Supply Chain Management in Oil Downstream Distribution Business: A perspective of IT Alternatives and Solutions

By
Kanika
R060105008

Guided By
Mr. Avinash Bhardwaj
Senior Fellow
University of Petroleum & Energy Studies

A DISSERTATION REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR MASTER OF TECHNOLOGY (PETRO-INFORMATICS) OF UNIVERSITY OF PETROLEUM AND ENERGY STUDIES, INDIA

UNIVERSITY OF PETROLEUM & ENERGY STUDIES,
DEHRADUN
APRIL 2007

ACKNOWLEDGEMENT

This is to acknowledge with thanks the help, guidance and support that I have received during the completion of my dissertation.

At the very outset, i express my gratitude and obligation to Mr. Avinash Bhardwaj (Senior Fellow), who has given me proper guidance and helped me in completing my dissertation in spite of his busy schedule.

I have no words to express my deep sense of gratitude to the management of University of Petroleum & Energy Studies, for giving me an opportunity to work on this dissertation.

I would like to express my heart full gratitude to Mrs. Mousumi Dasgupta (Programme Director, M.Tech, Petro Informatics) for her regular motivation and eagerness towards completion of this dissertation for her valuable support.

Kanika
M.Tech (Petro-Informatics)

K

DECLARATION

This is to certify that the Dissertation Project Report on **"Supply Chain Management in Oil Downstream Distribution Business: A perspective of IT Alternatives and Solution"**, submitted to University of Petroleum & Energy Studies, New Delhi, by **Kanika** in partial fulfillment of the requirements for the award of degree of Master of Technology (Petro Informatics), is a bonafide work carried out by her under my supervision and guidance. This work has not been submitted anywhere else for any other degree/diploma.

30/4/2K7

MR. AVINASH BHARDWAJ
SENIOR FELLOW

Abstract

he oil downstream distribution segment is increasingly adopting a variety of ply chain solution. From crude selection to product distribution at the retail outlet, ; a chain with many links. The unpredictability in oil prices, refining margins and long lead times associated with vital functions like crude buying and product ding make the entire process challenging.

e product development companies have introduced some good products in the :M space. Implementation of these solutions on large installations, however, is ıat the world is watching, as huge oil companies struggle to "chain" the business. tegration with existing IT solutions used in the industry is also major challenge in ıe sector. The industry has a pressing need for both implementation and integration cills for taking the best value out of different supply chain solutions available.

CHAPTER # 1

INTRODUCTION

1.1 Definition of SCM
1.2 Objective of SCM
1.3 Fundamentals of SCM

1.3 Fundamentals of SCM in Petroleum Business

Modern optimization techniques have challenged organizations to rethink the way they conduct business both internally and externally, i.e. how efficiently and effectively their entire supply chain is managed. Supply Chain Management (SCM) is one such business function that has benefited substantially from optimization software advances and solutions. The primary goal of SCM is to maximize profit by integrated management of material and transactional flows within a business and to customer and partner companies.

The petroleum refining industry has effectively embraced the software solutions to optimize the business supply chain to maximize the profit margins and create order in the chaos of numerous opportunities and challenges. The supply chain of a typical petroleum refining company involves a wide spectrum of activities, starting from crude purchase and crude transportation to refineries, refining operations, product transportation and finally delivering the product to the end user. The nature of the value chain is such that its economics are extremely complex and heavily linked (Refer to Fig. 1.0). For example, the process of selecting the right crude is linked not only to the transportation costs involved in delivering it to the refinery, but it must take into consideration the refinery configuration, capabilities and constraints in converting the crude into products, as well as the product volume and price fluctuations.

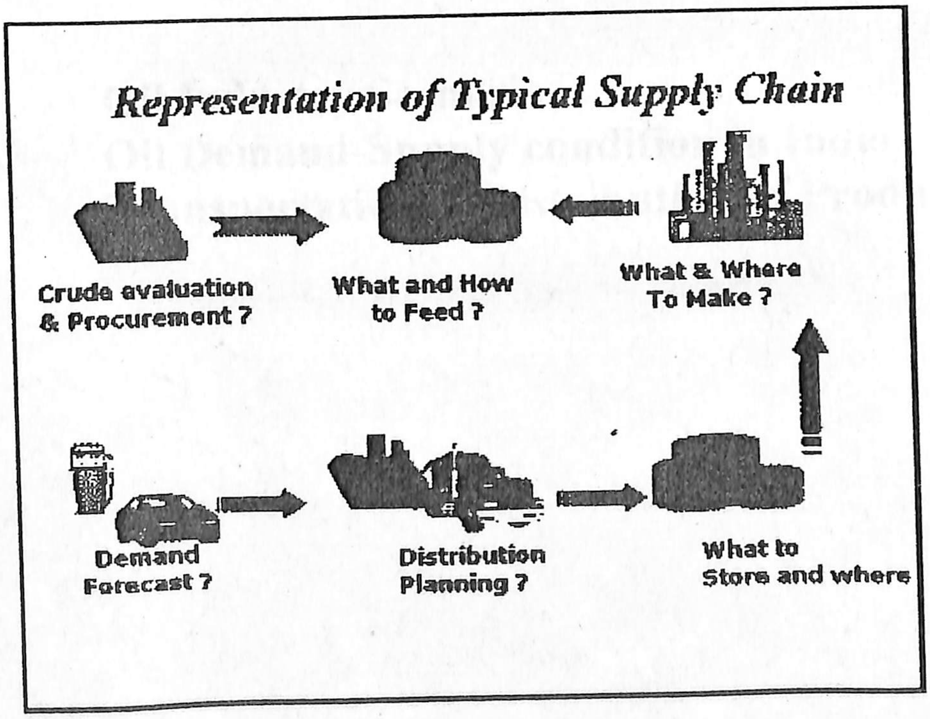


Figure 1: Typical Supply chain of Petroleum business

CHAPTER: 2

Petroleum Industry Scenario

2.1 OIL INDUSTRY SCENARIO

The oil industry in India is on the threshold of deregulation with the emerging competition creating dramatic changes in the marketplace. Oil is a growth industry with worldwide demand for hydrocarbons increasing from 4900 million tonnes in 1990 to nearly 5700 million tonnes in the year 2000 with a projected demand of nearly 6600 million tones by the year 2010. Much of the incremental demand is coming from Asia. According to British Petroleum, 20 years ago, one barrel out of 20 produced was consumed in Asia. Today, it is one barrel in four and by 2010 it is expected to be one barrel in three! Within Asia, the largest growth is happening in India and China.

Oil prices however, have shown volatility and have been unpredictable. Globally, oil prices have fluctuated from a little over $ 10 a barrel in March 1999 to $ 37 in early 2000. As on September 10, 2001, oil was at $ 27 a barrel with prices coming down to $ 22 per barrel due to the September 11 incidents. India however, has little control on prices and are essentially price takers. Increase in crude price, coupled with the declining value of the rupee has a direct bearing on domestic prices and consequently, on demand.

Even though India is among the top ten oil consumers in the world, the per capita consumption is amongst the lowest. Per capita consumption of hydrocarbons is 113 kilograms of oil equivalent (KgOE) as against the world average of 927 KgOE. This yawning gap shows how much potential there is for increase in consumption. With growth in GDP and a corresponding increase in individual prosperity, more and more people will have the ability to buy more and more energy. Also, people will consistently graduate to more convenient and cleaner forms of energy. This growth potential presents a great opportunity.

Of particular significance are the trends in Diesel, which constitutes about 40% of the total consumption basket. During the past few years, the growth in this product was in the range of 6 - 8%. However, during 1997-98 and 1998-99, growth was hovering at around 3%. During 2000-01, for the first time in recent years, a negative growth has been registered. If this trend continues, it could have an impact on the network expansion plans of the oil industry. As against the total consumption of approximately 100 million tonnes of petroleum products (including imports and sales by private parties) during 2000-01, the country's installed refining capacity is 112 million tonnes. Thus, from a position of being short on refining capacity since independence, India today has surplus refining capacity. The surplus refining capacity will tend to increase the exports as well as reduce the refinery throughput

2.2 OIL DEMAND-SUPPLY CONDITIONS IN INDIA

Petro products play a vital role in every industry. The main products that are distributed by the oil companies are Liquefied petroleum gas (LPG), High-speed diesel (HSD), Motor spirit (MS), Naphtha, Light diesel oil (LDO), low sulphur heavy stock, furnace oil (FO) and lubricants. Barring LPG, with nearly 85% domestic consumption, all other products are used across industries. The consumption pattern for all these products is given in Annexure-1.

