21 Oil Industry

Mario Roitsch[1] and Herbert Meyr[2]

[1] OMV Refining und Marketing GmbH, Supply Chain Development, Lassallestraße 3, 1020 Wien, Austria
[2] Technical University of Darmstadt, Department of Production & Supply Chain Management, Hochschulstraße 1, 64289 Darmstadt, Germany

The oil market is a worldwide market. Due to an increasing demand of the fast growing countries like China and India, the oil market has been changing to a strong emerging market. Due to these effects the prices of raw material and finished goods have extremely increased and are strongly volatile. Faced with very complex production techniques and high investment costs for enlarging production capacities a European company needs a very high level of integration in planning and scheduling in its supply chain to survive in the world market.

This case study from an oil industry's downstream business is structured as following. Section 21.1 describes the oil industry supply chain itself and its classification according to the supply chain typology of Chap. 3. The next section draws a picture of an "ideal" planning system meeting all these challenges. Derived from there the company's realization of the advanced planning, optimization and scheduling systems will be described. Afterward Sect. 21.4 provides the implemented solution, its modules as well as their interaction. The Sect. 21.5 is focused on the description of the APS introduction projects "Supply & Demand Manager" and "Product Supply Scheduling". Finally, the overall benefits are presented and an outlook on future activities is given.

21.1 Supply Chain Description and Typology

The described company acts in the oil industry's downstream business — Refining (production) and Marketing (sales) — in 14 countries of Middle and Eastern Europe and is facing a lot of big challenges in its supply chain (see Fig. 21.1).

At first, one of the essential specifics of this oil industry's supply chain is the long lead time for the supply of crude oil. The crude oil is purchased from all over the world and has to be transported via ship. Due to the fact that the refineries we look at in this case are not situated at sea, the crude oil has to be pumped to the refineries via pipeline. So the total procedure of crude oil procurement takes between 2 and 8 weeks. Further it exists a great variety of crude oil grades, which are differentiated in their composition, yields and characteristics. In addition, the prices for raw materials (crude and semi-finished products) are very volatile. The right selection of crude

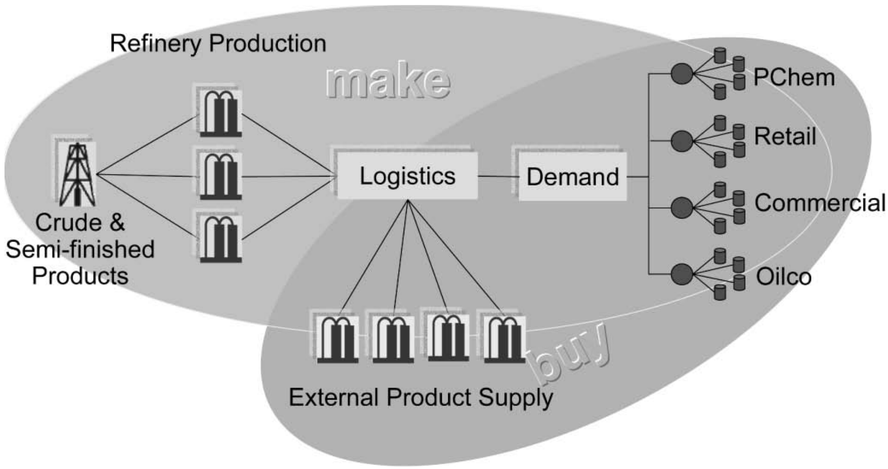

Fig. 21.1. Supply chain structure

oil is directly connected to the second main supply chain characteristic, the co-production. Dependent on the sort of crude oil, the refineries produce different quota of products like gasoline, diesel, heating oil, kerosene, liquid gas, as well as bitumen or petrochemical products like ethylene and propylene. This technical production process of distillation, conversion and treatment is very restrictive and complex.

Furthermore, the existing refinery capacities are nearly fixed and their extension is only possible with long lead times and very high investment costs. Alternatively, the purchase of finished products from competitors is possible. The distribution of the finished products to the customer is divided into primary logistics — the transport from the refinery to the tank farms via tank wagon (railway), ship or pipeline — and secondary logistics — the transport from a tank farm / refinery to the customer via truck (road transport).

The market demand and the customer behavior for these different (co-) products are very heterogeneous. Since the products are commodity products, a high price competition is the result. The present, here assumed, market model is an oligopoly, whereby in a market with a refinery the position usually is a market leadership, where a local price setting is possible. The prices for the purchase of crude oil as well as of finished products can not be influenced because they are strongly driven by the market and their environment. The stock exchange for crude oil and finished products — Rotterdam for Europe — sets the price base, which is the reference price or subscription charge in a company's price calculation.

Table 21.1 summarize the attributes of the oil industry's supply chain according to the typology of Chap. 3.

