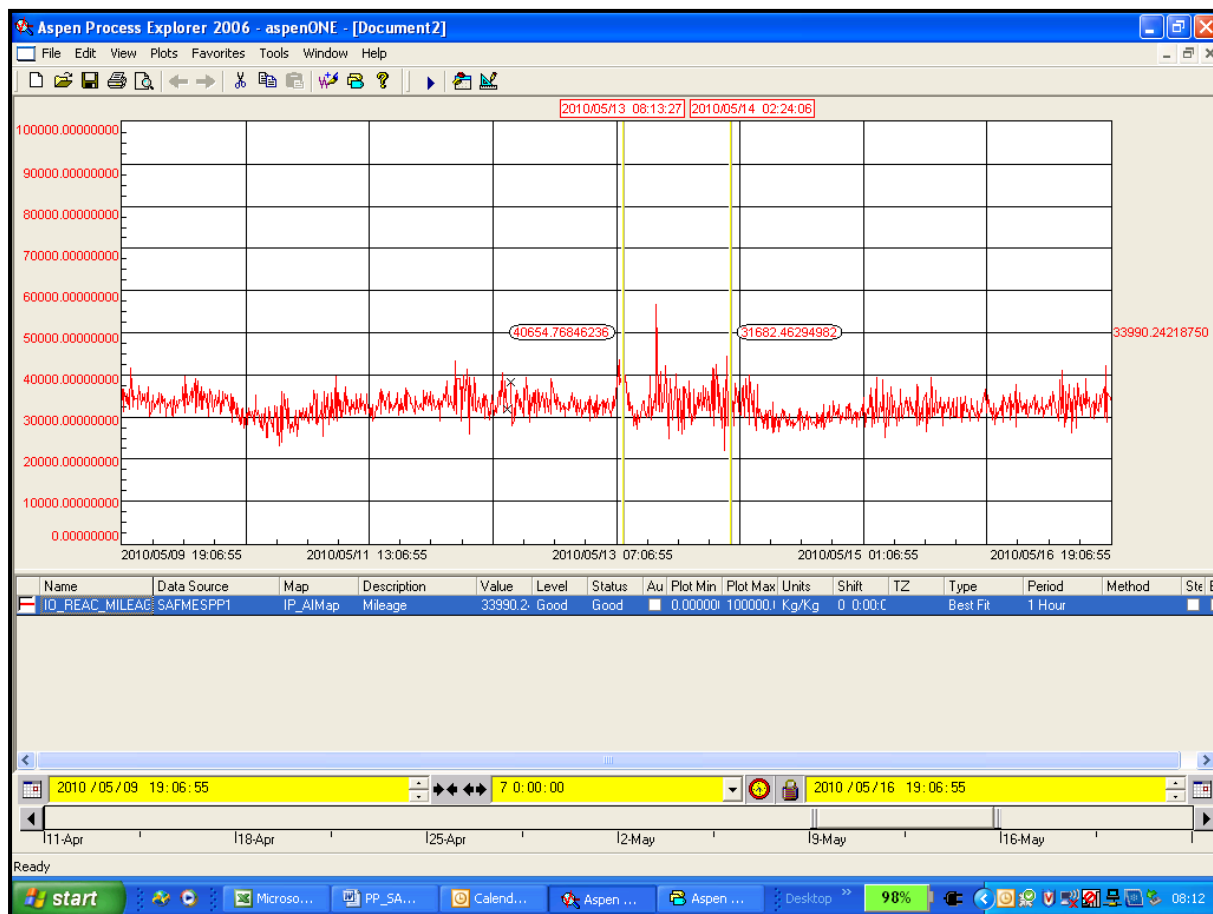
**Figure 4.3: Trend of propane and propylene purity in plant**

Source: Safripol

Catalyst mileage was not negatively affected by the higher propane concentration in the plant. The original design of the plant is 20.5% propane concentration. Propane is acting as an inert in the polymerisation process and therefore not polymerising nor is reaction with the catalyst taking place.

When the propane concentration increases in the plant the result is that the catalyst mileage decreases because the catalyst is not reacting with the propane.

The red line in figure 4.4 shows that at 22.5% propane concentration in the plant, the catalyst mileage is not negatively affected.



**Figure 4.4: Trend of Catalyst Mileage over 7 days trial period**

Source: Safripol

The 98% propylene purity trial was completed according to plan and the results were according to expectations. No interference or incidents occurred as a result of the trial and therefore it can be concluded that the trial was a success.

## **4.3 Plant capacity and performance enhancement study.**

### **4.3.1 Background**

The PP train performed a capacity trial during a period of four weeks where there was excess monomer available from Sasol due to their Polypropylene-2 plant in Secunda that was down.

The Polypropylene plant manages to perform the trial with almost the entire product mix. However the following grades could not be covered with this trial due to the production schedule not allowing it:

- 1) R100P
- 2) H506P

### **4.3.2 MAC definition**

Maximum Asset Capability:

- 1) 100% of time running at maximum rate and 100% converted to prime product for any 30 day period.
- 2) The PP plant MAC (maximum asset capability) is currently at 349.3 mt/day.

### **4.3.3 Method of conducting trial**

- 1) Plant throughput was increased to maximum in order to highlight limitations.
- 2) All parameters were recorded with the Aspen process explorer IP-21 and Asset Utilisation Data Base (AUIDB).
- 3) Product trials conducted during the trial were included in the results.
- 4) Powder inventory was kept at a maximum level of 132 MT in the intermediate powder silos. Once this level is exceeded the polymerisation plant will cut throughput.

#### 4.3.4 Summary of trial results

The Polypropylene plant MAC was increased from 349.3 MT/day to 364MT/day or 15.2MT/hr with the entire product mix.

##### 4.3.4.1 Production figures:

Best week:	2614 MT
4 Weeks total:	10 0069 MT

##### 4.3.4.2 Highest throughput per day

Area	Grade	MT/day	MT/hr
Granulation	C770-70RNA	421	17.5
Polymerisation	C722P	427	17.8

#### 4.3.5 Main throughput limitations per area

A list was created showing the throughput limitations per area:

1) Polymerisation section:

- a) Reactor cooling system

2) Granulation section:

- a) Extruder capacity with low MFR grades resulted in high main drive torque.
- b) Maximum cutter speed was observed with certain grades.
- c) Could almost match the polypropylene rates but no catch-up capacity for any planned or unplanned events.

3) Packaging section:

- a) Could match the granulation rates but no catch-up capacity for any planned or unplanned events.

Table 4.3 gives a summary of the grades produced during the capacity run period with the throughput limitations per grade and area of the plant.

Grade	MT/hr	MT/day	Throughput Limitations	
			Polymerization	Granulation
H510P	15.13	363.07	1. Extruder capacity: Building powder level in Silo's 2. R-201 cooling capacity	Line 3 and 9 main drive torque near tripping limit
H106P	15.13	363.07	1. Extruder capacity: Building powder level in Silo's 2. R-201 cooling capacity	Line 3 and 9 main drive torque near tripping limit
H511P	15.46	371.07	1. Extruder capacity: Building powder level in Silo's 2. R-201 cooling capacity	Line 3 and 9 started to experience cut issues. Cutter speed maximum upper control limit reached
H326P	15.46	371.07	1. Extruder capacity: Building powder level in Silo's 2. R-201 cooling capacity	Line 3 and 9 started to experience cut issues. Cutter speed maximum upper control limit reached
H713P	15.44	370.49	1. R-201 cooling capacity	Could match poly rates but no catch-up capacity for any unplanned incident/event
R701P	14.16	339.78	1. R-201 cooling capacity 2. R-202 outlet valve > 80% open 3. Loop reactors densities cycling	Could match poly rates but no catch-up capacity for any unplanned incident/event
H504P	15.44	370.49	1. R-201 cooling capacity	Could match poly rates but no catch-up capacity for any unplanned incident/event
C142P	14.63	351.14	Transition batch between Homo and Copo. Only 132 MT produced	Could match poly rates but no catch-up capacity for any unplanned incident/event
C765P	15.35	368.34	1. R-201 cooling capacity 2. R-202 outlet valve > 80% open	Could match poly rates but no catch-up capacity for any unplanned incident/event
C740P	13.40	321.58	1. Conveying system high pressure 2. Copo reactor high pressure and level 3. Copo reactor cooling limitation	Could match poly rates but no catch-up capacity for any unplanned incident/event
C770P	15.92	382.18	1. R-201 cooling capacity 2. R-202 outlet valve > 80% open	Could match poly rates but no catch-up capacity for any unplanned incident/event
C722P	16.33	391.84	1. R-201 cooling capacity 2. R-202 outlet valve > 80% open	Could match poly rates but no catch-up capacity for any unplanned incident/event
<b>Average</b>	<b>15.2</b>	<b>364</b>		

**Table 4.4: Throughput limitations per area**

Source: Safripol

## **4.4 Technology support study**

All the potential companies that can be engaged into a technology agreement contract with Safripol were researched and listed.