The Indian oil sector is at the threshold of decontrol. The government is gradually slackening controls over the 5 products (MS, HSD, Aviation fuel, Kerosene and LPG) that contribute 70% of the volumes. However with crude prices touching new highs with no corresponding rise in product prices the refining margins are largely affected. For FY01, domestic production from refineries is estimated to be 109.58mtpa (about 2.31 million barrels per day) while consumption is expected to be around 104mtpa. During the said period, the 17 refineries together would process about 112mtons of crude. The domestic crude supply is expected to be around 31.97mntons and imports, including imports by Reliance Petroleum Ltd and Mangalore Refinery and Petrochemicals Ltd are estimated to be about 80.9mnt.

2.3 TRANSPORTATION AND DISTRIBUTION OF PRODUCTS

Considering the geographical spread of the country, the infrastructure for movement of petroleum products is woefully inadequate for handling the growing volume of petro products. Not much thought has been given for development of pipelines. Due to non-availability of tank-wagons, oil movement is undertaken by road which is not only hazardous and polluting but also 15 to 20 times costlier (in terms of energy consumption) compared to pipelines and 5 times costlier than railways. In a country where oil is being imported, expenditure on movement of petro products by road results in serious drain of foreign exchange. The losses due to road/ rail transportation are also 3 to 5 times higher compared to transportation through pipelines. Inventory management is critical in such an environment and senior managers at BPCL knew that updated information about the stock of their products held the key to successful inventory management.

CHAPTER # 3

Supply Chain Management in Distribution Sector (Downstream)

3.1 **How Downstream Petroleum Different from Other Industries**

3.2 **Role of Supply Chain in Petroleum Industries**

3.3 **Components of Downstream Supply Chain**

3.4 **Software Tools Available**

3.1 HOW DOWNSTREAM PETROLEUM DIFFERENT FROM OTHER INDUSTRIES

Start by recognizing how downstream petroleum is different from other industries

Supply chain solutions that work well in other industries must be modified for downstream petroleum. This industry presents complexities not present in others:

• The inventory is commodity-based and fungible. Competitors within the same part of the supply chain can, and do, trade with each other. Associated financial markets for both crude and refined products play a large part in how supply chains are managed, and these markets can be exceptionally volatile.

• Companies' supply chains are often discontinuous. Because inventory is a commodity, any given molecule is often traded several times or resold before it is consumed. Oil companies regularly trade inventory in and out of their systems multiple times, increasing transaction volume but not necessarily increasing or decreasing actual inventory. In most other industries, inventory that's been acquired is not traded again.

• Inventory is process-based and nondiscrete. Inventory is not packaged and can't be separately identified. Typical techniques and tools for tracking inventory, such as stock keeping unit (SKU) or part numbers, bar codes, radio frequency identification (RFID) and packaging (pallets and containers), do not yet apply to crude or refined products.

• Compared with other industries, the production flow is reversed. In downstream petroleum companies, inventory starts as a few products (crude's) and creates many products, which can then be recombined. An end product, such as gasoline, can be created in many different ways. Tools that calculate derived demand based on bills of material are ineffective.

• Legal and environmental regulations mandate minimum inventories, raise antitrust concerns, require unique reporting, and emphasize safety and quality of the end product.

• A downstream petroleum company's assets are inflexible. A refinery can change capacity only within narrow ranges because of its inherent processing complexities. Stopping and restarting production within refineries is difficult and risky.

• Transportation costs and low relative value combine to limit the number of locations products can cost-effectively be shipped to.

In some ways, however, supply chains in downstream petroleum are simpler than in other industries:

• Product life cycles are longer. Unlike other industries that must contend with the product obsolescence that follows constant innovation, downstream petroleum has a stable and static product mix.

• Products are not perishable. Holding inventory may be costly from a capital standpoint, but these costs can be recovered. Aging and stock rotation issues do not affect downstream petroleum companies.

• Demand is less fickle. Though demand may vary among petroleum companies, total demand for a given market is much more stable than it is in other industries. Demand does not change based on product innovation or consumer tastes, and downstream petroleum companies can use history as a reliable forecast base.

• There are fewer products to track than in most other industries.

• There are far fewer methods of viable transport for products.

Given these factors, we need to address supply chain improvement efforts holistically and pragmatically, with collaborators who deeply understand your unique industry issues.

Many downstream petroleum companies that engage in supply chain optimization initiatives make the same crucial error: They attempt to transform their entire operations all at once, and the anticipated return on investment (ROI) is distant.

One of the most important aspects of supply chain transformation is a big-picture view of the operations and how information the company owns is disseminated and is used.

But we encourage downstream petroleum companies to execute this vision in a tactical, phased manner. Implementing supply chain changes incrementally and pragmatically can enable to meet the business goals without disrupting operations.

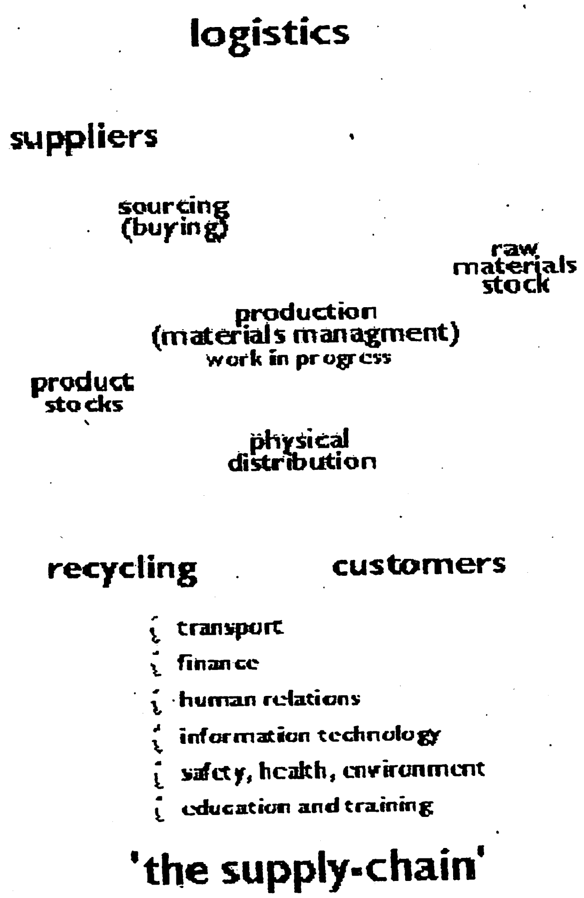
3.2 SUPPLY CHAIN IN PETROLEUM INDUSTRY

The supply chain of the petroleum industry is extremely complex compared to other industries. It is divided into two different, yet closely related, major segments: the upstream and downstream supply chains.

The upstream supply chain involves the acquisition of crude oil, which is the specialty of the oil companies. The upstream process includes the exploration, forecasting, production, and logistics management of delivering crude oil from remotely located oil wells to refineries.

The downstream supply chain starts at the refinery, where the crude oil is manufactured into the consumable products that are the specialty of refineries and petrochemical companies.