Tab. 21.1. Typology for the oil industry's downstream supply chain

Functional attributes	
Attributes	Contents
number and type of products procured	few (200 crude oil sorts possible), standard (20 crude oil sorts used)
sourcing type	multiple (of crude)
supplier lead time and reliability	long, unreliable
materials' life cycle	long
organization of the production process	co-production (distillation, conversion, treatment)
repetition of operations	batch production
bottlenecks in production	known
working time flexibility	low, none (alternative production)
distribution structure	2 and 3 stages, regionally org.
pattern of delivery	cyclic and dynamic
deployment of transportation means	standard routes and individual links
availability of future demands	forecasts and contracts
demand curve	seasonal
products' life cycle	years
number of product types	few
degree of customization	standard products
bill of materials (BOM)	split (divergent)
Structural attributes	
Attributes	Contents
network structure	mixture
degree of globalization	procurement: global sales: several (European) countries
location of decoupling point(s)	deliver-to-order
major constraints	co-production and lead times
legal position	intra- and inter-organizational
balance of power	customers, but oligopoly market
direction of coordination	central coordination
type of information exchanged	orders and contracts

21.2 Requirements for Planning

On the base of these supply chain characteristics the main challenges for a planning, optimization and scheduling system are as following. Due to the long lead times for the refinery's crude oil supply, the decision of crude oil purchase, i.e. which kind of crude oil sort in which quantity, at what purchase price and at what time — which is the most important financial decision — is the major focus. Therefore high forecast accuracy for a future customer demand per single product is fundamental.

After this decision about the crude oil supply the degrees of freedom for changes are limited, i.e. the ordered crude oil transported by ship cannot be switched or sold easily, at most with financial losses.

Furthermore, a planning system should cover the production specifics, i.e. the processing of the crude oil sorts with their different yields and their possible production procedures (distillation, conversion, treatment), with an optimization and a simulation over the different single plants and their interaction in a refinery. In addition to technical possibilities and their dependences, the plant capacities and the existing storage capacities for raw material and finished products have to be considered. With respect to the available transport and storage capacities an optimal transportation path through the distribution network to the point of sale has to be found. Additionally, the fact that alternative finished product supply is available has to be taken into consideration. A further aspect is the safety against price risks of the inventories. A price risk exists, if there is a difference between planned inventories of crude oil and inventories of finished products. These price risks have to be secured on the market and these hedging costs have to be taken in the planning system as an element of costs. Thus, the overall objective is maximizing revenues minus all variable supply chain costs within the minimum sales requirements and the maximum sales opportunities of the different markets.

21.3 Description of the (Ideal) Planning System

For all decisions mentioned in Sect. 21.2 an integrated planning system, which generates solutions in an optimal way on various questions concerning the whole supply chain at different points in time, is required.

Figure 21.2 describes the entire planning system architecture. In this section, every single planning module of the developed planning system will be described. The corresponding software modules are then added in Sect. 21.4.

Every planning cycle starts with the *Supply & Demand Planning* (S& DP). The base for these forecasting processes will be delivered from market analysis department and their estimations for the expected market demand in every market, for the demanded product qualities and especially for the expected price levels (quotations) for crude oil and finished products. Based on this information, planned sales numbers for the individual sales markets will be collected from every sales channel, e.g. estimated sales quantities and sales prices per region for diesel. Parallel to this the evaluation of quantities, available on external supply sources and their corresponding prices (purchase costs) for different crude oil sorts, semi-finished products and finished products takes place, e.g. the available quantities and the purchase costs of the finished product diesel at an external refinery. To leave freedom for optimization the potential sales quantities as well as the available purchase quantities are planned as minimal and maximal bounds on sales / purchase. Addition-

