Business value of hydrocarbon production accounting

The gains that a refiner made by implementing an enterprise-wide hydrocarbon accounting system were both financial and cultural

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This article describes seven years of committed use of a hydrocarbon yield accounting and mass balance system at ANCAP La Teja refinery's storage and distribution plants and the resulting improvements, site-wide integration, economic impact, cultural transformation and other major achievements.

ANCAP over the years has learnt how to get the most out of such systems through the proper use of the information they generate. The lessons learned and how ANCAP has been able to get the entire organisation – from the operators to the refinery manager – to use the system will be described. As a result of this work, significant savings have been experienced by the company as a whole.

ANCAP is the Uruguayan national oil company (NOC). It operates in several sectors including crude oil refining, refined oil products marketing and sales, administration and exploitation of the alcohol business in Uruguay and the industrialisation and commercialisation of Portland cement.

ANCAP's hydrocarbon business consists of: one single buoy mooring (SBM) and crude oil reception terminal (Terminal del Este) with a total capacity of 536 000 m^3; an oil refinery (La Teja) with a capacity of 50 000 b/d; and six distribution plants for refined oil products located strategically throughout the country (La Teja, La Tablada, Juan Lacaze, Paysandú, Durazno, and Treinta y Tres).

La Teja refinery was inaugurated in 1937 and has been debottlenecked and undergone the addition of new processing units from 1937 to 2013 (see **Figure 1**). It is a small refinery with an equivalent distillation capacity (EDC) of 420 000 and a medium complexity factor of 8.3 (see **Table 1**).

La Teja refinery's main units

Unit	Nominal capacity, bb/d
Crude unit	50 000
Vacuum distillation	18 000
Visbreaking	7000
Catalytic cracking	12 000
Catalytic reforming	12 000
Isomerisation	6000
Prime G unit	5000
Distillate desulphurisation & treating	4950
Naphtha hydrotreating	18 000
Diesel hydrotreating	18 000
SRU unit	40

Table 1

Hydrocarbon accounting systems

Hydrocarbon accounting systems are information and control systems also known in the industry as yield accounting systems or production accounting systems or mass balance systems.

At the heart of these systems there is a mass balance model comprised of nodes and connections that represent the entire site including process units, storage tanks and all the streams that are part of the movements, purchases and sales of crudes and products.

The inputs to the system come automatically from several sources, such as distributed control systems (DCS), supervisory control and data acquisition (SCADA), laboratory information management systems (LIMS) and automated tank gauging (ATG). But there are also input data that are entered manually.

In order to resolve the inconsistencies that exist in these different measurements, the system uses sophisticated mathematical routines to reconcile the measurements and solve inconsistencies. The result of this is that the raw data that come

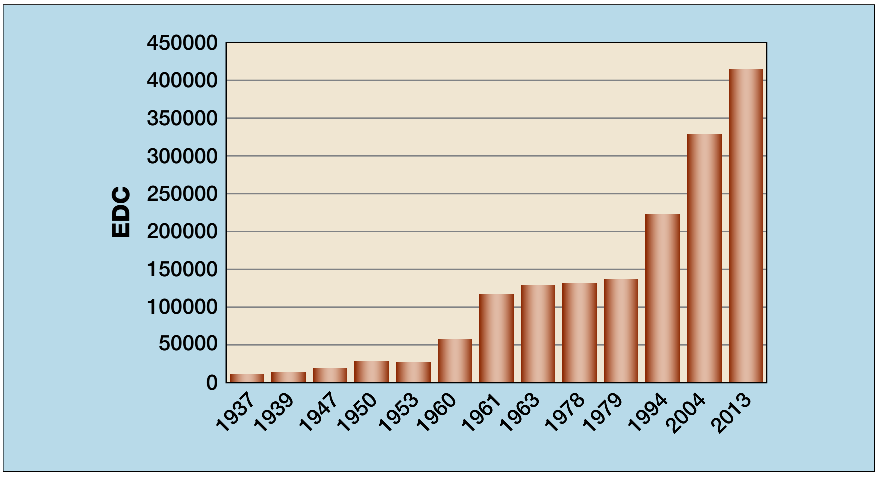

Figure 1 La Teja refinery's evolution

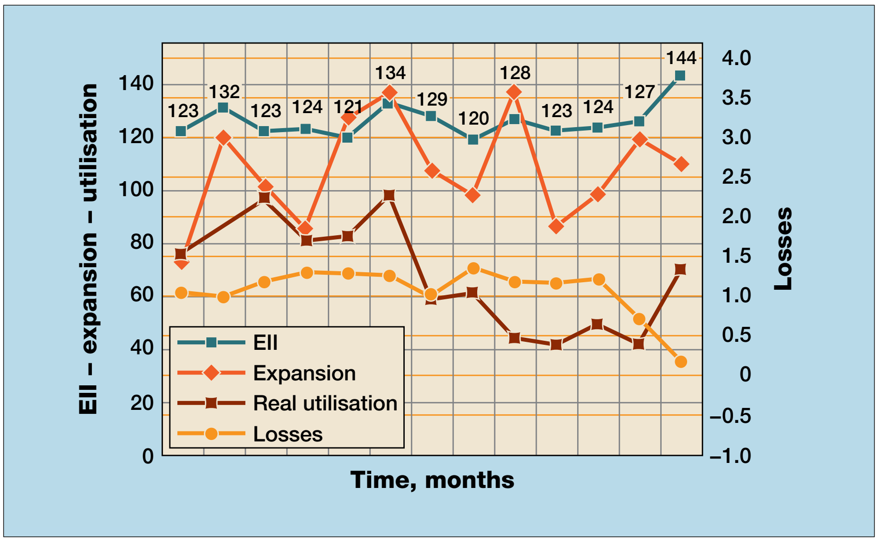

Figure 2 EII, losses, utilisation and expansion evolution

from the plant floor are transformed into trusted information.

