A Refinery Model Report

Objective:

The purpose of this project was to investigate how to optimize the operating policy of Scottish Petroleum's refinery. The refinery consists of 3 distillers that can work independently. Therefore, the aim is to find a suitable operating policy such that the distillers are meeting demand whilst the costs of running them and the waste produced is kept to a minimum.

Part 1:

The initial stages of the investigation consisted of trying to create a model of the system using Xpress-MP. We declared our variables which we would be using to try and find a solution to the problem. These variables included the costs, products and demand. The costs consisted of both the Operating Costs and the Disposal Costs. The Disposal Cost came into play when the refinery produced more than the demand and the remaining products had to be disposed of. For each product, there was a corresponding market demand that we could not exceed but we had to obtain. Therefore we also included some variables that would be changeable. These variables helped us understand how each distiller behaved individually and how their production levels affected the number of products made. Furthermore, we also considered the fraction of quantities that we discarded. The table in Appendix [A] illustrates how the problem was set about, with each distiller column (A, B, C) having it's corresponding product and the demand for each. Furthermore there is an additional aspect in which the distillers create products that are not the final products themselves but will have to be mixed to create the finalized Product. These products are: Petrol, Kerosene and Diesel.

By having defined our initial variables, we then proceeded to define what our total costs were as well as the corresponding value when operating at this policy. The total costs included both the production costs and the disposal costs. The production cost was a function of the distiller, the operating costs and was defined for each individual distiller column. The disposal costs were a function of the products, including the fractions, tar and waste. In addition, the disposal costs also included disposal cost and the fraction of the total products which were disposed. With these defined, we proceeded to find the total value of the products, this was found by multiplying the number of products made with its corresponding price for all product and then summing them. Therefore we could define our objective function which we denoted as profit to be the value minus the costs. It is important to note that although the initial goal was to find the operating policy and not the profit, the two are highly correlated and therefore by maximizing the profit we are also optimizing the running time for each column of the distiller.

We were also faced with a number of constraints. These included time constraints where the columns could run for up to 24 hours a day. Also, we had to ensure that the total number of products made would not exceed the demand and that each individual column did not produce more than they were capable of. Having thus simply formulated our model, we were able to try and maximize our profit to find out whether our optimal operating policy would result in a loss or a gain. The following Table summarizes our results:

Table 1

	Column A	Column B	Column C	PROFIT($)
Running Time	24 hours	24 hours	4.295 hours	780,966

We can see from this table that our optimal operating policy is to have Columns A and B run all day and have Column C run for 4.295 hours. This yields a profit of $780,966.

Part 2:

The second part of our investigation considered the fact that it would be possible to sell the waste or surplus at a discount rate. Therefore, we changed our model around to find out how this would affect our results and determine which discount rate is the best. In our model, we introduced a new variable which would no longer treat the surplus as waste but as a new product. This product was added to the total value as this value would not be increased as by us selling our surplus. We introduce a discount multiple that varies from 0 to 1. At 1, the surplus is being sold at the same price as our original product and at 0 the product is not being sold. This multiple was increased by 0.1 and the corresponding operating policy and profit was found for each increase in discount multiple. In addition we added a new constraint such that the total number of products would not exceed that of the sum of our original products and our “waste” products. It is important to note that our demand was still fixed with the original product as the demand never increased. The following Table summarizes our results with varying multiplier M

Table 2

Running Time	Column A	Column B	Column C	PROFIT ($)
M = (0 to 0.33)	24 hours	24 hours	4.295 hours	780,966 to 803,697
M= (0.34 to 0.47)	24 hours	24 hours	8.028 hours	805,268 to 831,403

M= (0.48 to 0.99)	24 hours	24 hours	24 hours	839,938 to 1,305,780

We can see from table 2 with a discount multiplier of 0 to that of 0.33 our profit remains largely the same as does our operating policy. This increases slightly, with an increase in multiplier to 0.47 where our Column C starts to work approximately two times as much. However, between 0.48 and 0.99 all our columns work at full capacity and our profits vary largely.