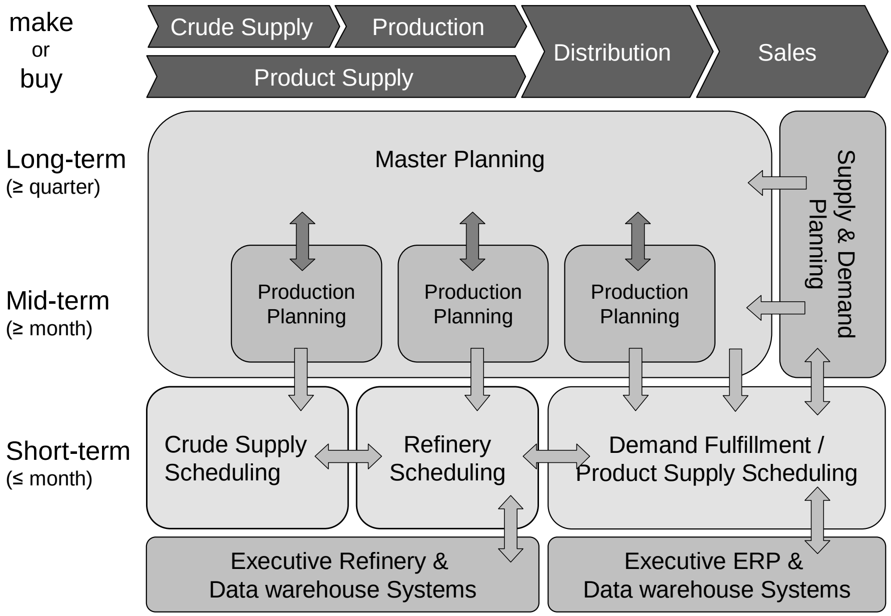

Fig. 21.2. Architecture of the planning system

ally, availabilities of finished products on external sources (as input for a "make-or-buy" decision) and their purchasing costs have to be estimated.

All this market information, together with information on production (e.g. currently available inventories of crude oil and finished products; capacities and variable costs of the refineries' plants), as well as information on distribution (like possible transportation paths and their different costs, depot throughput costs and additional fees for customs) are input data to the integrated *Master Planning (MP)*. This Master Planning, also called the "global optimization model", strictly follows the objective of maximizing the total supply chain profit with respect to supply, production and storage capacities, the technical limitations of the alternative production processes as well as the potential distribution and sales channels to the customers.

The decisions on production in the own refineries (make) or purchase of finished products from external refineries (buy), as well as the decision on the supply sources, which the customer will be delivered from (either directly or via tank farms), are the essential components. In Master Planning decisions are made for the whole supply chain network, i.e. three refineries, 80 supply sources (tank farms), and markets in 11 countries with 100 regions.

Thereby the optimization model have to fulfill two targets. Firstly to reach a stable optimization solution, i.e. in order to be usable for the following production scheduling, the MP of the whole supply chain plan have to be unaffected by small changes in the frame conditions, and secondly to handle the complexity of the supply chain model. Therefore an iterative information exchange between the global optimization model and further, more detailed, local *Production Planning* models (one model per refinery) takes place.

That way the results of the (rough, aggregate) global optimization model can be simulated and tested concerning their probable real-world effects by the more precise, local optimization models. If the local models reveal problems caused by the directives and inaccuracies of the global model, this knowledge is again put into the global optimization model (e.g. by modifying its input data or by adding additional constraints). This hierarchical, iterative process has to be run through until a feasible overall optimization result is generated.

The Master Planning model is the core of the oil company's planning system. It is used several times for different planning purposes. Table 21.2 gives an overview of the different planning levels and planning cycles applied. Before coming back to the short–term planning modules of Fig. 21.2, these different planning cycles need to be explained in more detail.

Tab. 21.2. Planning cycles of the downstream supply chain

Cycle	planning horizon	bucket lengths	re-planning frequency
a)	36 months	quarters / years	once a year
b1)	12 months	quarters	once a year
b2)	6 months	quarters	once a year
c1)	3 months	months	monthly
c2)	12 weeks	weeks	weekly

Fundamentally, the planning process as a standard process is based on an exactly fixed schedule for all planning cycles. Additional planning cycles can be triggered separately by the so–called "deviation management". The entire planning process starts with the strategic prospect into the future with the budget planning or the investment planning cycle (Tab. 21.2–a). This planning cycle drives decisions on very cost-intensive refinery investments or extensions as well as decisions on strategic contracts concerning raw material, semi-finished procurement or the purchase of finished products and in the different sales channels. Mostly in the middle of a year, long-term forecasts on market development of sales quantities per product, on demanded future product qualities, on crude oil prices and on product quotations are made. These forecasts for the next three years and the strategic company targets form the basis for the (in this case long–term) S&DP. The global Master Planning model delivers the results for six periods — quarterly for the following year and yearly units for the next two years.

At the end of the year, a recalculation of this budget planning takes place, i.e. the quarterly recalculation of the following year (Tab. 21.2–b1). Based on these recalculation strategic decisions for the next year are approved or adaptations are made, if necessary. This planning cycle is part of the “preview planning”. It is the operative framework for the next year as well the prerequisite for the decision on further agreements and contracts. This planning cycle will be repeated before the middle of the year for each of the last two quarters of the running year (Tab. 21.2–b2). This way the achievement of the budget targets can be assessed and necessary adaptations for the second half of the year become visible.

The highest level of detail for S&DP and MP is reached in the short–term monthly planning (Tab. 21.2–c1). Here, the next quarter of the year is optimized in a monthly revolving planning in order to synchronize the operational processes of the supply chain as a whole. Further on, there is also a weekly Production Planning cycle (Tab. 21.2–c2), which takes decisions on the short-term crude oil supply for the next twelve weeks. For this, only the local optimization models (refinery models) are run.