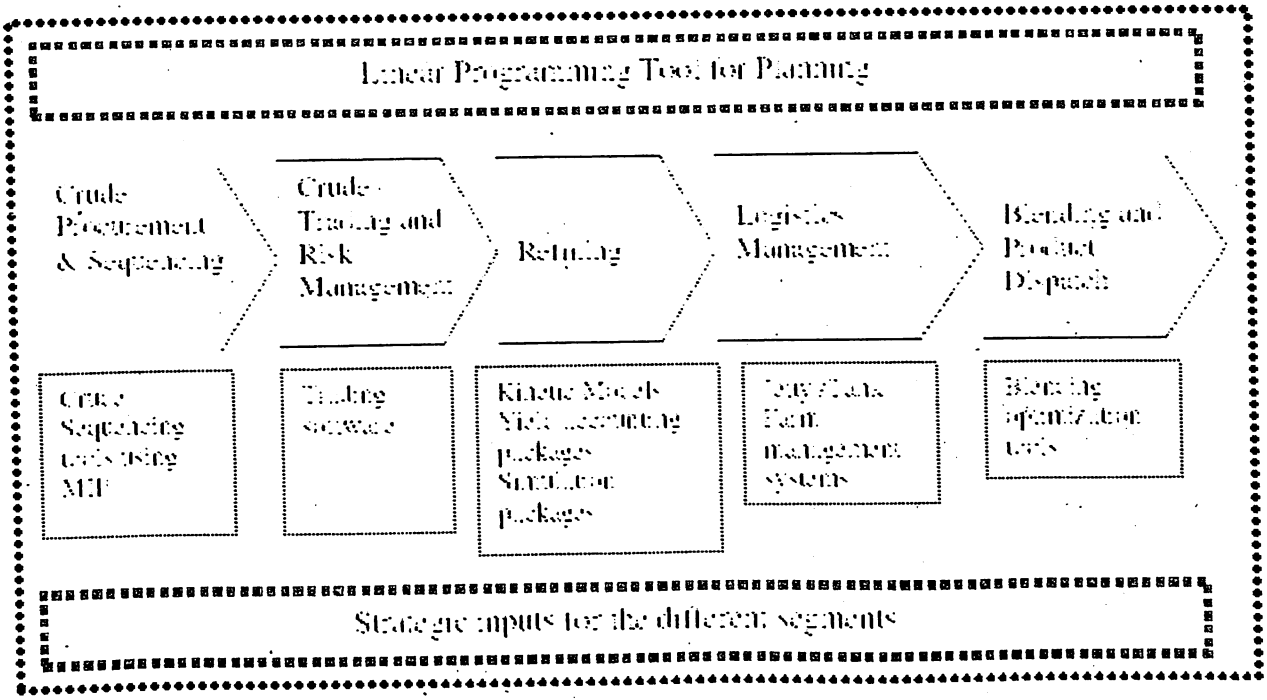
The downstream supply chain involves the process of forecasting, production, and the logistics management of delivering the crude oil derivatives to customers around the globe. Challenges and opportunities exist now in both the upstream and downstream supply chains.



3.3 COMPONENTS OF DOWNSTREAM SUPPLY CHAIN

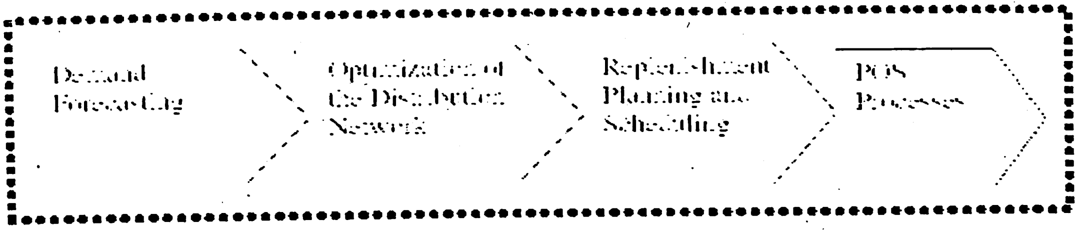
The downstream business is divided into Refining and Distribution segments. This paper focuses more on the Distribution segment. Since there is a lot of interplay between the two segments, a brief description of the Refining business is also included.

The important components of the Refining business supply chain and the interplay between them is shown below. All the important functions in this business are enabled by IT applications, which optimize the different portions of the value chain.



The Refining business segment supply chain is managed by using linear programming packages, which can evaluate crude's, schedule cargoes, and blend streams to give products. In addition, in manufacturing, kinetic models and yield accounting packages optimize the performance of different conversion units. The major challenges in the supply chain in this sector are the integration of all these packages with the trading software and with transaction tracking packages like SAP. Hence, even considering the benefits of LP (Linear Programming?) and scheduling tools, the disconnect between the kinetic models, yield accounting packages, trading software and the LP does leave some room for making the supply chain more responsive and headed in a single focused direction.

Now, let us move to the distribution segment whose vital links are as shown below.



The above functions are also enabled by different IT applications. Seamless flow of information across these functions is vital for streamlined performance of the value chain.

Distribution Segment

There is a definite shift in focus in the industry toward the distribution segment. The big oil companies have started monitoring the inventories of gas stations and are using the demand data from such outlets to plan for the refinery throughputs.

The issues at the refinery level are: Which crude to use? Which units to run? Which products to make and in what quantities? While the issues at the customer facing end or at the gas stations are basic, namely, run outs and retains. How the entire supply chain is gearing up to address these issues is the challenge in front of the oil companies.

There are two objectives from the point of view of supply chain integration in the downstream distribution segment, viz.:

1. To get data from the POS and other sources so that the demand forecasting numbers are accurate, and integrate this data so that the refining business has a good idea about the different demand numbers of different products.

2. To optimize further within the distribution sector itself so that the costs are minimized.

The important functions within the distribution segment are demand forecasting, optimization across alternative means of transportation, replenishment methods to avoid retains/run outs and finally scheduling, which sequences the dispatch. Let us look at these functions in a little more detail.

1. Demand forecasting: The demand number for each product for the forward month is one of the key inputs, which is essential for the refinery LP to perform the optimization studies. This input actually determines the rate at which the refinery operates for the next month. This decision helps in buying crude so that there is no "dry-out" or lack of crude for running the units, or demurrage due to a high inventory build-up.

The demand numbers are generally taken based on following inputs.

- Historical data for the similar period
- Forward trades data, based on deals done or committed in the forward months
- POS systems which give the latest updates
- Macroeconomic indicators reflecting the economy
- Marketing inputs based on marketing plans to introduce new schemes, etc.
- Meteorological department's inputs, as the gasoline and heating oil requirements are very weather sensitive

Even though all these inputs are considered, an element of subjectivity comes in while giving weightages for each of these factors. The weights can vary with time or with individuals, leading to different predicted numbers.

2. Supply and distribution plans:

The logistics management group coordinates the movement of products from the refinery gate to different customers and retail outlets. Movement of products by ships needs proper jetty management and scheduling. A ship waiting to be loaded/unloaded costs demurrage (a crude VLCC alone incurs around $30,000 /day of waiting) and the customer waiting to get the cargo may also levy penalty clauses for the delays. If there is a delay in product evacuation due to improper scheduling, the product tanks get filled up and leading to a chance of throughput reduction of the refinery itself. In worst cases, there is a chance of crude vessels incurring huge demurrage. On the other hand, the early arrival of product vessels may lead to insufficient stock in the tanks and there would be dead freighting which is uneconomical.

3. Replenishing the retail outlets:

The fundamental issues for a gas filling station are run outs and retains. Both run outs and reruns are discussed earlier. Even though there is a weekly and monthly plan for distribution for all the gas stations, the scheduling for refilling of these stations needs to be done properly. If there were unlimited tankers topping up these gas stations, there would be no issue. But typically there would be a single tanker, which would cater to a neighborhood having many filling stations, and its optimum utilization means better utilization of the tanker itself as well as prevention of run outs and reruns. It makes economic sense too as each fruitless visit of a tanker costs around $150 and with a midsize company having around 4,000 outlets, these costs add up fast.

3.4 Software Tools Available

Software Tools Available

1. Demand Forecasting:

A variety of models are used for answering the basic question of how much product will be needed at each of the terminals for a particular time period. Intelligent neural network algorithms are being used for making such models. The Neural Network simultaneously evaluates various statistical forecasting methods and weighs them according to their accuracy as compared to historical data to create a composite algorithm.

Some of the attributes of this function, specifically desired for bulk refined product demand planning are:

- Demand planning by individual product and customer/channel of trade
- The demand plan to be done over different time periods (short, medium, long-term)
- The economic impact and the effect of price and availability of a substitute for products on demand to be considered

The demand forecasting tool using Neural Network apply the forecasting methods like daily average, day of week average, seasonal, etc., which learns from past experience and projects for the future. These models use other functionalities like Linear Regression, which find the best straight line through the last two years of data and extrapolate this line into the future to predict future sales. Sometimes, exponential regression, which attempts to best fit an appropriate exponential function using power regression where the data is best fit according to a power function, is used.

The forecasting tools have evolved to such an extent that they allow users to modify or enhance the forecast using other tools for sales anomalies that the system would have no way of predicting. Sometimes, the users need to retrieve from the historical database an "event" that caused a fluctuation in demand. They can then map the historic sales patterns of those days to a future period of time.