Research into companies that will be able to supply into Safripol's needs regarding technology support revealed the following results.

### **4.4.1 LyondellBasell**

LyondellBasell will be able to satisfy all Safripol's needs according to the support required table. LyondellBasell currently has more than 100 licensed plants across the globe using the same Spheripol technology as the Safripol polypropylene plant.

LyondellBasell releases, on a yearly basis, a Spheripol stream factor survey including the following aspects to all the plants:

- 1) Safety improvements.
- 2) Environmental improvements.
- 3) Plant specific improvements.
- 4) Process improvements.
- 5) Product developments.
- 6) Benchmarking survey.

The benchmarking survey involves all the licensed Spheripol technology plants according to the following criteria:

- 1) Plant asset availability; plant stops.
- 2) Plant mechanical reliability.
- 3) Quality performance.
- 4) Amount of grade changes.



#### **4.4.2 Grace Davison**

Grace Davison currently supplies Safripol with a Ziegler Natta catalyst for the polymerisation process.

Grace Davison has no licensed Spheripol plants and is only a catalyst supplier. The company however operates a few Spheripol plants licensed to LyondellBasell.

#### **4.4.3 BASF**

The company has basically the same portfolio as Grace Davison and will also be able to supply in most of the needs of the Safripol Polypropylene plant.

#### **4.4.4 The Dow Chemical Company**

As discussed in the literature review chapter Safripol used to be part of the Dow Chemical Company and received all the required support via Dow. The company still has two other licensed Spheripol plants and therefore the support is still there and available.

#### **4.4.5 Sud-Chemie**

Sud-Chemie is only a Ziegler Natta catalyst supplier and will therefore be limited to catalyst support.

#### **4.4.6 Mitsui**

Same principle of support as Sud-Chemie will be received from Mitsui due to the fact that the company is also limited to a catalyst supplier.

Table 4.4 is listing the potential companies that can be engaged into a technology agreement contract with Safripol with the criteria they are complying to.

<b>Company</b>	<b>Product development</b>	<b>Safety support</b>	<b>Plant support</b>	<b>Technology support</b>	<b>Catalyst support</b>	<b>Quality support</b>	<b>Benchmarking</b>
LyondellBasell	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grace Davison	Yes	No	Yes	Yes	Yes	Yes	Yes
BASF	Yes	No	Yes	Yes	Yes	Yes	Yes
Dow Chemicals	Yes	Yes	Yes	Yes	No	Yes	Yes
Sud-Chemie	No	No	No	No	Yes	No	No
Mitsui	No	No	No	No	Yes	No	No

**Table 4.5: Technology partners**

The next step will be to rate the above companies according to the best option that can be offered to Safripol.

## **4.5 Scenario planning process**

A few key employees of Safripol came together with Pete Laburn as facilitator to follow the scenario planning process for Safripol in the polymer industry. This process is fitting in perfectly with this research problem of repositioning Safripol in the South African polymer industry. Following is the process that Safripol followed for the scenario planning:

### **4.5.1 Key drivers listing**

Key driving forces that are fundamentally shaping the industry in the future were identified by the Safripol team. Below is the list with the key driving forces randomly identified:

- 1) Feedstock, propylene and ethylene sourcing and pricing.

- a) The Middle East that is in turmoil will have a negative influence on the main raw materials pricing supplied to Safripol.
  - b) Oil supply is also questionable due to the unrest in the Middle East. This is causing oil prices to be volatile.
- 2) Utilities (Energy and water).
- a) Supply of utilities in South Africa is under pressure, especially electricity supply. The electricity load shedding schedule enforced by Eskom in 2009 had a negative influence on Safripol's operation.
  - b) South Africa's questionable fresh water supply and quality is constantly being analysed and published in newspapers.
- 3) The removal of duty on finished polymer goods imports may cause threat of cheap imports from China and India.
- 4) China and India's investment into specific industry sectors; i.e. the automotive industry in Africa, is trend setting and needs to be aware of. Polymers are an integral part of the automotive industry.
- 5) Shift of economic dominance from West to East is changing the way that the world is doing business.
- 6) Infrastructure development in the SADC region will be concentrated in areas where there is economic growth like Maputo and Luanda.
- 7) Environmental legislation is changing regularly in respect to the following:
- a) Biotechnology and biofuels
  - b) Recycling of plastics
  - c) Plastics consumption

- 8) Population growth in Southern Africa is changing the population profile of the region and focus needs to be shifted to:
  - a) SADC challenge and potential in managing the population growth.
  - b) Growth of middle class and utilisation thereof.
  
- 9) World of work changes influencing the working environment regarding the following burning issues:
  - a) Shortage of talent and skills, especially in technical fields.
  - b) Ageing skills and workforce of companies.
  
- 10) Global political instability concentrated in the following regions:
  - a) Oil producing countries and especially in the Middle East.
  - b) World markets that are showing slow economic recovery.
  - c) SADC region.

### 4.5.2 Listing rules of the game

Once the driving forces were listed, the Safripol team differentiated them into those that were certain and they are therefore rules of the game. The rules of the game were also rated according to their impact and probability. Below in figure 4.5 is an outline of the rating:

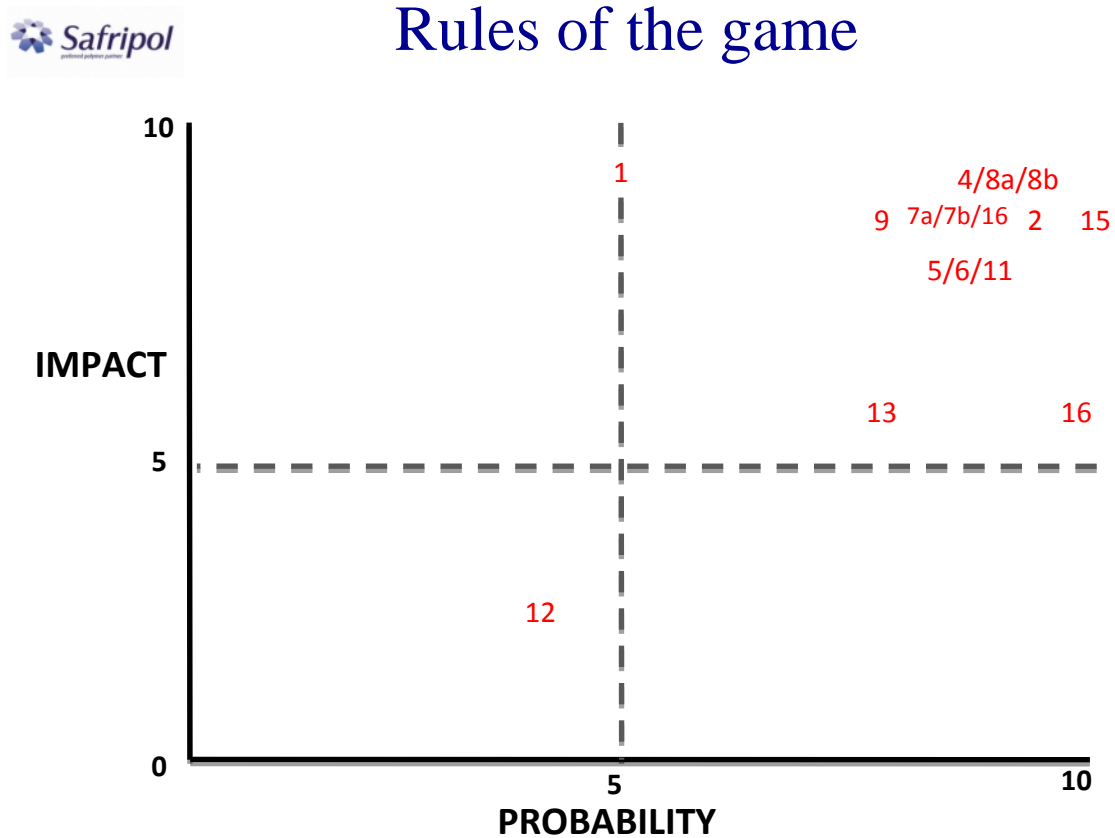


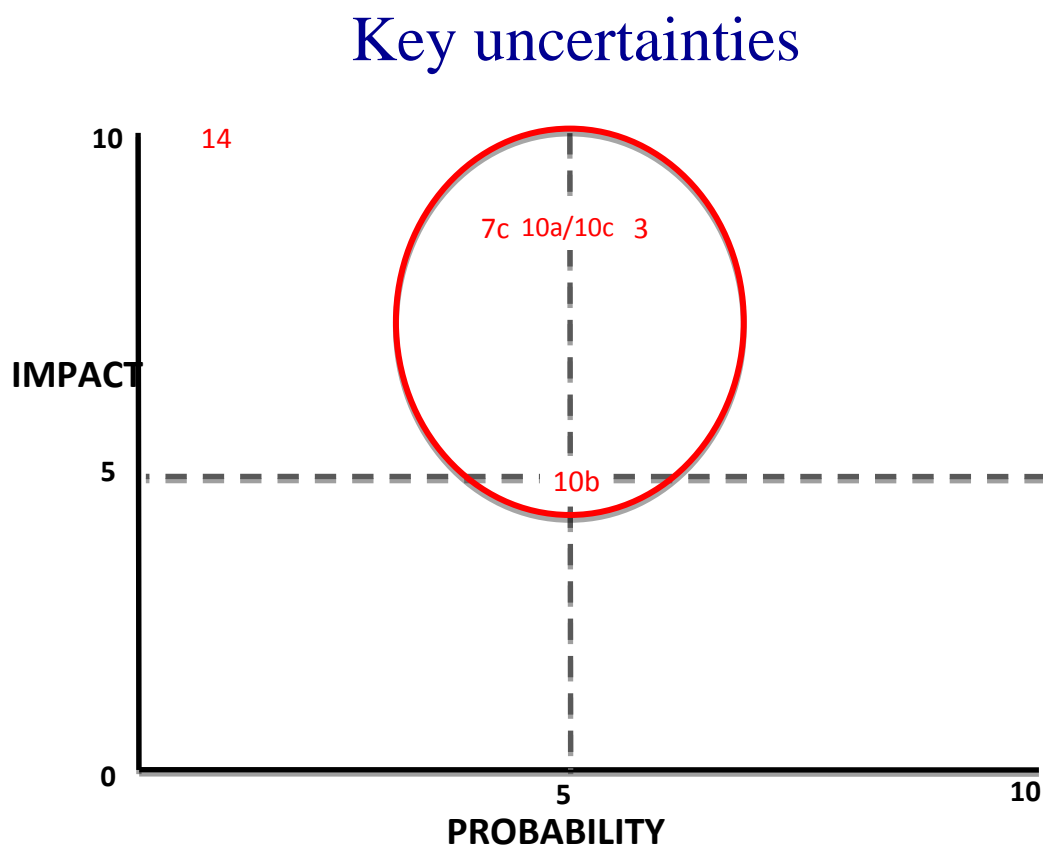
Figure 4.5: Rules of the game

Source: Safripol

### 4.5.3 Listing uncertainties

Driving forces where there is no certainty or it is just too unclear to make any judgment were listed by the Safripol team and they are called key uncertainties. Their potential impact and risk uncertainty were also plotted.

Below in figure 4.6 is an outline of the key uncertainties rating with the Y-axis showing the impact of the uncertainty and the X-axis the probability:



**Figure 4.6: Key uncertainties**

*Source: Safripol*

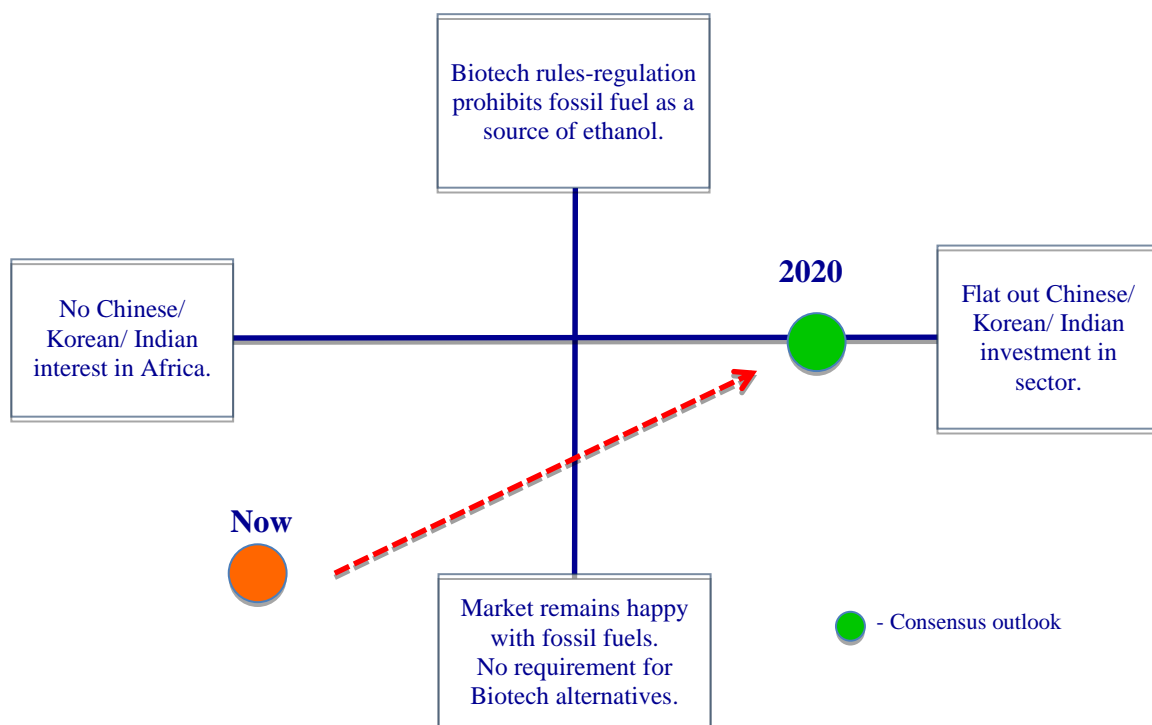
The uncertainties that will be used in developing scenarios for Safripol are the two with both high probability and high impact should they materialise.

The possible scenarios are now based on the different possibilities from each of the two critical uncertainties in the industry:

- 1) Biotech rules-regulation prohibits fossil fuel as a source of ethanol.
- 2) Market remains happy with fossil fuels. No requirement for Biotech alternatives.
- 3) No Chinese, Korean or Indian interest in Africa.
- 4) Chinese, Korean and Indian investment in industry sector.

Figure 4.7 indicates the vision for Safripol for the year 2020 according to the possible scenarios that were listed above:

## Where we see ourselves 2020



**Figure 4.7: Vision for 2020**

Source: Safripol

#### 4.5.4 SWOT analysis

A SWOT analysis can now be developed. Below are the results from the SWOT analysis performed on Safripol:

##### 1) STRENGTHS

- a) Values and culture of the company is unique and cannot be compared with other petrochemical companies.
- b) State of the art polymer manufacturing technology that benchmark with the best in world.
- c) Size and capacity of both plants fits the South African polymer requirements and market.
- d) Experienced workforce with majority of employees having 10 years or more service with the company.
- e) Skilled workforce with representation of all engineering and artisan disciplines on site.
- f) An undeveloped piece of land next to Safripol, part of Safripol's assets, is big enough for a new plant. This piece of land is currently not utilised and used for a small game reserve.
- g) Multiple suppliers of additives across South Africa and the rest of the world. Safripol is therefore almost 100% secure of additives supplies.
- h) Existing market share of Safripol in South Africa whereby high-density has 70% and polypropylene 40% of the local market.
- i) Best employer, talent recruitment. Safripol was awarded the Best Employer award for the third year in a row by Corporate Research Foundation's Best Employer evaluation process (*Safripol, 2010*). This prestigious award will ensure that Safripol is attracting people with talent.