After the results of the monthly Master Planning have been visualized, checked and agreed on, they are sent to the decentralized planning departments, responsible for the short–term Crude (oil) Supply Scheduling, Refinery Scheduling as well as Product Supply Scheduling (see Fig. 21.2).

In *Crude Supply Scheduling* (CSS) the optimized monthly quantities per crude oil sort to be purchased are split into daily quantities of the following month and the sequence of the influx to the refinery (the so-called “patch”) is optimized. The output of CSS is the exact point of time when a crude oil sort has to enter the pipeline from the ship and how it has to be pumped to a respective refinery in the best possible way.

This process of crude oil pumping is also the first part of the *Refinery Scheduling* (RS). The results of the monthly MP (e.g. which crude oil sort in which quantity, the semi-finished product quantities, production quantities per product, transportation quantities between refineries and inventories at the end of a month) are used as directives for RS. These quantities are disaggregated, i.e. they are split in weeks and days. Within these temporal boundaries a short–term production and refinery optimization takes place. RS generates a detailed production plan with plant input, plant throughput and production routes. These data are put into the different refinery execution and monitoring systems and are then the basis for the daily operation of the refinery plants.

The results of the monthly MP are also communicated to and agreed with the sales channels and sales markets. In the *Demand Fulfillment and Product Supply Scheduling* (PSS) the allocation of quotas to the different levels of the sales hierarchy takes place. At this stage, the aggregated sales quantities of the MP (per product, supply source and sales channel of a regional market) are broken down to more detailed sales quotas (also called “allocated ATP”; see Sect. 9.4.4). They only differ from the original (non aggregated) forecasts of the S&DP if the capacities of the MP and Production

Planning models have been too tight. There are two essential tasks of this planning module, first the hierarchical disaggregation of the sales channel quantities to the customer groups and customers (as part of the so-called "sales channel management"), and second their disaggregation from a monthly to a daily basis. Both planning modules PSS as well as S&DP will be referred to in Sect. 21.5.

After finishing the PSS planning (at the end of a month) the resulting plan for the coming month will be handed over to the *Executive ERP Systems & Data Warehouse Systems* (like SAP R/3 and the delivery system TAS) in form of "purchase contracts". They can be used for a daily availability check per single order.

21.4 Modeling and Implementation of APS

For the implementation of the planning concept of Sect. 21.3 within a real-world planning system a variety of commercial software modules is needed (see Fig. 21.3). Their detailed description is the focus of this section.

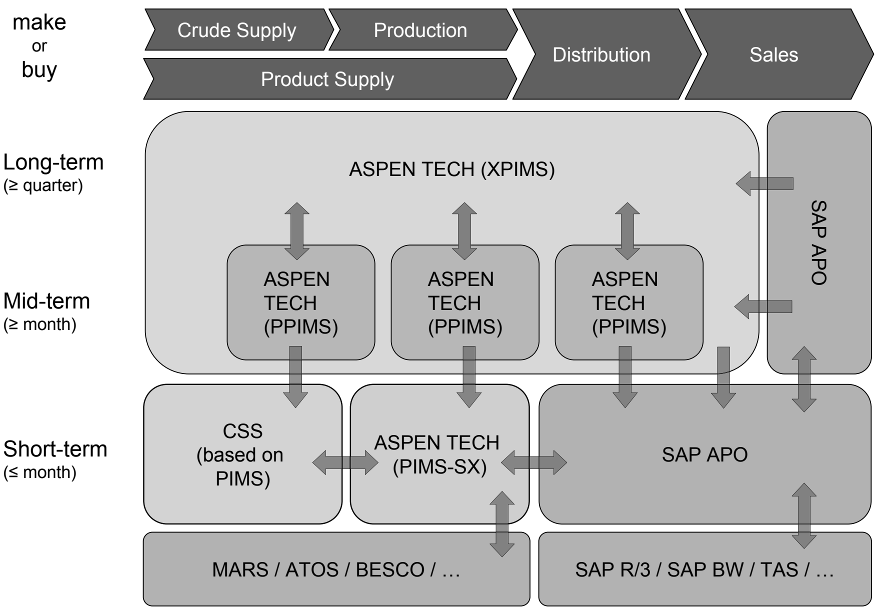

Fig. 21.3. APS modules and their integration

To put the S&DP into practice the SAP module SAP APO DP (see Chap. 18) has been selected. Hereby it is unconventional for an APO DP usage that not only the demand but also sales prices are forecasted and aggregated over three stages of the customer hierarchy. Additionally, availabilities, purchase prices and logistics cost rates of the crude oil supply have to be estimated.