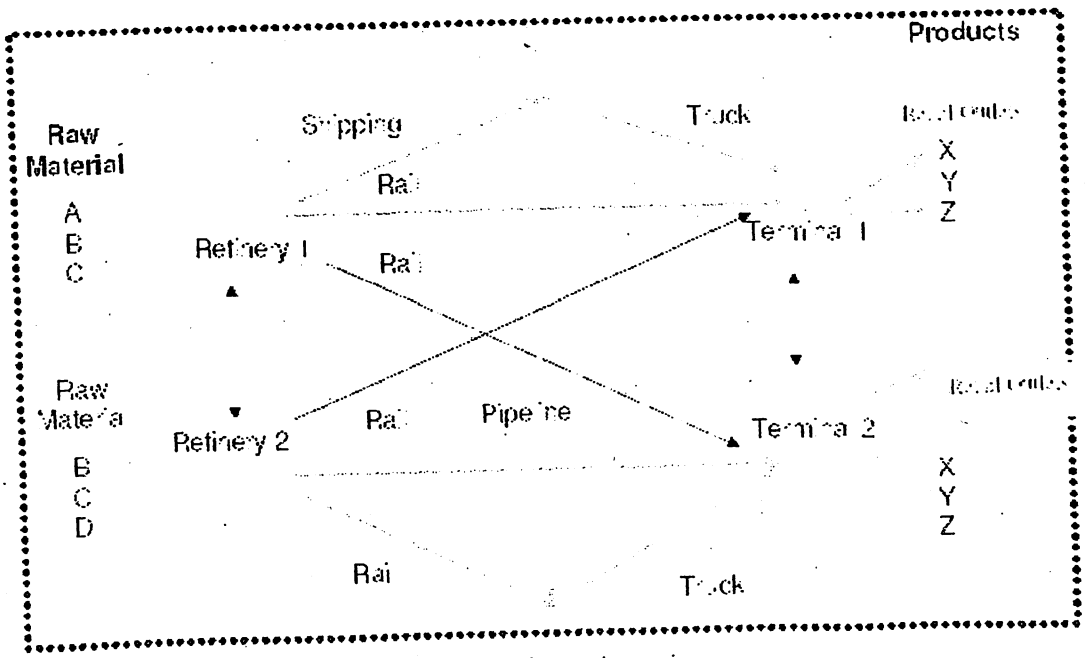
2. Supply and Distribution Optimizer:

This tool is primarily for optimizing the distribution segment. The purpose of this tool is to evaluate the different options of transporting the different products to different terminals based on demand forecasts and forward prices so that the margins are maximized.

The economic optimization is accomplished by using the Linear Programming technique. The margins calculated include sales revenues as well as the costs of purchase, production, inventory holding, transportation and materials handling.

By using its Mixed Integer Programming (MIP) option, the Network Optimizer also permits the user to define variables that can only take on integer values. This capability permits the modeling of the use of whole container or vessels, and a variety of "either/or" situations. The Optimizer input/ output may have a number of maps associated with the model. These maps are used to input data as well as view results. The Distribution Network Optimizer plays a key role in not only making the best use of capacities in the system (asset utilization), but also ensures that all forecast demands are met (prioritizes the distribution to make the most economic sense). There are different means of taking the product from one place to the other. It can be a pipeline, a container, rail wagons, or road tankers. It can also be a combination of two or more means of transportation.

The different entities, which comprise the distribution network for the downstream sector, are shown below.



3. Replenishment and Scheduling:

The above two steps clarifies how much quantities are to be moved and from where so as to get the optimum routes which would minimize the costs.

The important question to be answered now is when. There are tools available which work with LPs to arrive at schedules. They use heuristic algorithms that analyze all possible combinations of delivered volumes and available transport to come up with a lowest cost, highest profit solution. These systems determine "delivery windows" rather than simply run out points in order to allow added flexibility for the application to minimize costs and eliminate supply chain failures.

By determining both the retain (no-fit) point and the run out point, the Replenishment Scheduling tool gives itself added abilities to evaluate all opportunities before generating the optimized replenishment plan.

To generate the optimized plan, the Replenishment Planner utilizes cost minimization and profit maximization heuristics. This replenishment plan considers:

- Product demand

- Associated transportation resources and costs

- Available storage

- Product acquisition costs, physical constraints and restrictions (Pipeline maximums/minimums, cycle times and product sequences, etc.)

- Exchange product sources to generate the optimized replenishment plan

Users can manually create their own movements, trades or exchanges, and lock them into the replenishment plan. Movements are defined by products, product volumes, source location, destination, transportation resource, etc.

In this process, the Scheduler can make necessary changes to the "optimized" plan if there are modifications to the transport schedule, sudden transport unavailability, sequencing delays, compartmentation modifications, etc. Those changes are then sent back to the Replenishment Planner for schedule confirmation. These new actuals trigger a series of automated supply chain adjustments that can extend up into the refinery and crude selection, if warranted.

The end result is a completely integrated, dynamic and self-adjusting supply chain planning and scheduling.

CHAPTER # 4

Software Techniques and Models and their Application in SCM

4.1 **Linear Programming Model**

4.2 **Optimization Techniques**

4.3 **Experiences and Benefits**

Software solutions based on Linear Programming (LP) technique have emerged as leaders among various mathematical optimization techniques available to optimize the entire supply chain from crude evaluation and selection, production planning and product logistic planning.

The objective of this is to create an application of Linear Programming (LP) in refinery planning and optimization as a key component of the business supply chain.

This includes:

- **Petroleum Refinery:** Complexity of operations and the need and scope of optimization
- **Implementation of Linear Programming** for refinery planning and optimization
- **Experiences in implementation** and usage of Linear Programming

Refinery planning and optimization is mainly addressed through successive linear programming software like RPMS (Honeywell Hi-Spec Solutions), PIMS (Aspen Technology), and GRTMPS (Haverly Systems), while more rigorous non-linear planning models for refinery planning have been recently developed. The experiences discussed here pertain to RPMS (Refinery and Petrochemical Modeling System). RPMS is used today at more than 100 refineries and petrochemical plants worldwide for operations planning, crude oil evaluation and selection, inventory management, future investment analysis and to analyze "what if" scenarios.

NEED AND SCOPE FOR OPTIMIZATION IN REFINERY OPERATIONS

Most refineries are owned by integrated oil companies having a variety of interests, from exploration and production through refining and marketing to retail sales. Within such an organization the refinery works under the direction of the Head office. The Head office negotiates long-term and short-term crude supply contracts while the product Supply and Distribution department sells products. The refinery itself typically works within the overall framework of the organization to maximize the corporate profitability. This makes the refining an extremely complex and dynamic activity. Along with the complexity of refining, there also exists a great degree of freedom in refinery operations. Therefore, the refiners have got both an enormous complexity and considerable freedom to satisfy the customer requirement and make profit. This requires the optimization of multiple objectives in the refinery's business supply chain.

The table below provides a glimpse of the multiple objectives of refinery optimization:

Minimize crude landed cost at refinery
Optimize refinery crude mix
Optimize black oil generation and upgradation, optimize overall product mix and dispatch
Minimize quality giveaway
Optimize fuel consumption, minimize losses
Optimize utilization of the assets
Optimize inventory management
Optimize capacity utilization and shutdown planning
Optimize unit operations maintaining highest standards of safety, catalyst life and activity, etc.

All of the objectives mentioned above present a refinery with a challenging problem and an opportunity to maximize the overall profitability.

In a nutshell, the need and scope for optimization is so vast in a refinery that it is essential to use software tools not only to arrive at the best plan, but also to quickly evaluate the new optimum with internal or external changes in the business scenario.

MEANING OF OPTIMIZATION AND LINEAR PROGRAMMING

Optimization means "the action of finding the best solution within the given constraints and flexibilities." Linear Programming (LP) is a mathematical technique for finding the maximum value of some equation subject to stated linear constraints. It is commonly used in refinery planning to identify with confidence the most profitable refinery-wide operating strategy.

The "linear" in LP stands for the algebraic aspect, i.e. all the constraints and objective functions are linear and satisfy two fundamental properties: proportionality and additivity. The "programming" in LP actually means "planning" only. The implementation of LP involves the development of an integrated LP model representing the refinery operations with all constraints and flexibilities and then solving it to determine the optimum plan.

The refinery-wide optimization using an LP model has been proven to bring economic gains far higher than unit-specific simulation models or advance process control techniques.

In short, the LP model is an excellent economic evaluation tool to drive the entire supply chain toward higher profit.

Some of the key areas for LP applications in the oil industry are:

- Grassroots refinery design/configuration
- Selection and evaluation of crude oils and raw materials
- Long-range and short-term operations planning
- Capital investments evaluation for process equipment
- Analysis of the profitability of merging and acquisition plans and the creation of ad-hoc models for joint venture refineries
- Evaluation of processing agreements and product exchange contracts
- Evaluation of new process technologies
- Control of the refinery performance
- Product blending control
- Down-time planning
- Inventory management

IMPLEMENTATION OF LP FOR REFINERY PLANNING AND OPTIMISATION

Refinery planning forms the foundation for the business decisions that have the biggest impact on refinery profitability.