## **2) WEAKNESSES**

- a) Location (feedstock). Safripol is supplied with monomers via a 141 km pipeline from Sasol situated in Secunda. Propylene is also supplied via railcars from Sapref in Durban.
- b) Technology available for the Ethylene to Ethanol project is not being utilised in Southern Africa and the process to acquire the technology can be costly.
- c) Ageing workforce with critical skills that needs to be replaced when retiring, whereby people with similar skill levels are rare.
- d) Monomer suppliers. Sasol is Safripol's only ethylene supplier and major propylene supplier.
- e) Infrastructure of the site, i.e. electricity is limited to the polypropylene and high-density plants.
- f) Capital is limited due to world economy slow recovery.
- g) No technical or technology partner fulfilling in all the technical requirements of the two plants.
- h) The high-density plant is almost 40 years old and in global terms the plant needs to be replaced with newer technologies.
- i) Utility availability is limited due to the design of the steam, nitrogen, air, water and electricity to the site.
- j) Loss of polypropylene market share via imports.
- k) No agricultural partner lined up if Safripol plans to go the route of ethylene from ethanol.
- l) Lack of government contacts regarding the ethylene from ethanol route.

## **3) THREATS**

- a) Lack of feedstock. Propylene and ethylene supplies to Safripol are limited and there is no forecast for immediate growth.
- b) Increase in raw materials, utilities and labour costs that are well above inflation targets for South Africa.
- c) Natural disasters threatening sugar and maize crops as a potential supply for ethylene from ethanol.

- d) Alternative packaging like glass and paper is taking market share away from the polymer market.
- e) Skills and talent shortage is threatening to stop or decrease economic growth and in Safripol's situation growth for the company.
- f) Availability of specialised equipment in South Africa. With specialised equipment failure, delivery is mainly sourced from Europe with lead time of 4 – 6 weeks resulting in plant downtime.
- g) Lack of investments from abroad in the local polymer industry.
- h) Dumping of plastics from the east below the cost of sales price of the local polymer suppliers.

#### **4) OPPORTUNITIES**

- a) Agricultural growth in Southern Africa, specially Angola and Mozambique, giving the opportunity for exploring ethanol from sugar or maize.
- b) Develop underdeveloped areas in Southern Africa. Vast underdeveloped areas in Southern Africa that has the potential to be developed and having above average crop yields.
- c) Exports of ethanol fueled by the significant growth in the global demand of green fuels.
- d) New technology and processes that the ethylene from ethanol process can offer Safripol.
- e) New markets that start to emerge in Southern Africa and the rest of Africa.
- f) Carbon credits to be gained by Safripol by the move to utilise ethylene from ethanol processes.
- g) Lower conversion costs of the ethylene from ethanol process as the current conventional processes.
- h) Safripol is proving by its track record that it is taking part in a sustainable industry with steady growth.
- i) New business partners that engage in the potential growing opportunity of Safripol's involvement regarding ethylene from ethanol.

#### 4.5.5 Suggested recommendations for Safripol

Once the SWOT analysis was completed, future scenarios could be listed with recommended suggestions to investigate further. The following list was compiled by the Safripol team and the points were further elaborated upon.

- 1) Existing plant upgrade program to continue as planned. Creep debottlenecking to be completed in different planned phases.
- 2) Develop scale and diversity options according to the following criteria that are outlined below:
  - a) Biofuels plan to be implemented regarding:
    - i. Market research and intelligence of biofuels globally and in Southern Africa as potential feedstock for ethylene.
    - ii. Investigate alternative product options LDPE and LLDPE when sufficient ethylene from ethanol is available.
    - iii. Investigate the opportunity of a technology partner in Brazil due to the proven technology that exists for the fuels from sugar processes.
    - iv. Investment partners in China and India mainly because of the size and growth of the two countries and therefore the opportunities that exist.
    - v. Agricultural partner (SADC wide Government support).
    - vi. Bulk supply and location of sugar ensuring that enough feedstock is available for the production of ethanol on a continuous basis.
    - vii. Distribution partner for imported polymers creating new market potential due to the polymer expertise of Safripol.
  - b) New fossil fuel expansion plan in SADC:
    - i. Identify technology partners for polypropylene or polyethylene plants for expansion outside South Africa.
    - ii. Identify feedstock supply of monomers regarding the source of fossil fuels.

- iii. Investigate distribution partners and requirements for new fossil fuel refineries and plants.
- 
- 3) Attention and focus needs to be given to skills development of Safripol's employees. Developing employees in technical and management areas need to be addressed.
  - 4) Potential shareholders buying into the company will create more capital investments and opportunities for growth.

## **Chapter 5**

### **5. Results discussion and interpretation**

#### **5.1 Introduction**

This chapter presents the analysis, discussion and interpretation of information gathered during the research problem investigation. It further presents personal views and proposed solutions to help resolve the research problem.

#### **5.2 Analysis of interviews**

The interviews and written communication with both Peter Raine and Geoff Gaywood is discussed below:

*i) Peter Raine interview and written communication:*

Each propylene supplier will be analysed and discussed according to the research work that was done.

##### **5.2.1 PetroSA**

The fact that PetroSA has used the same purity of 99.8% in a 1997 study on propylene production indicates that the propylene quality of PetroSA is polymer grade. Therefore the PetroSA propylene purity will be according to Safripol's specification criteria.

Potentially available amount of propylene is 127 KT/a and will be more than enough for the Safripol Polypropylene plant's total propylene demand. Safripol will only be able to benefit from the project of producing chemical grade propylene.

The Safripol Polypropylene plant can run on chemical grade propylene although efficiencies will be sacrificed.

The most cost effective delivery solution from Mosselbay to Sasolburg needs to be determined quickly and accurately once the basic economic indicators are seen to be positive.

### **5.2.2 Engen**

Safripol has a propylene and propane splitter at SAPREF and this prompts the consideration of relocating the SAPREF splitter to the Engen refinery in the event that the negotiations and propylene trials at SAPREF do not deliver according to expectations or design criteria.

### **5.2.3 SAPREF**

SAPREF wants to finalise the contract for propylene supply to Safripol and is willing to participate with Engen in a mutual supply agreement.

There is also no perceived urgency on SAPREF's part to expedite the contract itself and demonstrate an enthusiasm for the proposed association with Engen.

### **5.2.4 NATREF – Total**

Safripol currently receives propylene from Natref via a pipeline and the additional 10 - 12 kt/a propylene that is currently available at Natref belongs to Total. This additional stream of propylene from Total can easily be accommodated by means of the propylene pipeline to Safripol.

Total approached Sasol to share this additional propylene with Safripol but with the complexity of the formula and other conditions Total decided against it.

Given the current standoff on Sasol's part to Total's request and also the complexity of the formula and other conditions, this volume is not likely to be realised easily.

### **5.2.5 NATREF – Sasol**

With the current price formula with Sasol, Safripol will pay a premium on extra propylene available from Sasol and the price will be at a tier 2 price formula.

The tier 2 pricing formula will come into effect when Safripol receives propylene in excess of 45 kt/a; therefore it will financially not be feasible for Safripol to increase their propylene supply from Sasol and to pay more for the additional propylene molecules.

### **5.2.6 CHEVRON (Caltex)**

If propylene production was to contemplate separation of C3's and C4's it would be necessitated first followed by olefin and saturates separation and this is not seen by Chevron as being a viable option currently. The distance factor between Cape Town and Sasolburg has also to be comprehended.

Chevron is clearly last on the list of possible propylene sources in South Africa.

ii) *Geoff Gaywood interview:*

- 1) The utilisation of the SAPREF PPS splitter by Engen will be of no advantage if the unit has no extra capacity. According to the SAPREF 98% propylene trial results SAPREF doesn't foresee any additional capacity by running at 98% propylene purity.
- 2) The Competition Commission ruling of Safripol being fined R16.5m for price-fixing with Sasol will hopefully clear the conflict between Safripol and Sasol regarding monomer pricing.
- 3) The commission further referred complaints of collusion and excessive pricing in the plastics sector against Sasol Chemical Industries and Safripol to the Competition Tribunal for adjudication (*Fin24, 2010*).