Thereby an open (for the next 3 years) planning horizon in SAP APO DP was created for sales and supply. So, whenever needed, the MP has the chance to take the latest available data (for demand & supply) into its optimization models. Normally, the MP receives and freezes the data according to the planning process time schedule of Tab. 21.2 and stores them in the Business Warehouse (BW) of the SAP APO. The Business Explorer (BEx) serves as the interface to extract these frozen data from the BW and to convert them to the input format necessary for MP. Since the optimizer in the MP can not (and should not — see Chaps. 4 and 8) decide on the allocation of every single customer, an aggregation over customers and customer groups per sales channel takes place. Hereby, for the demand side, the sales quantities are summed over all minimum and maximum bounds on sales, respectively, per region. Additionally, the weighted average sales price per region is calculated and used as input to the MP. On the supply side, however, the minimum and maximum purchase quantities available from external supply sources are directly (i.e. without any calculation) put into the MP model.

As optimizer for the MP the in this industry widespread non linear programming modules (solver) of AspenTech (see Chap. 18) have been chosen, because these software modules are able to model and simulate the technically complex production processes of a refinery at best. For the global MP decisions the software module XPIMS of AspenTech has been chosen, since there an optimization for the various markets, with the different refineries and their corresponding plants, as well as the representation of several discrete time periods is possible (global optimization model: multi-plant and multi-period). In addition, for the Production Planning of a refinery AspenTech's software module PPIMS is used. It permits the more detailed optimization and simulation of the production processes of a single refinery with its affiliated plants for several time periods (local optimization model: single-plant and multi-period). Due to the fact that these software modules are not running on a common database, data are iteratively exchanged between X- and PPIMS via spreadsheets. The MP solution, achieved in the iterative cycle between the global and the local LP models, will be handed over to the short–term software modules: the Crude Scheduling System (CSS) for raw material scheduling, AspenTech's PIMS-SX for scheduling the different refineries and a separate allocation planning sphere within SAP's APO DP for demand fulfillment and PSS.

The CSS is an in-company developed module, which bases on the non linear algorithm of PIMS and helps to model the time dimension more flexibly. Thus it is possible to optimize the daily patch sequence of crude oil sorts arriving at the refineries.

Likewise PIMS-SX optimizes the detailed refinery schedule within a month. Hereby, the daily sales patterns of finished products should be met for each refinery. These sales patterns are determined by PSS and are handed over via BW from the separate planning sphere of SAP APO. This is done at every month's end to give a preview of the following month, as well as weekly for unexpected, shorter–term production adjustments.

In the PSS adaptation of SAP APO DP, on the one hand monthly quotas are created on the lowest level of the customer hierarchy ("Allocation Planning") and, on the other hand, information about the daily consumption of these quotas is provided. The latter is helpful for the manual "Quota Management" which is necessary when the stream of incoming customer orders significantly deviates from the original demand forecasts and corresponding customer quotas (see Sect. 21.5). From a technical point of view, at first the monthly sales channel allocations of XPIMS and PPIMS as well as S&DP time–series information about customer demand, which is held in the forecasting sphere of SAP APO DP, are consolidated via SAP APO BW and written in a separate demand fulfillment sphere of SAP APO. In this sphere the sales departments are allowed to refine their aggregate quotas down to the lowest level of the hierarchy — the customer. After this allocation planning the sales quotas are available for every product, supply source, sales channel, region, profit center and customer. Via transaction (interface) the customer quota will be handed over to the execution system of SAP R/3. The operational test of availability (test whether there is enough quota to fulfill a certain customer request) takes place between the SAP modules MM and SD as well as between the distribution systems TAS and TASC.

21.5 Modules in Detail

The implementation of the S&DP and PSS planning logic in SAP APO took place in two large APS projects, which will in the following be presented in detail. Thereby, the time period of carry out extended over three years.

21.5.1 Introduction of the Supply & Demand Manager

The first project, the "Introduction of the Supply & Demand Manager (S& DM)", was motivated by the following objectives:

- introduction of a standardized and integrated planning system in all countries for the S&DP, including the features:
  - automated collection of all relevant MP data, uniform for all countries and sales channels,
  - creation of a harmonized data base for all planning data,
- simultaneous forecasting of quantities and prices / costs (concerning customer demand, external purchasing and crude oil supply),

- enabling process transparency & -monitoring (alerting),
- increase of forecast accuracy by introduction of an APS-based Demand Planning module,
- higher transparency of the MP results by implementing a web-based front end reporting.

Thus an APS module was looked for, simultaneously supporting both the existing MP solution and the above mentioned aims. After an extensive blueprinting and a following proof of concept SAP APO was chosen as the software module for putting the S&DP processes into practice.