A refinery typically prepares the following types of plans:

- **Annual plans** for annual budgeting, term crude contracts and maintenance shutdown planning
- **Monthly rolling plans** for spot crude purchases and conducting refinery operations inline with product demands
- **Weekly plans** for finding operating strategies for units at the weekly level, i.e. the refinery knows precisely which crude it has and must decide which crude cocktails to run, how long to do so and how it is going to meet any particularly large or difficult product demands
- **Strategic plans** for future years and expansion projects
- **Profitability improvement plans** for plant -level modifications and revamp projects

The preparation of any of the above types of plans requires a set of standard procedures and an LP model customized for the refinery configuration.

DEVELOPMENT OF A REFINERY LP MODEL

Development of a refinery planning LP model primarily involves customization of commercially available LP modeling software to refinery configuration. Development of a refinery LP model is an arduous task that demands sound, accurate and complete understanding of the refining process and planning functions. It requires compilation of enormous plant data and meticulous documentation of the same.

Major steps the in development of a refinery LP model

Some of the major steps involved in the development of a refinery LP model include:

- Mapping of the existing planning process and data collection
- Development of a future planning process inline with best practices
- Finalization of Functional and Design Specifications (FDS) for the refinery LP model building, software and hardware configuration
- Refinery model building as per FDS
- Factory acceptance test of refinery model
- Tuning of model at site and trial usage for planning and case studies
- Site acceptance test of the refinery LP model .

The list of steps mentioned is not exhaustive and requires micro-level activity planning. The role of an LP consultant is very important as he has to balance the needs of the refinery planner and the intricacies involved in modeling each constraint and options. Initially, it is better to keep the model simple and understand its behavior. The complexities must be added gradually, keeping in mind what economic impact they have on refinery profitability.

Some of the **key features of a refinery LP model** include:

Objective function in an LP model

A refinery LP model is generally configured with a single objective function of maximizing the profit as explained below:

- To maximize {□ (Product value) - □ (Raw Material cost) - □ (Refinery Variable Costs), subject to the various constraints defined in the model including the inventory value and carrying cost parameters.

Modeling techniques and optimization features

A refinery LP model contains modeling capabilities like Successive Linear Programming (SLP), Mixed integer programming (MIP), Implicit and Explicit Pooling, Multi-period modeling, Distributive property recursion, attribute error tracking, rigorous sulfur distribution, etc. Compared to an approach based on average values, these techniques provide very accurate estimates of yields and qualities of finished goods, all the while keeping short computation times.

Model Input

Once all the static data is configured, the model is updated with the variable data in model for solving a particular problem. The common variable data required includes:

- Crude oil or any other raw material prices and minimum and maximum availability
- Selling prices and minimum and maximum demands for the different finished goods

- o Available process unit capacities
- o Available Inventory stocks and minimum and maximum storage limits
- o Quality specifications, etc.

User Interface

LP software commercially available today is highly advanced with features to provide a maximum user-friendly experience.

RPMS has a powerful Graphical User Interface (GUI), which provides a highly effective and intuitive interface for working with the model.

It contains a model navigation window with graphical objects. The graphical objects contain information on Charge Yields, Feeds, Products, Results, etc. Data and Report factory is an integrated application of RPMS for input of static and variable data and generating standard reports in Excel

TRADITIONAL LIMITATIONS AND LATEST ADVANCES IN LP

The LP technique is far superior when compared to any Excel programs traditionally used for planning. However, it is worthwhile to keep in mind certain limitations of LP in order to appreciate the LP solutions:

1. **Non-linear nature of refinery processes:** The nature of the refining processes is mainly non-linear whereas linear programming - as the name already suggests - assumes that a linear combination of the provided options is valid. RPMS uses a specialized recursion technique called Successive Linear Programming (SLP) for modeling and solving non-linear problems. For most of these, engineers have developed "linear blend indices," which transform the measured qualities into index values, which can be constrained using ordinary linear constraints.

2. **Data overload:** While developing the model, providing all the possible processing options is impossible. Increasing the number of variables and constraints increases the efforts to maintain the database and the difficulty to maintain the required data consistency. It also reduces the system's transparency, therefore increasing the chances of big errors in data and logic. RPMS has a powerful interface with Excel and tools like Fast Data Import, model comparison, etc. to minimize the data errors.

3. **LP does not consider the elements of time and storage:** It assumes that all activities occur simultaneously and that all identified components are separately available for further processing or blending (like there are separate tanks available for all individual components). A refinery may process HS and LS crudes in a blocked-out fashion, whereas an LP model mixes HS and LS crudes simultaneously.

4.3 EXPERIENCES AND BENEFITS

Building a refinery LP model is not a trivial exercise. It needs clear understanding of the entire web of refinery operations and the compilation of good quality data. The model development activity is very time consuming and can take about a year for developing a good and robust model.

Interpretation of LP Output: The task of analyzing the LP output is not a simple exercise, mainly due to the limitations of the technique and the complexity of its output. It requires sustained effort in generating and analyzing the various feasible and optimum solutions and rigorous sensitivity analysis.

Computation Time: Today, we solve substantially more complex LP problems in mere seconds on our desktop PCs. The running time limitations have lost much of their relevancy with the availability of desktop PCs with higher computing power.

CHAPTER # 5

Research Design, Methodology and Plan

5.1 IOCL Case Study

5.2 Data Collection

5.3 Analysis on Consumption Trend

5.1 IOCL CASE STUDY

Overview

Indian Oil Corporation (IOCL) is India's number one oil company and holds the 189th spot on the famed Fortune 500 list of companies. It is the19th largest petroleum company in the world and has also been recognized as the number one company in petroleum trading among the national oil companies in the Asia-Pacific region.

As India's flagship national oil company, IOCL accounts for 56% petroleum products market share among public companies, 42% national refining capacity and 69% downstream pipeline throughput capacity. The company has a countrywide sales network of more than 23,000 retail outlets, including more than 10,000 petrol/diesel stations – backed by 165 bulk storage facilities, 95 aviation fuel stations and 85 LPG bottling plants. Its subsidiary, IBP Co. Ltd., has another 3,000 retail sales outlets.

IOCL operates 10 of India's 18 refineries with a combined rated capacity of one million barrels per day (bpd). The company also owns and operates the country's largest network of cross-country crude oil and product pipelines of 7,730 km, with a combined capacity of 58.62 million metric tons per annum.

For the year 2004-05, IOCL sold 50.1 million tones of petroleum products, including exports of 1.96 million tonnes. It's seven own refineries achieved a throughput of 36.63 million tonnes, and the pipeline network transported 43.03 million tonnes of crude oil and petroleum products.

Challenges

As a leading oil supplier, IOCL had the multifaceted challenge of maintaining its leadership position and meeting its vision of being a diversified, integrated energy company with a strong environment conscience and national role in oil security and public distribution.

As the company looked for ways to maximize profits one thing was clear – more visibility into the supply chain and finding ways to optimize this value chain was critical. IOCL evaluated different supply chain management solutions to address this business problem and how best to implement a solution that integrates five separate refineries.

A multi-site refining company has various supply chain problems to solve including: which crude to buy, where to process it, how much to buy and make, what to make and where and how to transport it

Optimization, IOCL. Traditionally different departments or divisions within one organization manage their own disparate project of this complex process and don't always talk with one another. As a result, decisions are sometimes made based on incomplete data or they can't be applied across the entire corporation.

The challenge was how to plan for various possible breaks that could occur in the supply chain and how to best optimize each specific point to increase our profitability and link activities of five separate refineries.

Solution implementation

IOCL selected Honeywell to provide and implement the solution. The supply chain management solution consists of an integrated suite of advanced forecasting, planning and scheduling tools to more effectively manage the broader supply chain.

An integrated framework throughout the solution supports various modules and state-of the art tools for a broad range of business decisions. These enable the company to monitor the condition of the supply chain in real-time or near real-time and provide immediate feedback and exception notices.

The models developed with the supply chain management solution covered IOCL's entire supply chain, from crude purchase to finished product distribution, including demand, refinery process models, blending models and distribution system models.

The solution combines the new visibility with advanced execution solutions, allowing the right decisions to be made more quickly and more often while minimizing disruptions.

The result is substantial improvement in profitability through measurable inventory and product cost reductions, faster reaction to market opportunities, improved customer relations and stronger collaboration with suppliers and customers.

Supply chain planning solution.