- 4) Due to the uncertainties regarding PetroSA feedstock availability and also the distance of delivery this option needs to be put on hold on the short term. The moment PetroSA feedstock contracts and availability are sorted out, Safripol can proceed with negotiations.
- 5) Ethylene from Ethanol project was completed and this project is on hold for the short to medium term basis.

### **5.3 Market survey: Monomer availability study**

The SAPREF propylene purity and capacity trial results discussion and interpretation will be done in two sections:

5.3.1 Safripol feedback

5.3.2 SAPREF feedback

#### **5.3.1 Safripol feedback**

The SAPREF 98% propylene trial was executed with low throughputs of 11.5 tons/hr on the Safripol polymerisation plant and with propane concentrations ranging from 1.38 – 1.58%. The 11.5 tons/hr is the original design throughput of the plant before it was debottlenecked.

When running higher throughputs, an increase of propane content will limit the capacity of the plant due to propane that is acting like an inert.

The polymerisation plant throughput limiting or bottlenecking areas due to higher propane concentrations were identified as the following:

- 1) Lower catalyst conversion.
- 2) Higher product fines content.
- 3) Existing propylene feed-pumps cannot handle the higher feed rates.



The trial period was too short to reach steady state, but on test (original plant design) throughput a negative influence on catalyst mileage could not be detected.

SAPREF stated in their propylene trial feedback report the increase of propane concentration in the monomer will not lead to an overall increase of monomer supply to Safripol.

It is not recommended to change to lower purity propylene as this will restrict throughput of the polymerisation plant and also have a negative effect on plant efficiencies.

However, Safripol needs to continue discussions with SAPREF to investigate the possibility of increasing the overall monomer supply.

### **5.3.2 SAPREF feedback**

The 98% propylene test run was conducted with approximately 230 tons of propylene with a weighted average of 98.2% propylene purity. The balance was made up with propane.

The typical propylene and propane recovery of 60% (mass on feed) was unchanged and no net increase in propylene and propane rundown was realised during the test run, this is consistent with the very low propylene content that is left behind in the propane; namely 2%.

If in the future the PPS separation is compromised and the propylene content in propane is consistently more than 8%, the 98% test run should be re-visited to evaluate the increased throughput on the propylene.

## **5.4 Plant capacity and performance enhancement study**

The Safripol Polypropylene plant is divided up into three sections and each one will be discussed separately:

### **5.4.1 Polymerisation**

The plant was running its production or throughput above the maximum asset capability of 349mt/day or 14.5mt/hr. It could easily run at 15.2mt/hr during the capacity trial and a number of debottlenecks were identified that needs to be addressed.

In order for the Polymerisation plant to reach the next step of 17mt/hr from 15.2mt/hr extensive capital will have to be spent in order to remove these limitations.

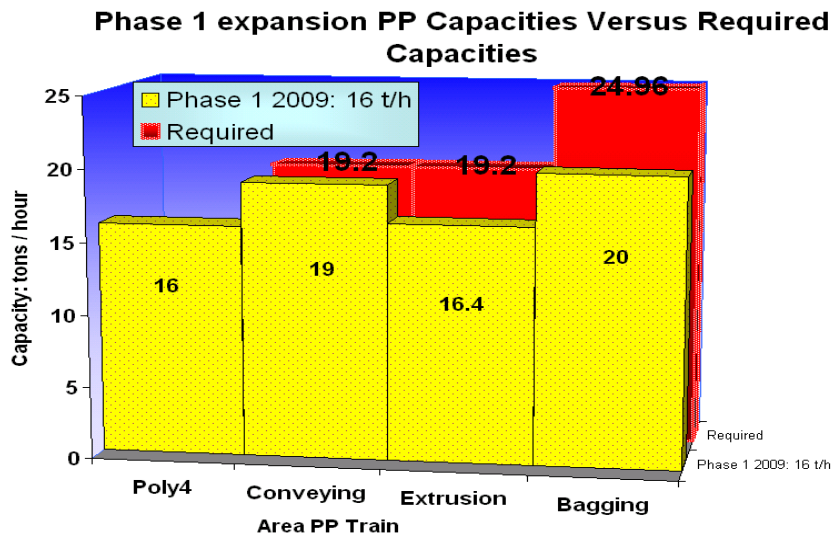
The main areas of expansion will be:

- 1) Reactor volumes
- 2) Reactor cooling systems

### **5.4.2 Granulation**

The main concern regarding the extruders is that there is no catch up capacity from the extruder area. Where the Polymerisation plant is running continuously with almost 95% availability, the extruders' availability is 90%.

Therefore the required capacity of the extruders will have to be at least 19.2mt/hr. See figure 5.1 below showing in red the required capacity of the conveying system and extruders compared to that of the Polymerisation or poly 4 plant:



**Figure 5.1: Expansion capacities versus required capacities**

Source: *Safripol*

The main limitations of the extruders were discussed in the previous chapter; paragraph 4.3.5 point 2. In order to debottleneck the extruders from the current 16mt/hr to 19.2mt/hr the business will have to request for capital for the following:

- 1) Improved extruder screw configuration to increase throughput to 19.2mt/hr.
- 2) Granule conveying system capacity increase with variable speed drives on existing rotary feeders.

### 5.4.3 Utilities

With the capacity run and also with history figures the following concerns regarding utilities were identified:

- 1) Electricity supply increase.
- 2) Locomotive for offloading of propylene railcars from SAPREF.

With the increase of plant throughputs electricity consumption increased and the maximum demand from Eskom peaked close to Safripol's maximum allowable demand of 20 MW.

With the strong possibility of future load shedding schedules and the industry requirements of 10% electricity saving, the electricity supply and usage for the site is a limiting factor regarding higher production volumes.

Higher production also means more propylene railcars to be shunted with the locomotive for offloading purposes. This locomotive should be replaced to make provision for increase in work load.

## 5.5 Technology support study

According to the research done regarding technology partners the best option to peruse will be the following:

Company	Product development	Safety support	Plant support	Technology support	Catalyst support	Quality support	Benchmarking
LyondellBasell						Yes	Yes
Grace Davison					Yes		
Dow Chemicals	Yes	Yes	Yes	Yes			

**Table 5.1: Summary of technology partners**

Therefore it is concluded that Safripol needs to engage into a contract with the above technology partners listed in Table 2 with the relevant options that they offer. The following options are available from each potential technology partner:

- 1) Safripol has a technical agreement contract in place with LyondellBasell. This contract spreads over a five year period and is due for renewal in 2011.
- 2) Grace Davison is producing Ziegler Natta catalyst for Spheripol plants and also supplying Safripol's catalyst. Therefore they do have the expertise for catalyst knowledge and support.

- 3) Dow Chemical's plant in East Germany has support regarding; product development, safety, plant and spheripol technology.

## 5.6 Scenario planning process

The key output and strategy of the scenario planning process was for Safripol to identify current and future scenarios that the business can investigate in order to grow.

Each one of the scenarios below was discussed in detail regarding the strategies to be followed by the Safripol team:

- 1) Sustainable 120-140kt/a polypropylene by securing sufficient propylene supply

Maximum utilisation of existing PP train in Sasolburg. Ensure plant is running efficiently on maximum propylene that is available from Sasol and SAPREF.

- 2) Better pricing model for monomers from Sasol

New pricing formula must be implemented before end 2010. This is also part of the Competition commission ruling of an interim price structure and formula between Sasol and Safripol.

- 3) Enter the *Goods for Resale* arena using Safripol's established customer and support structure.

Secure partnership with foreign polymer producers and act as a supply source of their products in Southern Africa. This product mix may include polymers not in Safripol's current portfolio. This strategy will also be in line with company vision of becoming Southern Africa's preferred polymer partner.

This action can be in collaboration with existing players such as Plastomark or Protea chemicals and can also include imports of bulk granules or powder for local processing or rebagging.

The following alternative types of polymers can be investigated to fit into Safripol's product range

- I. Low density polyethylene (LDPE) and linear low density polyethylene (LLDPE).
- II. Polystyrene, PET, etc.