For this newly defined planning process different challenges had to be coped with. One of the essential changes facing the existing process was the introduction of a common planning preview being long enough to cover every planning cycle of Tab. 21.2. It had to offer a single view into the future and to guide the persons responsible for S&DP to put their forecasts into the same planning file. Formerly the strategic planning, like budget or investment planning, was fully separated (likewise in the ideas of those responsible for planning) from the preview or monthly planning. Thus forecasts were only available on Excel spreadsheets with different levels of detail.

In order to sufficiently represent the existing business model, six forecast dimensions as well as nine related attributes had to be introduced and stored. In the following examples (see Fig. 21.4) we will concentrate on the three dimensions

- *sales channel*, comprising product (groups) like gasoline, diesel, heating and aviation fuel, which are assigned to business units like "Retail" (responsible for filling stations) or "Commercial" (responsible for heating, aviation, etc.),
- *geography*, comprising customer (groups), regions, countries and clusters (i.e. a set of countries), and
- *time* (e.g. days, months).

The planning process of the S&DM usually starts with forecasting the future (basic) prices of crude oil (Brent), the finished products' quotations or reference quotations for local markets as well as the exchange rates for the relevant countries. For markets, which are not directly following the global prices, a local finished product price scenario and local purchase prices (prices which the company could buy for from external refineries) have to be estimated. All this information is put into a spreadsheet first, there worked up and then uploaded into the SAP APO. Based on these basic price estimations further individual forecasts have to be made, e.g. on minimum and maximum sales quantities per product and region, as well as on regional sales prices (either as a differential on the reference quotation or as absolute sales prices).

The forecasting takes place hierarchically over a maximum of three hierarchy levels (customer, country and cluster level). These different levels

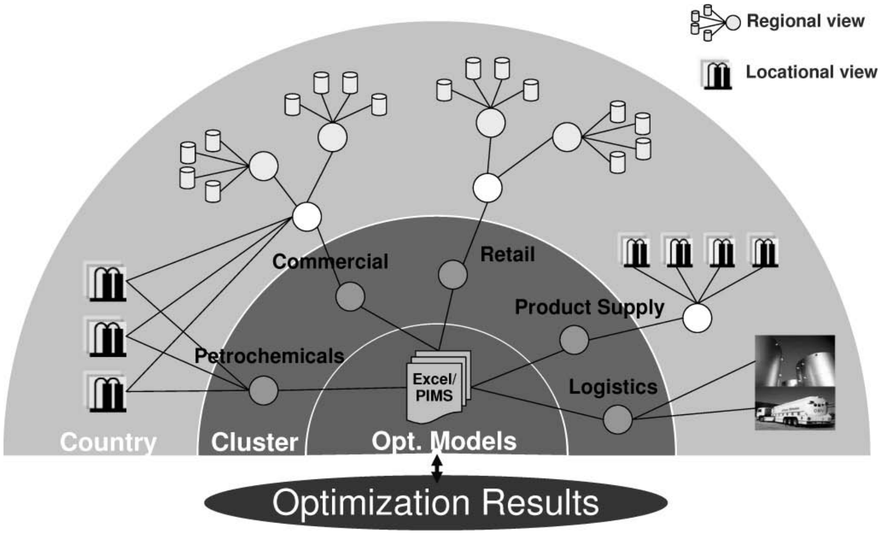

Fig. 21.4. Supply & Demand Planning structure in detail

represent different levels of accountability in the organization, which are responsible for consolidation and approval of these data per sales channel. For example, a key account manager of the business unit Commercial (heating, aviation fuel etc.) is responsible for all customers (heating retailers, airlines and airports etc.) in her/his regional area (level 1), a country manager for all the key account managers in her/his country (level 2) and a cluster manager again for all countries in her/his cluster (level 3).

Forecasts are made on the lowest, i.e. most detailed, level but are visible on or can be copied to the next higher level, too. For planning purposes (e.g. as input for the Master Planning or to increase the forecast accuracy), however, they need to be aggregated. Therefore, a summed volume and weighted average price per level of aggregation and intersection of forecasting dimensions / combination of attributes can be computed (see Fig. 21.5). Only by handing over data to the non linear optimization models (freezing of data) detailed information will get lost for the moment. For a later disaggregation of the MP results, however, this information (or even an updated version) will still be available.

The entire forecasting and aggregation process from the upload of quotation and exchange rates up to the handing over to the MP — and the following announcement of the MP results — is supported via alerting and mailing. Thus, permanent visibility of the planning progress is ensured.