The solution consists of the following modules:

1. **Demand planning:** for demand forecasting and aggregation of the final demand numbers based on supply chain requirements

2. **Integrated planning:** for IOCL's complete supply chain based on demand numbers

3. **Distribution planning:** generating operational plans for distribution

4. **Refinery production planning:** generating operational plans for production.

These modules were supported by various enablers that facilitated IOCL's planning activity.

These include: assay database, assay manager and assay conversion utility; supply chain database (bolt-on database); geographical information system (GIS); and data interfaces.

To make IOCL's supply chain more responsive to demand, the solution is driven by the demand numbers. Location-wise demands are uploaded into the supply chain database. This is the repository of the entire logistic-related data, which includes static data like modes, terminals/depots and linkages.

It also contains dynamic data such as demand data and product prices for depots and terminals, linkage costs based on freight, duties and taxes, and crude availability and costs.

These data are used by the integrated planning model. The model also contains the refinery configuration. The refinery and the supply/demand structure form the basis on which the optimized plan for the entire corporation is generated.

The geographical information system is used to obtain the distances between locations, which is used as a basis for freight calculation.

Demand planning

To make IOCL's supply chain more responsive to demand, the solution is demand-driven. The demand-planning module takes into account such things as forecast sales of finished product, contractual production obligations and real-time market pricing and trends, allowing IOCL to take advantage of profitable opportunities in real-time.

Aggregated demand numbers from the demand-planning module are then uploaded to the supply chain database, which is the repository for all logistics-related data. From there, the data is incorporated into the integrated planning model.

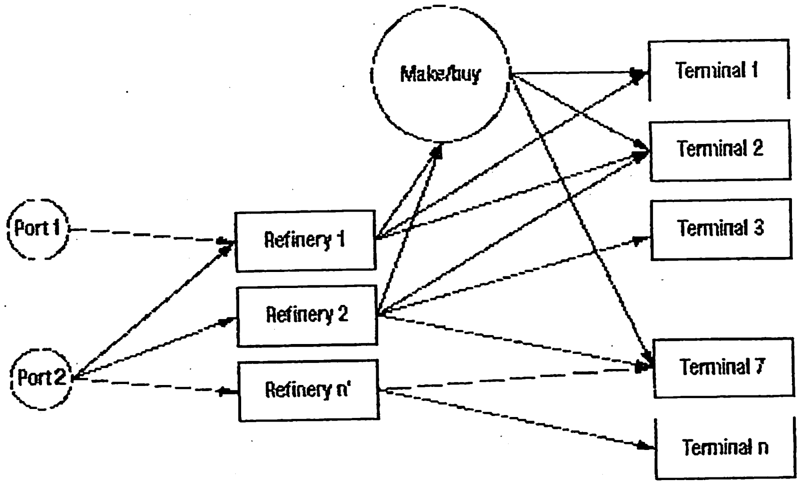
Integrated Planning Model

The integrated planning model is actually an aggregation of refinery, distribution and demand sub-models, each requiring large amounts of data.

The integrated planning model was developed using refinery LP software with multiplant features. The model covers IOCL's entire supply chain from crude purchase at the refinery gate or ports to product distribution at the terminals. This makes it one of the largest scopes of this type (Fig. 2).

The three main objectives of the integrated planning model are:

Crude selection, crude allocation to refineries and optimization of the refineries' product pattern.



Typical inputs and outputs of the integrated planning model :

<u>Inputs</u>

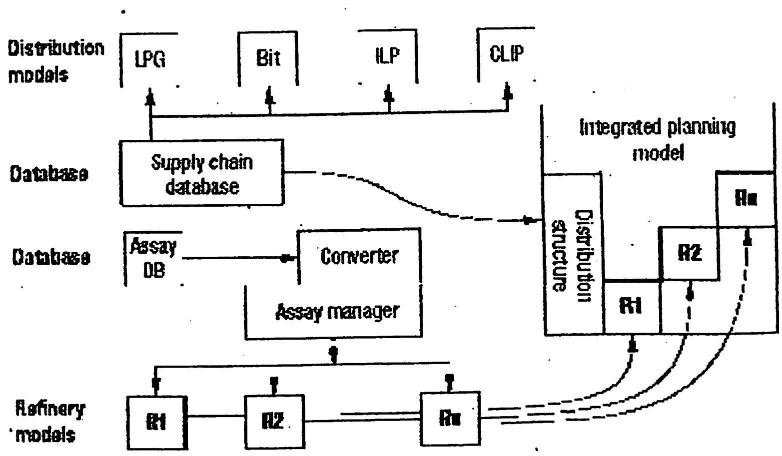
- Crude availability at ports/refineries
- Location level demand (at all terminals/depots/major customers)
- Desired inventory buildup/depletion
- Committed exports, imports
- Exchanges with OMCs
- Planned shutdown schedule
- Changes in product specifications
- Crude prices/purchase cost
- Product prices
- Yield vectors of extreme-point refineries

Outputs

- Refinery-wide throughput and crude allocation
- Future crude requirement
- Refinery-wide product pattern
- Detailed distribution plan product-wise, mode-wise
- Purchases, exchanges
- Gross margin

Supporting models and software.

The integrated planning model is actually an aggregation of refinery sub models and the distribution models. These models, in turn, require databases to construct them. There is a small difference in the way refinery structure and distribution structure is handled.



Refinery planning model

The proprietary Honeywell Refinery and Petrochemical Modeling System (RPMS) contains integrated planning features, cost-effective implementation and investment modeling capabilities. It also incorporates data from the crude assay database

These refinery models, along with the crude assay data, are directly embedded into the integrated planning model, with supply and distribution structure obtained from the supply chain database. This design allows the flexibility to model greater detail in the distribution models than is required merely from the perspective of corporate-wide optimization.

Supply chain database, distribution models.

The supply chain database has these functions:

• **Temporal integration:**

Data for yearly and quarterly models are available in one place and can be rolled up or down as required.

• **Hierarchical integration:**

Aggregation for the integrated model is done based on detailed data available for operational distribution models.

• **Calculations:**

Final linkage costs are calculated using tax logic, current prices, distances and freight rates.

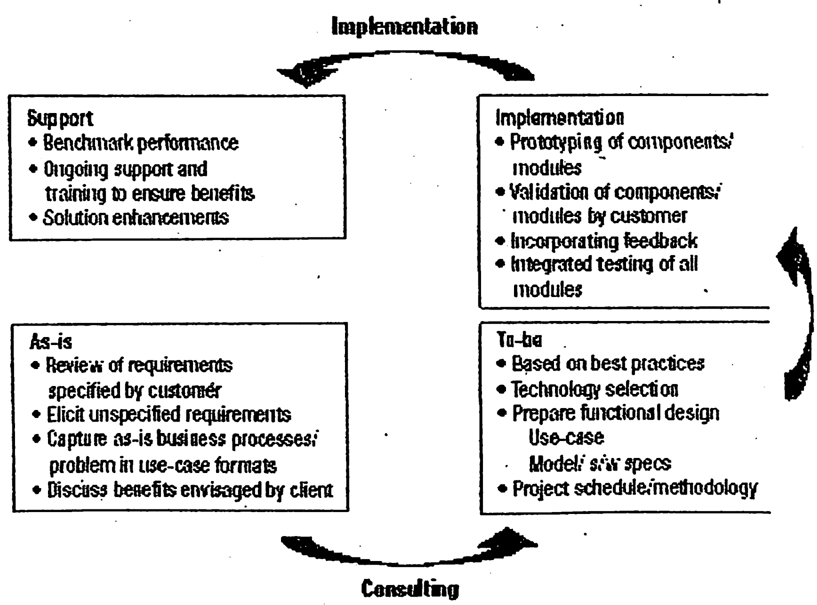
The supply chain database provides distribution-related inputs to both the integrated planning and distribution planning models. Integrating the software, models and database required a number of data interfaces. These included middleware technology for enterprise application integration, IT infrastructure monitoring tool, and a combination of third-generation language and a relational database management system.

Implementation Methodology

Both IOCL and the solution provider's resources were involved at each stage. Broadly, these phases were the consulting, implementation and support stages.

The implementation stage involved model prototyping and development (Fig. 4). User feedback was applied to fine-tune the models and software. The various models and software were tested individually, eventually in the integrated planning environment. IOCL's involvement in this stage was critical for the technology transfer.

During the support stage, the solution provider helped IOCL in benchmarking the complete planning process. Under the support agreement, the consultants pay regular visits to IOCL sites to ensure that benefits are sustained.