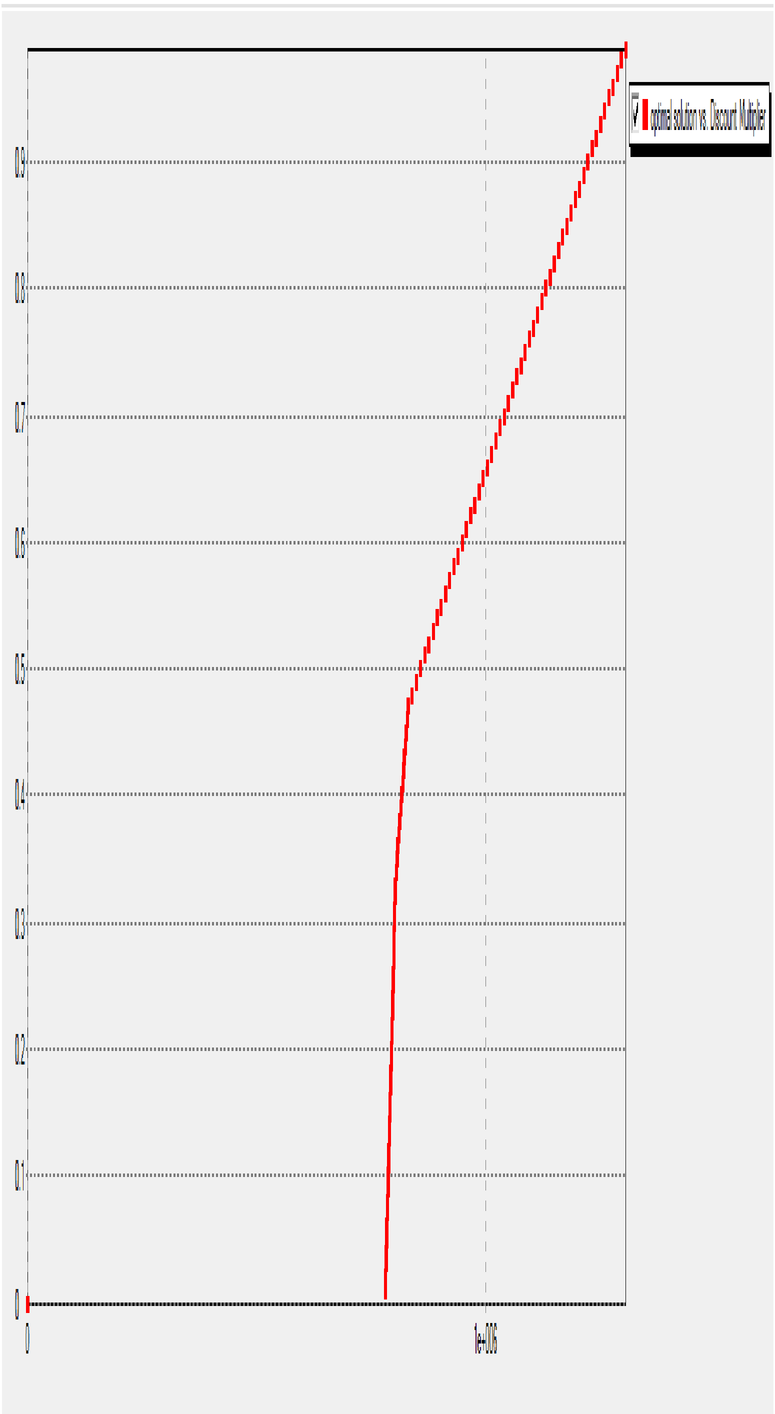
The table in Appendix [B] shows more precisely how the change in discount multiplier affects our profits.

Conclusion and Discussion:

In conclusion, with these following results it is up to the company to make a decision on which approach suits the company best. By introducing a discounted product from the surplus, we can increase our profits however this also requires the refinery to be working longer hours. This may have consequences and costs that were not included in this model such as overhead costs and staffing costs. Without introducing a discounted product we can see that Column C operates a lot less than the previous two, therefore it would be in the interest of the company to re-evaluate which products to focus on and which ones are not worth having. Given further time, it would have been beneficial to investigate at which point getting rid of the surplus is actually more beneficial than selling a discounted product. This would largely due to the fact that the disposal costs would be less than that of the production costs. Furthermore, it will be necessary to further enhance our models to include more variables from real world situations such that we can obtain a more realistic result.

APPENDIX [B]

Graph illustrating how the Profit is Affected with Increasing Discount Multiplier from 0 to 0.99



APPENDIX [A]

Diagram illustrating the original Problem

BUTANE

Column A	45 tons of Butane	per day
Column B	63 Tons of Butane	per day
Colomn C	95 Tons of Butane	per day

We need per day 3000 Tons of Butane

FRACTION 1

Column A	28 Tons of Frac1	per day
		per day
Column B	35 tons of Frac 1	
Column C	58 tons of Frac 1	per day

FRACTION 2

Column A	23 Tons of Frac2	per day
Column B	38 tons of Frac 2	per day
column C	58 tons of Frac 2	per day

FRACTION 3

Column A	35 tons of Frac3	per day
Column B	40 tons of Frac 3	per day
Column C	50 tons of Frac 3	per day

TAR

Column A	20 tons of tar	per day
Column B	25 tons of tar	per day
Column C	25 tons of tar	per day
we need:	500 tons of tar	per day

Petrol:	0.5 Frac 1
	0.35 frac2
	0.15 frac 3
we need:	2000 tons per day

Kerosene	0.3 frac1
	0.5 frac2
	0.25 frac3
we need:	1500 tons per day

Diesel	0.15 frac1
	0.20 frac2
	0.55 frac3
we need:	1750 tons per day

WASTE	**Column A**	50 tons of waste	per day
	Column B	50 tons of waste	per day
	Column C	25 tons of waste	per day
	we need:	0 tons of waste	per day