In order to provide the MP with the latest prices, it is sufficient to update the quotations just before handing over the data to the MP. In this case, all (detailed and aggregate) forecasts which base on a price differential are

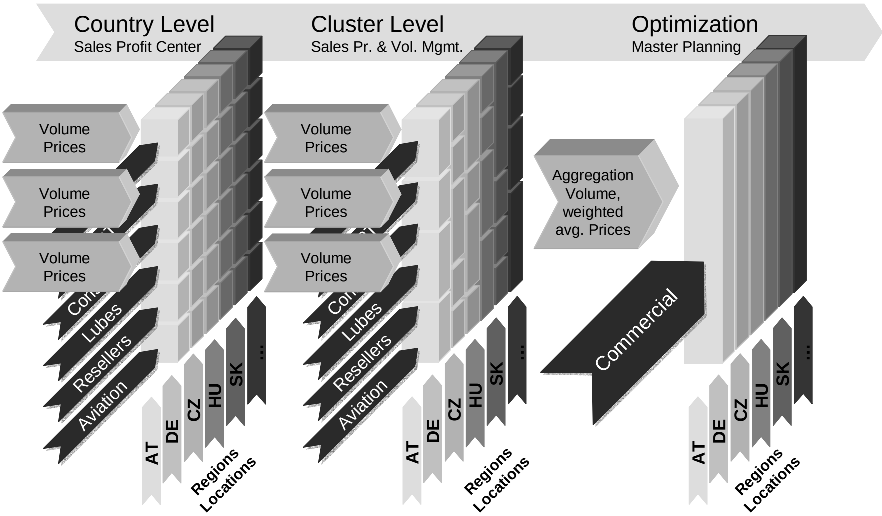

Fig. 21.5. Hierarchical aggregation in Supply & Demand Planning, e.g. Commercial's business unit

floating with this new quotation and a new and up-to-date total sales price will again be calculated.

The next step in the planning process is to freeze all information (safety lock of all data in the BW) and to simultaneously create all input tables (demand tables, supply tables, local tables) for MP. After the already described iterations between the global optimization model and the local optimization models the confirmed results are uploaded via transaction and stored in the SAP APO BW. Additionally, an alert is created to inform all users on the availability of these MP results. The results are published in two different ways, a planning file and a web-based front end reporting tool. The web reporting is able to customize the planning results to every user's needs and to present them graphically as well as in tables.

21.5.2 Implementation of the Product Supply Scheduling

The second project, the "Implementation of the Product Supply Scheduling", had the following objectives:

- introduction of a standardized and integrated Allocation Planning and Quota Management system in all countries to close the gap between MP and the operational fulfillment of the customer demand, including the features
  - hierarchical disaggregation of the MP results as part of the Allocation Planning,
  - possibility to provide sales & supply patterns for all quotas,

  - automatic handing over of monthly quota information from SAP APO to SAP R/3 - MM purchase contracts,
- calculation and estimation on the progress of quota consumption during the month for all responsibility levels (refinery production, depot supply & management, sales, purchase) and aggregation levels,
- monitoring, alerting and web-based presentation of unexpected deviations in quota consumption,
- setting up a performance management to measure the planning quality, the scheduling efficiency (sales pattern accuracy) and Quota Management efficiency for all responsibility levels.

This project builds on the results of the preceding S&DP and MP and continues the monthly, integrated forecasting and optimization process for the customer–oriented demand fulfillment part of the supply chain. As already mentioned, the PSS is divided into two process steps, the Allocation Planning and the Quota Management.

The MP optimization results, which are stored in the SAP APO BW, are the starting point for the *Allocation Planning* (AP). They are uploaded into a separate planning sphere for both AP and the later Quota Management. Since the MP results are only available in an aggregate form, e.g. over all customers of a business unit, it is up to AP to disaggregate them again according to the different dimensions of the forecasting hierarchy (see Fig. 21.6). This is a crucial task if the scarce capacities of MP led to (aggregate) shortages of the original (detailed) forecasts (see Sect. 9.4.4). AP supports this allocation by providing rules for the automatic disaggregation along intersections of the sales channel/geography dimensions and along the time dimension.

To create this separate sphere the structure of the optimization result has to be extended for the missing attribute combinations, e.g. from business units/clusters to products/customers. Next the allocation of the available quantity per product/customer along the sales channel/geography dimensions takes place as following: at first the minimally demanded quantity (i.e. the detailed minimum sales quantity forecasted in S&DP, the so–called "contract quantity") will be replenished on the lowest level of the hierarchy. Thereafter the residuary quantity, which is the quantity the optimization model has determined between the aggregate minimum and maximum boundaries of MP, will be allocated to the customer with the highest sales price. The quantity on that customer is replenished until its maximum is reached (i.e. the detailed maximum sales quantity forecasted in S&DP). After that the customer with the second highest price gets the quantity up to its maximum and this sequence goes further until all MP quantities are allocated. In the case of abridgment below the minimum, the rule will be applied in an analog way: customers with the highest prices receive their quantities at first. In the following process step this system supported allocation of the total MP quantities will be handed over to the people responsible for sales as a proposal. Then the proposed monthly allocation will be approved or, if nec-