5.2 DATA COLLECTION

Type of data

The type of data is available from two sources

Primary data: ICOL visit, Faridabad (Project Manthan)

Secondary data: Internet, Company Manual, External source

Primary data sources:

Survey Method: It was done by survey with the help of questionnaire

Secondary data sources:

Internal sources: Meeting with the Retail Outlet official.

In proceeding with the study I made a random survey of different Retail Outlet in South Delhi. I also collected Information about different retail outlet. Study focused on the Monitoring of supply trend of petrol of different outlet.

For this I have selected Motor Spirit and High Speed Diesel as my target product because of the following reasons.

The break-up of MS/ HSD sales into retail and direct, over the last two years is given Table. Thus, IOC is a very large player in the direct market with 90.4% share in MS-Direct and 76.0% share in HSD-Direct

Table-2: Break-up of MS/HSD sales

Year	MS			HSD			Total	Total
	Retail	Direct	Total	Retail	Direct	Total	Retail	Direct
1995-96	4511	177	4688	24240	8019	32259	28751	8196
1996-97	4820	166	4986	26660	8590	35250	31480	8756
1995-96	96.22%	3.78%	-	75.14%	24.86%	-	-	-
1996-97	96.67%	3.33%	-	75.63%	24.37%	-	-	

Thus the below chart will show the sale pattern of the Motor Spirit for the Current year and the Last year of the retail outlets of South Delhi.

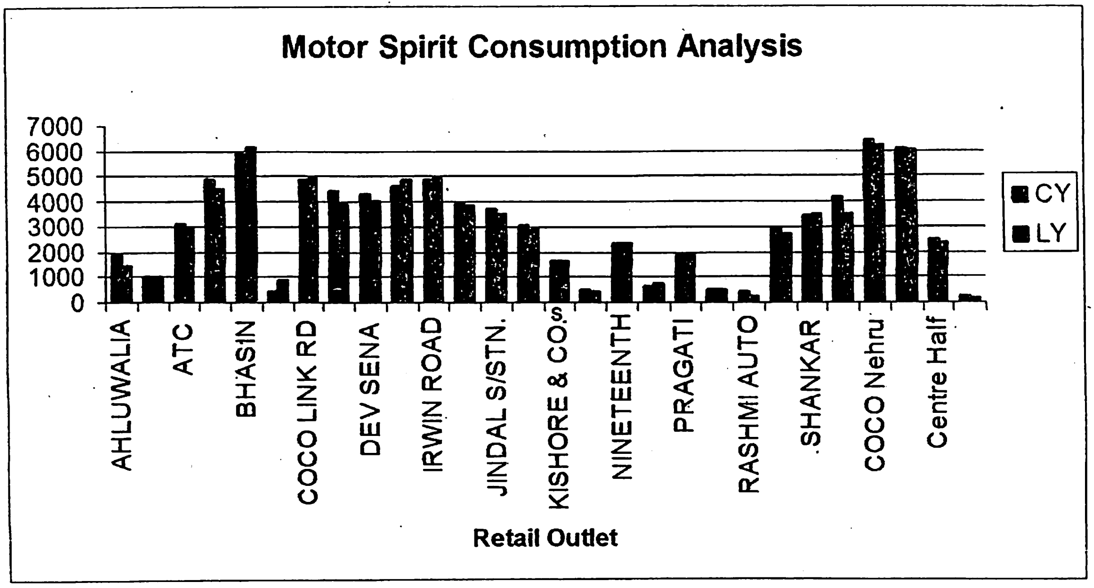
MIS MAR'07 MS IOCL RETAIL OUTLET					CUMULATIVE			
	CY	LY	+/-	%	CY	LY	+/-	%
AHLUWALIA H'WAY PETROL PUMP	192	120	72	60%	1932	1488	444	29.8
ASHISH S/STN.	108	84	24	29%	1032	1008	24	2.4
ATC	300	252	48	19%	3132	2998	134	4.5
AUTOYARD	420	384	36	9%	4896	4506	390	8.7
BHASIN	516	504	12	2.4	5952	6180	-228	-3.7
COCO- CP	24	60	-36	-60.0	468	912	-444	-48.7
COCO LINK RD	420	408	12	2.9	4872	4920	-48	-1.0
DELHI AUTOMOBILES	396	336	60	17.9	4440	3928	512	13.0
DEV SENA S/STN	360	324	36	11.1	4291	4024	267	6.6
INDRAPRASTHA S/STN.	400	372	28	7.5	4604	4864	-260	-5.3
IRWIN ROAD S/STN.	432	396	36	9.1	4872	4932	-60	-1.2
JAI SAI MOTORS	336	318	18	5.7	3936	3822	114	3.0
JINDAL S/STN.	324	288	36	12.5	3732	3540	192	5.4
KAILASH S/STN.	276	228	48	21.1	3060	2928	132	4.5
KISHORE & CO.	144	138	6	4.3	1676	1662	14	0.8
MEHRA BADARPUR S/STN.	60	52	8	15.4	492	436	56	12.8
NINETEENTH HOLE S/STN.	216	180	36	20.0	2364	2388	-24	-1.0
PEAREY LAL & SONS	60	60	0	0.0	672	756	-84	-11.1
PRAGATI	168	144	24	16.7	1944	1972	-28	-1.4
RAJDHANI S/STN.	48	36	12	33.3	528	528	0	0.0
RASHMI AUTO	48	24	24	100.0	444	288	156	54.2
SARITA S/S	276	228	48	21.1	3012	2772	240	8.7
SHANKAR AUTOMOBILES	324	288	36	12.5	3444	3540	-96	-2.7
SUPER AUTO CENTRE	372	312	60	19.2	4152	3540	612	17.3
COCO Nehru Place	516	516	0	0.0	6408	6212	196	3.2
Dhingra S/Stn	480	504	-24	-4.8	6108	6060	48	0.8
Centre Half	240	192	48	25.0	2484	2388	96	4.0
THE METROPOLE S/STN.	24	12	12	100.0	228	192	36	18.8

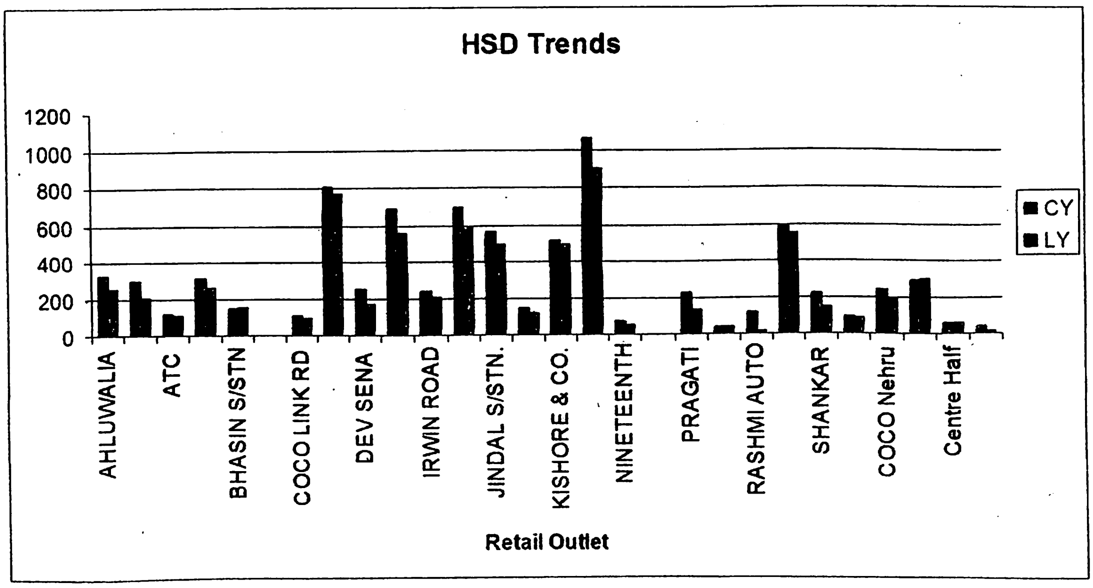
Below chart will show the sale pattern of the High Speed Diesel for the Current year and the Last year of the retail outlets of South Delhi.