4) Secure access to ethylene supply from new EPU5 ethylene facility at Sasol, and other opportunities

Safripol needs to engage in the process of investigating the sourcing of additional ethylene from EPU5.

5) Composition of product range

Product wheel can be changed to use ethylene and propylene for more profitable grades and imported products can then be used to substitute some manufactured grades.

6) Reporting and Information exchange optimisation – Alternatives for Electronic recording process

New Electronic reporting process (ERP) system to be investigated. Reason is that Microsoft Dynamic has running costs of R450 000 compared to SAP's running costs of R 3 million pa.

7) Establish Operational Excellence Centre

Safripol has a unique set of work processes and tools that can be formalised and selectively shared with the rest of the industry.

8) Update Six Sigma methodologies with current global trends

In the six sigma methodology LEAN and TRIZ principles from the Japanese manufacturing industry can be included. Recommitment from management to the methodologies needs to be shown.

9) Employee exchange program

Establish an employee exchange program with partners such as Qenos and Basell to increase the expertise, knowledge and experience of employees.

10) Enter specialised downstream industry

Safripol can enter the converter industry like pipe manufacturing selectively in order to grow market share and to ensure monomer consumption increase.

11) Migrate packaging to bulk containers

The timing of this incentive is of the essence due to the long time period needed to implement bulk container facilities at customers. The reason for this approach is to show Safripol's commitment to its customers and the fact that the existing packaging machines are reaching the end of their life.

12) Investigate the sale of polymer powder instead of granules

This will save costs because Safripol will not need to granulate the powder and to add additives. The customers will be responsible for this.

13) E-commerce or E-collaboration with suppliers and customers

Investigate trends and opportunities ensuring customer relationships are improved by utilising the internet and Safripol's intranet more effectively.

#### 14) Enter the monomer production arena

More control over performance of monomer units regarding quality and availability will be guaranteed by producing Safripol's own feedstock.

#### 15) Establish facilities at new locations where monomer may become available: Coega, Angola, Mozambique.

Keep in contact with all new developments in the Southern African environment to ensure that Safripol is updated with potential availability of monomers.

#### 16) Ethylene from Ethanol – part of grid

If Safripol has an Ethylene to Ethanol plant on site, ethylene can be supplied to and source from an ethylene grid depending on supply or demand balances. This strategy can be applied similar to the electricity grid principle.

#### 17) Ethanol production – On site and regional

Ethanol can be produced on Safripol's site from refined sugar by using local partnerships with Chemcity as basis. Sugar refineries need to be allocated close to the sugar cane fields with sugar being transported to Safripol.

## **5.7 Failure mode and effect analysis**

In order to give structure to the research objectives a failure mode and effect analysis (FMEA) was done on each research objective. The purpose of the FMEA is to prioritise the objectives and to give possible solutions for the most feasible options.

The FMEA table is also a strategic framework to determine the business support functions that will have the maximum impact on the company when they do fail. It provides a documented summary of the scenario planning team's thoughts regarding risk to the company if any of the key process inputs to the process fails.



The key process inputs were listed during a brain storming exercise and these inputs were rated according to a scale from 1 – 10, 10 having a high impact and 1 a low impact:

1) Severity

On a scale from 1 - 10 it shows the severity of the situation when the input fails.

2) Occurrence

On a scale from 1 - 10 determine how often the cause of the failure occurs.

3) Detection

On a scale from 1 - 10 determine how effective the current controls can detect the cause of the failure.

4) Risk priority number (RPN)

Multiply the severity, occurrence, and detection ratings together to calculate a RPN. The higher the RPN the higher the risk. The highest RPN inputs will therefore take priority when actions or solutions are to be taken.

Recommendations will be done regarding the possible solutions in the next chapter. Below in table 5.2 is the FMEA that was done with only the highest rated items listed:

**Failure Modes and Effects Analysis  
(FMEA)**

Title:	Strategic repositioning of Safripol in the South African polymer industry	Prepared by: WA du Plessis	Page 1 of 1
Responsible:	WA du Plessis	28 September 2010	

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	DET	RPN	Actions Recommended	Resp.
What is the input?	What can go wrong with the input?	What is the effect on the outputs?	How severe is the effect?	What are the causes?	How often does the cause make the failure mode occur?	How well can you detect cause?		What are the actions for reducing the occurrence of the cause, or improving detection?	Who's Responsible for the recommended action?
<b>3. Maintain raw material supply, at competitive prices (main raw materials)</b>	Decrease in propylene availability	Decreased efficiency	10	Under utilisation of monomer suppliers	9	8	720	Perform monomer capacity trials	PP Product director
	Increase of monomer prices	Decreased EBITDA	10	Sasol monomer pricing formula	10	7	700	Collaboration with competition commission	CEO

<b>1. Return on Capital (R300m EBITDA) &amp; maintain cash flow</b>	Losing market share	Decreased EBITDA	10	Sasol and importers gaining market share	7	5	350	Debottlenecking of PP Plant	PP Product director
<b>4. Maintain superior customer service levels</b>	Losing technology partners	Decreased efficiency	7	Change in business model of technology partners	7	7	343	Negotiate technology agreements	PP Product director
<b>8. Maintain and develop skills levels and leadership qualities</b>	Losing skills and competencies	Skills shortage on site	7	Skills shortage in South Africa	5	7	245	Employee exchange program	HR Director
<b>7. Environment (Carbon Footprint)</b>	Losing carbon credits	Decreased environmental image	4	Increased international awareness and regulation	7	7	196	Ethanol from Ethylene project	COO
<b>5. Maintain safe working environment and safety levels</b>	Losing plant's safety integrity	Environmental and safety incidents	10	Losing links with technology partners regarding safety	2	7	140	Technical agreement with technology partners	PP Product director
<b>2. Maintain product quality to competitive standards</b>	Product quality not according to customer requirements	Losing customers	7	No product development support	3	5	105	Technical agreement with technology partners	PP Product director
<b>6. Growth objectives (organic, acquisition etc)</b>	Failure to expand monomer supply	Losing market share	7	Limited production capacity	2	6	84	Enter specialised downstream industry	COO

**Table 5.2: Failure mode and effect analysis (FMEA).**

## 5.8 FMEA results discussion

The process that was followed by executing the FMEA was to list the risks and calculated what business support function will be impacted the most.

According to the rating of the FMEA that was done, the following areas were identified with the highest RPN and will be focused on when recommendations are given in the next chapter.

- 1) Additional propylene supply.
- 2) Increasing the Polypropylene plant capacity.
- 3) Technology partners.
- 4) Scenario planning process.

## Chapter 6

### 6. Conclusions and recommendations

#### 6.1 Conclusions

Safripol's Polypropylene plant is unique in the sense that it is the only stand alone Spheripol plant in the world. The company is not part or integrated into a bigger petrochemical site and therefore Safripol doesn't have the subsequent support systems associated with such a configuration.

Contributing further to the uniqueness is that the plant is not able to benchmark to other plants due to the fact that those plants belong to a petrochemical holding company. These plants are situated in large industrial sites with vastly different support structures regarding utilities, monomer etc.

With the disinvestment by Dow Chemical's the scenario regarding Safripol just got more complicated and it needed to be addressed by means of well defined research objectives.

The main purpose of this research document was to address the research objectives that were mentioned in chapter one as listed below:

- 1) Determine how the business support functions identified in the research problem contributes to the business success as a whole.
- 2) Identify and rank possible solutions to resolve Safripol's predicament.
- 3) Devise and recommend the implementation of viable solutions.
- 4) Provide a summary of the approach that was followed to resolve the management challenges following divestment by a strategic stakeholder.

Each objective will be discussed below by means of a short discussion and conclusion regarding the process that was followed.

### 6.1.1 Determine how the business support functions identified in the research problem contributes to the business success as a whole.

The business functions that were mentioned in chapter one is all important to Safripol's success and therefore the approach was to ensure that all of the business functions were covered.