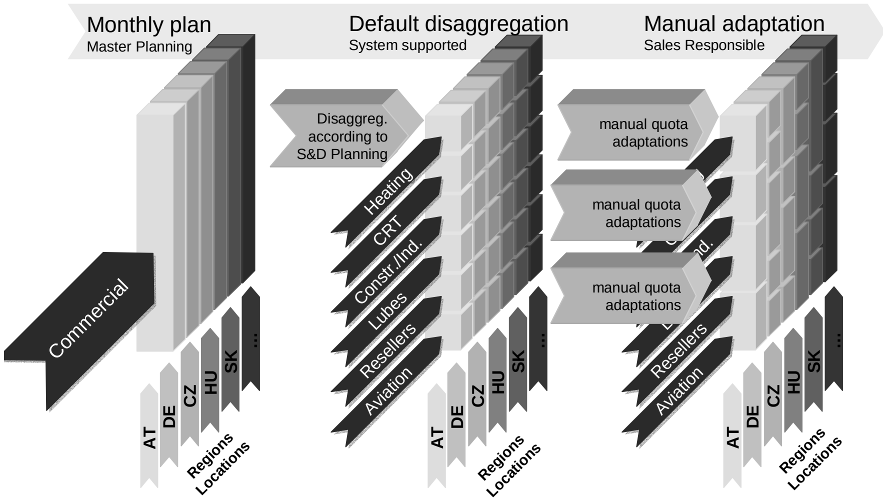

Fig. 21.6. Hierarchical disaggregation in Product Supply Scheduling, e.g. Commercial's business unit

essary, adapted manually in the planning file at first over business units and afterward in a business unit for their products and customers.

Additionally, along the time dimension a disaggregation of the monthly MP quantities into daily sales quantities is necessary. The default rule is to spread the monthly quantity equally on all working days of that month, which leads to a "regular" sales pattern for every working day. Supportively the user can chose between three interactive rules in addition to a manual adaptation, the allocation according to the pattern of the last month, the allocation according to the month of the previous year and the allocation according to the average distribution of the last 12 months. The necessary information about the time series is also uploaded from the S&DP section of SAP APO.

The planned sales pattern are finally summed over all sales channels in order to check whether the depots are able to supply these quantities on time, i.e. whether the daily production of the refineries and the inventories in the tank farms are sufficient to fulfill these daily delivery demands. If logistics approves the sales pattern, the monthly quotas will be created as "purchasing contracts" in the SAP R/3 MM module including their corresponding transfer price formula.

After the release of the AP quotas, the second process step of the Product Supply Scheduling — the *Quota Management* — starts. The usual ATP-check for incoming customer orders (see Chaps. 4 and 9) takes place in the R/3 system. Additionally, in order to control the allocation process and to be able to react on unforeseen events, once per day the up-to-date actual consumption of quotas will be transferred from the R/3 system via BW to the SAP APO. The monitoring of the quotas happens in the SAP APO itself as well as in the related web-based front end reporting. There the daily actual quota consumption will be compared with the planned consumption. If deviations outside the predefined limits (adjustable on every intersection of dimensions) occur, an alert will be triggered and a "traffic light" in the front end reporting will be switched to the yellow or red light. There are two potential reactions to a deviation, first the adjustment of the sales pattern for the remaining time period (e.g. if the sales forecast pattern was bad) and second an adaptation of the quotas and the SAP R/3 MM purchase contract (e.g. if the monthly sales forecast was bad or if a refinery can not deliver as promised).

21.6 Results and Lessons Learned

For both of these projects a detailed business case with a net present value calculation on the entire supply chain was employed in advance. The resulting, here represented, benefits evidently indicate a two-digit million Euro amount. For the monitoring of these benefits a continuous recalculation must take place. Simultaneously, a performance management system will be established along the new APS-supported processes.

Summarizing, all these benefits lead to a stable and durable enhancement of the margin contribution along the complete downstream supply chain and a competitive advantage of the company in the relevant market. At the same time especially the high grade of integration of the available planning, optimization, scheduling and management systems contributes to a higher forecast accuracy and efficient deviation management with:

- smaller raw material costs through an enhanced crude oil selection to fulfill the market demand,
- reduction of production costs through a decrease of variable production costs,
- reduction on costs of capital in inventories of crude oil and finished products,
- enforced utilization of margin upgrade potentials through increased transparency,
- persistent realization of the MP (optimization) results through quota formation and quota management, as well as its coordination over different responsibility levels,
- transparency and as a result acceptance of decisions.

Future main emphases will be identified and pursued further in the field of the optimized and automated deviation management as well as in the short-term scheduling and management of the customer demand under the criteria of revenue management.