MIS MAR'07								
HSD								
IOCL					CUMULATIVE			
RETAIL OUTLET	CY	LY	+/-	%	CY	LY	+/-	%
AHLUWALIA H'WAY PETROL PUMP	324	252	72	28.6	3744	2696	1048	28.0
ASHISH S/STN.	300	204	96	47.1	3048	2532	516	16.9
ATC	120	108	12	11.1	1452	1320	132	9.1
AUTOYARD	312	264	48	18.2	3780	3480	300	7.9
BHASIN S/STN	144	156	-12	-7.7	1872	1740	132	7.1
COCO- CP	0	0	0	#DIV/0!	0	0	0	#DIV/0!
COCO LINK RD	108	96	12	12.5	1260	1296	-36	-2.9
DELHI AUTOMOBILES	804	768	36	4.7	9824	8316	1508	15.4
DEV SENA S/STN	252	168	84	50.0	2864	1885	979	34.2
INDRAPRASTHA S/STN.	692	560	132	23.6	7476	6702	774	10.4
IRWIN ROAD S/STN.	240	204	36	17.6	2736	2640	96	3.5
JAI SAI MOTORS	696	600	96	16.0	8712	9048	-336	-3.9
JINDAL S/STN.	564	492	72	14.6	6204	4764	1440	23.2
KAILASH S/STN.	144	120	24	20.0	1740	1608	132	7.6
KISHORE & CO.	516	492	24	4.9	5868	6072	-204	-3.5
MEHRA BADARPUR S/STN.	1060	900	160	17.8	12616	9692	2924	23.2
NINETEENTH HOLE S/STN.	72	48	24	50.0	756	672	84	11.1
PEAREY LAL & SONS	0	0	0	#DIV/0!	0	0	0	#DIV/0!
PRAGATI	228	132	96	72.7	2352	1886	466	19.8
RAJDHANI S/STN.	36	36	0	0.0	552	552	0	0.0
RASHMI AUTO	120	12	108	900.0	888	408	480	54.1
SARITA S/S	588	552	36	6.5	6016	5592	424	7.0
SHANKAR AUTOMOBILES	216	144	72	50.0	2244	1980	264	11.8
SUPER AUTO CENTRE	96	84	12	14.3	1284	1056	228	17.8
COCO Nehru Place	240	192	48	25.0	2784	2404	380	13.6
Dhingra S/Stn	288	300	-12	-4.0	3888	4080	-192	-4.9
Centre Half	60	60	0	0.0	792	1176	-384	-48.5
THE METROPOLE S/STN.	36	12	24	200.0	384	312	72	18.8

Based on the data collected, analysis of their consumption behavior is done which shows the different consumption pattern of different retail outlets and based on their consumption behavior, their supply trend is depicted. And retail outlets which have less supply then the reason for that is analyzed and that may be due to any reason like adulteration, less delivery etc.

And accordingly the supply pattern is generalized and practices are done in order to improve the supply chain pattern.





5.3 Questionnaire Design Format

DATA COLLECTION QUESTIONNAIRE	
Name:	
Position:	
Name of the Retail Outlet:	
Location of the RO:	

Details of Products Handled by the Retail Outlet

Name of Product	Source of Supply	Volume Handled per Day	No of Tanker

CHAPTER # 6

Benefits and Recommendations

BENEFITS:

IOCL has also seen numerous tangible benefits from the project, including:

— Higher margins and increased profitability

— Crude selection and allocation, which takes into account product demands, refinery capabilities and the effect of crudes already in the supply chain

— Refinery production planning that includes crude assays, unit capacities, product specifications and demands, as well as feedstock availability

— Distribution planning that includes transportation costs, taxes and duties, as well as transportation constraints

— Improved visibility into the supply chain process across the five refineries

— Improved investment analysis for all capital expenditures

— Business analysis capabilities that enable strategies to meet future scenarios; i.e., specification changes, supply/ distribution infrastructure changes and competitive landscape changes

— Faster, more effective decision making on exchange strategies, imports and exports

— Improved response and execution capability.

RECOMMENDATIONS:

Thus:

Implementing this vision will allow companies to:

• Link manufacturing to market demand, sales channels, and customers.

• Exploit situational opportunities and market dynamics; enable real-time Availability to Promise and Planned Capable to Promise.

• Optimize margins across a complex and simple networks from single refinery to multiple refinery models.

• Perform crude selection at the supply chain level.

• Bring visibility into the extended value chain - plans and schedules are executable.

The benefits of using transparency, control and corporate governance will lead companies to be able to:

• Rapidly take advantage of crude and marketing opportunities, knowing that they were going to be profitable.

• Be more agile than competitors in decision making abilities.

• Replace transfer price mechanisms with integrated margin optimization.

• Eliminate minor disruptions through visibility of information.

Performing planning optimization will enable companies to:

• Eliminate infeasible plans by integrating planning and scheduling.

• Provide the feedback control loop.

Using advanced supply chain management techniques will allow companies to:

• Continuously optimize your physical assets and working capital.

• Continuously optimize your crude and product mix.

CHAPTER # 7

BIBLIOGRAPHY

Bibliography

1. Arntzen, B. C., G.G. Brown, T.P. Harrison, and L.L. Traffton, L. L. [1995], "Global Supply Chain Management at Digital Equipment Corporation," Interfaces, 25, pp. 69-93.

2. Atkinson, A. A., R. D. Banker, R. S. Kaplan, and S. M. Young, Management Accounting, Second Edition, Prentice-Hall, 1997.

3. Barboza, D., [1999], "Conagra Enlisting in the March Toward a Leaner Food Industry," Cohen, K. J. and Cyert R. M. [1965], Theory of the Firm: Resource Allocation in a Market Economy, Prentice Hall.

4. Conner, K. R. [1994] "A Historical Comparison of Resource-Based Theory and Five Schools of Thought within Industrial Organizations Economics: Do We Have a New Theory of the Firm?," Journal of Management, 17, pp. 121-154.

5. Crum, M. R., and M. C. Holcomb [1994], "Transportation Outlook and Evaluation," Chapter 21 in J. F. Robeson, W. C. Copacino and R. E. Howe, editors, The Logistics Handbook, The Free Press.

6. Hanssmann, F., [1959], "Optimal Inventory Location and Control in Production and Distribution Networks," Operations Research, 7, 483-498.

7. Holmstrom, B. R., and J. Tirole [1988], "The Theory of the Firm," in Handbook of Industrial Organization, edited by R. Schmalensee and R. Willig, North-Holland.

8. LaLonde, B. J., J. R. Grabner and J. F. Robeson [1970], "Integrated Distribution Systems: A Management Perspective," International Journal of Physical Distribution Management, 40.

9. Makridakis, S., and S. Wheelwright [1986], Forecasting: Methods and Applications, Wiley.

10. Porter, M. E., [1985], Competitive Advantage: Creating and Sustaining Superior Performance, The Free Press, MacMillan.

11. Porter, M. E., and V. E. Millar [1985], "How Information Gives You Competitive Advantage," Harvard Business Review, 149-160.

12. Pralahad, C. K., and G. Hamel [1990], "The Core Competence of the Corporation,' Harvard Business Review, May-June, 79-91.

13. Rajaram, K. R., Jaikumar, F. Behlau, F. van Esch, C. Heynen, R. Kaiser, A. Kuttner, and I, van de Wege [1998], 'Robust Process Control at Cerestar's Refineries," Interfaces, 29, 30-48.

14. Schrage, L., [1997], Optimization Modeling with LINDO, Duxbury Press.

15. Shapiro, J. F., V. M. Singhal and S, N, Wagner [1993], "Optimizing the Value Chain," Interfaces, 25, 102-117.

16. Shapiro, J. F., [1993], "Mathematical Programming Models and Methods for Production Planning and Scheduling," Chapter 8 in S. C. Graves et al, editors, Handbooks in OR & MS, Volume 4, Elsevier Publishers..

17. Sipper, D., and R. L. Bulfin [1997], Production: Planning, Control, Integration, McGraw-Hill.

18. Srinivasan, V., and A. D. Shocker [1973], "LP Techniques for Multi-Dimensional Analysis of Preferences," Psychometrika, 38, 337-369.

19. Stock, J. R., and D. M. Lambert [1987], Strategic Logistics Management, second edition, Richard D. Irwin and Company, Homewood, Illinois.

20. Wernerfelt, B., [1984], "A Resource Based View of the Firm," Strategic Management Journal, 5, pp. 171-180.

21. Wilson, R. H., [1934], "A Scientific Routine for Stock Control," Harvard Business Review, 13, 116-128.

22. Winston, W. L., [1994], Operations Research: Applications and Algorithms, Thgird Edition, Duxbury Press.

Website surfed

- http://www.scmtechnologyevolution.com
- http://www.scmworld.com/
- http://www.supplychainmanagement.com/
- www.google.com
- www.wikipedia.com
- www.bettermanagement.com
- www.iocl.com
- www.sas.com
- www.vivisimo.com