The table below is a summary of the business functions and the study or possible processes that will cover each function:

<b>Business Function</b>	<b>Study or process</b>
1. Monomer supply contract negotiation and leveraging	<ul style="list-style-type: none"> <li>• Market survey: Monomer availability study</li> <li>• Scenario planning process</li> </ul>
2. Technology partner	<ul style="list-style-type: none"> <li>• Technology support study</li> </ul>
3. Technology support	<ul style="list-style-type: none"> <li>• Technology support study</li> </ul>
4. Technology centre support	<ul style="list-style-type: none"> <li>• Technology support study</li> </ul>
5. Product development	<ul style="list-style-type: none"> <li>• Technology support study</li> <li>• Scenario planning process</li> </ul>
6. Proven most effective technology	<ul style="list-style-type: none"> <li>• Technology support study</li> <li>• Plant capacity and performance enhancement study</li> </ul>
7. International codes and standards.	<ul style="list-style-type: none"> <li>• Technology support study</li> <li>• Scenario planning process</li> </ul>
8. Work processes	<ul style="list-style-type: none"> <li>• Technology support study</li> <li>• Scenario planning process</li> </ul>
9. Human relations support	<ul style="list-style-type: none"> <li>• Scenario planning process</li> </ul>
10. Networking	<ul style="list-style-type: none"> <li>• Technology support study</li> <li>• Scenario planning process</li> <li>• Market survey: Monomer availability study</li> </ul>

**Table 6.1: Business function versus associated study or processes.**

It can be concluded by the above table that all the business functions that are critical for Safripol's success, and that the company has lost with the disinvestment of Dow Chemicals, were covered and included in the specific mentioned studies or processes.

### **6.1.2 Identify and rank possible solutions to resolve Safripol's predicament.**

A failure mode and effect analysis (FMEA) was done to help determine the business support functions that will have the highest impact on the company when failed. Below are the main focus areas with their solutions:

- 1) Additional propylene supply:
  - a. Perform monomer capacity trials.
  - b. Collaboration with competition commission.
  
- 2) Increasing the Polypropylene plant capacity:
  - a. Debottlenecking of PP Plant.
  - b. Running PP plant at maximum availability.
  
- 3) Technology partners:
  - a. Negotiate technology agreements with potential technology partners.
  
- 4) Scenario planning process:
  - a. Summary of various best practises mentioned with the scenario planning process.
    - i. Employee exchange program.
    - ii. Ethanol from Ethylene program.
    - iii. Enter specialised downstream industry.

The FMEA that was completed confirmed that the research that was done was accurate and to the point with feasible solutions which Safripol can successfully implement.

### 6.1.3 Devise and recommend the implementation of viable solutions

The suggested solutions or actions were ranked according to their risk if there is a failure of one of the critical business function or processes. Table 6.2 shows the applicable actions with their respective owners:

What are the actions?	Who is Responsible for the recommended action?
Perform monomer capacity trials	PP Product director
Collaboration with competition commission	CEO
Debottlenecking of PP Plant	PP Product director
Negotiate technology agreements	PP Product director
Employee exchange program	HR Director
Ethanol from Ethylene project	COO
Technical agreement with technology partners	PP Product director
Enter specialised downstream industry	COO

**Table 6.2: FMEA actions and action owners**

The summary above is of all the viable solutions and is ranked from highest priority downwards with an action owner for each of the solutions.



#### **6.1.4 Provide a summary of the approach that was followed to resolve the management challenges following divestment by a strategic stakeholder.**

The approaches that will be discussed were followed with the disinvestment of Dow Chemicals. This process can be utilised and applied successfully with similar scenarios in the petrochemical industry regarding disinvestments.

The approach should be to firstly identify the critical business functions or processes that the company lost due to disinvestment.

Research the company's global and local history and determine its position in the market, thereby gaining a better view of the divestment scenario.

Both internal and external forces that have an influence on the business should be identified and these need to be researched further. Following are the approaches that were followed with a short description of each.

##### 1) Interviews.

Interviews with key players in the industry help to gather information regarding the company's specific situation and position in the market.

These interviews give clear guidelines regarding what is important to focus on with respect to the research problem and possible solutions. This will also assist with any study that needs to be performed like for example the following:

- I. Market survey.
- II. Plant specific studies such as performance and capacity tests.

## 2) Market survey.

Market surveys will gather information to support the most feasible options available for implementation of improvements and changes. As previously mentioned this helps in determining the company's position in the market and the divestment scenario. In Safripol's situation the market survey was concentrated regarding monomer availability.

## 3) A business function framework.

A business function framework can then be created that will be satisfied by identifying companies with similar functions. Business functions or technology agreements with certain technology suppliers can be identified and suggestions then made regarding the best options to peruse.

Typically the following functions or processes can be researched for potential support of similar kind of technologies:

- I. Product development
- II. Safety support
- III. Plant support
- IV. Technology support
- V. Catalyst support
- VI. Quality support
- VII. Benchmarking

The preferred companies identified in the business function framework needs to be capable of fulfilling the business needs.

## 4) Scenario planning process.

The scenario planning process is a summary of best practices that can be applied to any company's specific scenario of positioning itself in its business environment.

The key output and strategies of the scenario planning process identify current and future scenarios that the business can investigate in order to secure further growth.

## **6.2 Recommendations**

Recommendations will be done according to the outcome of the FMEA. The following areas were identified with the highest RPN ratings and will be briefly discussed:

- 1) Additional propylene supply
- 2) Increase the polypropylene plant capacity
- 3) Technology partners
- 4) Scenario planning process

### **6.2.1 Additional propylene supply**

The following recommendations are made to help Safripol with its quest for additional monomer supply with respect to this research.

- 1) PetroSA

Safripol needs to keep contact with PetroSA and draft a preliminary propylene supply agreement ensuring the relationships between the two companies are kept alive.

- 2) Engen

The SAPREF splitter first needs to be optimised before Engen is brought into the equation. It will therefore not make sense to source additional propylene from Engen if the SAPREF splitter is not optimised.

### 3) SAPREF

It is recommended that a second propylene purity trial combined with a capacity trial be conducted at SAPREF. All the structures regarding the 98% propylene purity trial was put in place and is still in place and therefore the trial can just be executed.

The design data of the splitter proves that additional capacity is available. Safripol and SAPREF need to change the hydrocarbon mix of the feed to the splitter to increase the propylene product stream. This will be to the advantage of both SAPREF and Safripol.

### 4) Natref

The propylene splitter at Natref has the same propylene purity as the SAPREF splitter. It is recommended that the propylene purity from the Natref splitter is also reduced to 98% to source additional capacity from the column.

The same strategy as with the SAPREF splitter can therefore be followed.

## **6.2.2 Increase the Polypropylene plant capacity**

Following are recommendations listed for each area of the plant to increase the capacity of the polypropylene train:

- 1) Feasibility study to define changes needed to increase the polymerisation reactor's pressure and temperature.
- 2) Safety study on emergency flaring at new operating conditions, including dynamic simulation of loop reactors, safety valve discharges and high pressure blow-down behaviour.
- 3) Invite LyondellBasell Expansion team to verify existing modifications and expansions on the plant.

- 4) Simulation and checking of existing equipment at new conditions and revised data sheet preparation.
- 5) Verify the need to revise the license agreement with LyondellBasell based on the recommended increase in capacity.
- 6) Sign expansion agreement with LyondellBasell in order to conduct a detail engineering study.
- 7) Process design package delivery with all the technical information (PFD, P&IDs, Equipment and Instrument Data sheets, etc.) for the suggested modifications to enable the plant expansion.

### **6.2.3 Recommendations with regards to technology partners**

Recommendations for technology partners will ensure that critical business functions are acquired. Therefore Safripol needs to negotiate the following with each potential technology partner:

- 1) With LyondellBasell the current conditions of the existing contract ending in 2011 needs to be negotiated to only incorporate quality support and benchmarking in the new contract from 2011 onwards.
- 2) Grace Davison is supplying Safripol's catalyst at a competitive price formula and therefore it is suggested to keep Grace Davison for catalyst support.
- 3) A Technical Agreement contract needs to be set up with the Dow polypropylene plant in East Germany. Safripol has the option of arranging support regarding; product development, safety, plant and technology.

## 6.2.4 Recommendations regarding the scenario planning process

The most feasible short term scenarios listed by Safripol during the scenario planning process will be listed below with recommendations regarding each.

- 1) Sustainable 120-140kt/a polypropylene by securing sufficient propylene supply. Maximise pipeline portion of mixture.

Use existing work process available on site effectively to maximise the plants availability.

- 2) Better pricing model for monomers from Sasol

Negotiations with Sasol regarding an interim propylene price structure to be completed before year end 2010.

- 3) Enter the Goods for Resale arena using Safripol's established customer and support structure.

Safripol must approach Plastomark and Protea chemicals to go into collaboration with imported specialty grades. Safripol has the polymer knowledge and expertise to take the lead.

- 4) Establish Operational Excellence Centre.

It is recommended that Safripol presents, together with the Plastic federation of South Africa, NQF approved courses regarding the work processes and electronic tools currently in use by Safripol.

- 5) Update Six Sigma methodologies with current global trends

The only way to revitalise the Six Sigma methodology on Safripol's site is to have a dedicated six sigma team.

Six Sigma black belts are project managers that were trained using the six sigma defect reduction or cost saving methodology. Currently Safripol has seven qualified six sigma black belt project leaders that can take part and get together on a regular basis setting up a forum.

#### 6) Composition of product range

Do margin velocities on all grades and eliminate the low margin products and replace with higher margin imported products.

### **6.3 Areas for further research**

Further research can also be done on any of the following long term scenarios;

- 1) Secure access to ethylene supply from new EPU5 ethylene facility at Sasol, and other opportunities.
- 2) Investigate alternative polymers in Safripol's product range.
- 3) Renewable energy packaging units (new technology).
- 4) Reporting and information exchange optimisation. Alternatives for electronic recording process.
- 5) Migrate from current packaging to bulk containers.
- 6) Investigate the sale of polymer powder instead of granules.
- 7) E-commerce or E-collaboration with suppliers and customers.
- 8) Enter the monomer production arena (Joint ventures with Sasol, e.g. Cracker unit).
- 9) Establish facilities at new locations where monomer may become available: Coega, Angola, Mozambique.
- 10) Monomer supply grid membership including Sasol (longer term strategy).
- 11) Ethylene from Ethanol; part of grid.
- 12) Ethanol production; on site and regional.

## Bibliography

Archaeology Dictionary 2010. 'The Concise Oxford Dictionary of Archaeology'. Oxford University Press.

A Bio-refinery for the Production of Ethylene Derivatives

[http://www.allriskengineering.com/AIChe\\_conferences/AIChe\\_2010/data/papers/P173759.pdf](http://www.allriskengineering.com/AIChe_conferences/AIChe_2010/data/papers/P173759.pdf)  
f Date access: 10 July 2010.

Bohlmann, GM. 2007. Process economics of ethanol production in Brazil: An in-depth, independent technical and economic evaluation by the PEP Program.

<http://www.bbibiofuels.com/few/2007/FEW07/FEW07-WS04--Bohlmann.pdf>

BASF

[http://www.basf.com/group/corporate/en/brand/LYNX\\_PP](http://www.basf.com/group/corporate/en/brand/LYNX_PP) Date of access: 19 July 2010.

CBI Lummus' Olefin Conversion Technology

<http://www.cbi.com/about-cbi/business-sectors/lummus-technology/>

CCD (2007). 'What is Failure Modes Effects Analysis?' CCD Health Systems

<http://www.sentinel-event.com/fmea-hfmea.php>

Chematur Engineering AB BIORSTIL® 2000 High Performance Ethanol Production

<http://www.chematur.se/> Date of access: 09 July 2010

Chematur Engineering Ethylene from Ethanol

<http://www.chematur.se/> Date of access: 09 July 2010

Chemical industry

<http://www.britannica.com/EBchecked/topic/108720/chemical-industry>



Chemsystems PERP report Green propylene. Process Technology, production costs and regional supply/demand forecasts.

[http://www.chemsystems.com/reports/search/docs/abstracts/0708S11\\_abs.pdf](http://www.chemsystems.com/reports/search/docs/abstracts/0708S11_abs.pdf)

Chevron South Africa

<http://www.chevron.com/countries/southafrica/> Date of access: 06 July 2010.

Daum, J.H. 2001. How scenario planning can significantly reduce strategic risks and boost value in the innovation value chain.

[http://www.juergendaum.com/news/09\\_08\\_2001.htm](http://www.juergendaum.com/news/09_08_2001.htm)

Engen

<http://www.engen.co.za/home/apps/content/default.aspx> Date of access: 05 July 2010.

Gaywood, G. 2010. Verbal communication.

Grace Davison

<http://www.grace.com/SpecialtyCatalysts/default.aspx> Date of access: 11 August 2010.

Green Propylene Production Technology, Plant Cost & Supply-Demand Market.mht

[http://www.chemsystems.com/about/cs/news/items/PERP%200708S11\\_Green%20Propylene.cfm](http://www.chemsystems.com/about/cs/news/items/PERP%200708S11_Green%20Propylene.cfm). Date of access: 10 July 2010.

Laing, Henry. CMCS 2006

Licensed Polyolefin Technologies and Services

[www.lyondellbasell.com](http://www.lyondellbasell.com)

London International Financial Futures and Options Exchange. (LIFFE)

<http://www.investopedia.com/terms/l/liffe.asp> Date of access: 25 September 2010.

McDermott, R.E., Mikulak, R.J. & Beauregard, M.R. 1996. The Basics of FMEA. Productivity Press. 80 p.

Mitsui

[http://www.mitsui.com/industries\\_chemicals.shtml](http://www.mitsui.com/industries_chemicals.shtml) Date of access: 27 July 2010.

Nonato, RV, Mantellato, PE & Rossell, CEV. 2001. Integrated production of biodegradable plastic, sugar and ethanol. *Applied Microbial Biotechnology*, 57: 1-5.

PetroSA

<http://www.petrosa.co.za/> Date of access: 10 July 2010.

Plastic Federation SA

<http://www.plasticsinfo.co.za/polymers.asp> Date of access: 22 July 2010.

Potgieter, Andre. 2009. Verbal communication

P.P. Splitter FWSA Contract 25145 Volume 2 Book A. Safripol PP Library.

Raine, P. 2010. Verbal communication

Raine, P. (peter.raine@rsaweb.co.za) 30 September 2008. Propylene Supply Project Update. E-mail to: Van der Walt, CP (cpvanderwalt@safripol.com).

Safripol

<http://www.safripol.com/> Date of access: 08 August 2010.

Safripol GPS program

<http://www.safripol.com/> Date of access: 30 August 2010.

Sasol

[http://www.sasol.com/sasol\\_internet/frontend/navigation.jsp?navid=700050&rootid=600001](http://www.sasol.com/sasol_internet/frontend/navigation.jsp?navid=700050&rootid=600001).

Date of access: 05 July 2010

Schoch, Joaquin. Safripol 2010

Schwartz, P. (1996). The art of the long view: Planning for the future in an uncertain world. NY, Doubleday Currency.

Schwartz, P. 1998. The art of the long view: Planning for the future in an uncertain world. New York: Wiley. 270 p.

Smith, M.D. 2009. The Shifting Sands of the Global Polyolefins Business. CMAI

South African Sugar association

<http://www.sugar.org.za/HomePage1.aspx>

Sud-Chemie

[http://www.sud-chemie.com/scmcms/web/page\\_en\\_6571.htm](http://www.sud-chemie.com/scmcms/web/page_en_6571.htm) Date of access: 05 August 2010.

The Black Belt Memory Jogger 2002. Six Sigma Academy, Goal QPC. 211 p. – 215 p.

The Dow Chemical company

<http://www.dow.com>. Date of access: 15 July 2010

Thoelke, M. 2007. Light Olefins Outlook. CMAI. [mthoelke@cmaiglobal.com](mailto:mthoelke@cmaiglobal.com)

Total

<http://www.SAPREF.co.za/>

Wack, P. (1984).

<http://royaldutchshellplc.com/1996/01/>

Wack, P. (1985). "Scenarios: Unchartered waters ahead." Harvard Business Review (September-October): 73-89.

Wack, P. (1985). "Scenarios: Shooting the rapids." Harvard Business Review (November-December): 139-150. The Art of the Long View (New York: Currency Doubleday, 1996)

Watkins, R & Leigh, D. 2009. Handbook of Improving Performance in the Workplace, The Handbook of Selecting and Implementing Performance Interventions. New York. John Wiley and Sons. 944 p