System implementation at ANCAP

In the refinery industry there is no standard to follow in the implementation and use of the systems and work processes for hydrocarbon production accounting.

Because of this situation, the ANCAP technical team developed their own procedures based on the experience that they had accumulated over time. For the first stage, the goal was that the system generated information would be:

- Trusted
- Believable
- Transparent
- Auditable
- Easy to access.

Since 1991, ANCAP has used several hydrocarbon accounting systems but none of them addressed all the needs of the company.

The company was seeking a tool that would help determine the real performance of its assets by including the participation of engineers and personnel on the plant floor in order to improve certain technical aspects, such as losses, emissions, and internal consumptions.

ANCAP was also seeking to reduce the time required to close the balances so that they could be delivered correctly and on time.

In 2006, the company chose the system VMPA – Visual Mesa Production Accounting (ex S-TMS), developed by Soteica Visual Mesa.

In the selection process, the following capabilities were valued highly:

- The calculation speed of its reconciliation engine
- That the system ran in a distributed web environment
- That it was available completely in the local language (Spanish), which meant that the input of manual data and other information could be dealt with directly by plant floor operators.

VMPA was implemented in two phases. In the first phase, the crude oil receipt terminal, the refinery and the two shipment terminals located in Montevideo were modelled. The modelling and commissioning of this first phase was completed in a short period, approximately four months, but to get the entire company to use it took several years.

The second phase started in 2012 with the addition of four shipment terminals located in the interior of the country. This phase required six months. Prior to the implementation of VMPA, these four plants made their balances independently with Excel spreadsheets, which resulted in inaccurate and inconsistent information.

Once the second phase was implemented, ANCAP was able to have a single integrated and reconciled balance of all its facilities, being able to define precise limits with regards to the closure of the mass balance at each plant and for the overall hydrocarbon balance of the company.

During the training of plant operators, special emphasis was applied to present VMPA as a tool that would make their daily tasks easier and give additional visibility to their work.

A certain amount of pushback was expected because of the changes to a daily routine that consisted of reporting data on paper spreadsheets, but the operators adopted the system very quickly.

Refinery performance: plan vs actual

Unidad	UEDC, %	UEDC plan, %
Topping atm	77.7	80.3
Topping vac	80.5	77.1
VSBK	59.8	61.3
FCCU	82.8	87.8
DSF	55.8	68.6
HDT	51.9	52.1
ISM	57.5	60.0
CCR	49.2	50.3
TTFG	100.0	100.0
HDS	73.4	76.3
PG	96.3	102.9
SRU	27.4	31.0

Table 2

Use of information generated by VMPA

After commissioning of the VMPA system came the challenge of using appropriately all the information generated by the system in the many areas of the organisation. Immediately and within a few minutes of training, all of the users in the company were able to access information easily, avoiding the time-consuming task of requesting information and/or reports from the personnel assigned to run the system.

This new situation enabled the following:

- **Production balances and control** uses the information generated by VMPA to calculate the monthly Solomon indexes and other plant KPIs (see **Figure 2**). The information generated by VMPA is sent monthly to the Balanced Scorecard (BSC) system which generates many of the strategic indicators of the company. Losses are controlled using the methodology from the Institute of Petroleum IP HM31.
- **Production planning** uses the

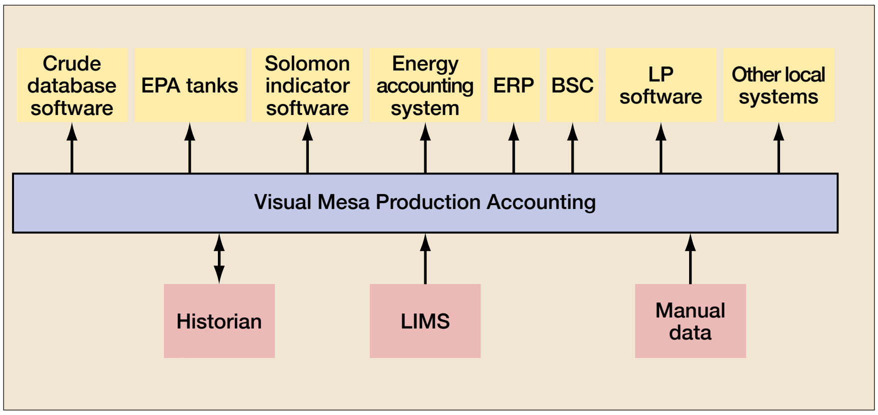

Figure 3 System inputs and outputs

information generated by VMPA to carry out control of the refinery's performance. The planning group compares what they planned for a given period using their LP tool with what really occurred in the plant (see **Table 2**). They calculate the gaps and they monetise those gaps. For crude oil yields, a comparison is made between mass balances and crude assays. With the information generated by the VMPA system, projections and analysis of the refining margins and profitability can be carried out.

- **Scheduling**: The daily information generated by VMPA is compared with what was programmed by the responsible person in the plant.
- **Refining**: The mass balances generated by the VMPA system are inspected and controlled, as well as the energy consumptions of the process units. Analyses of test runs of the process units are done to determine the impact of changes in control variables on the economics of the unit.
- **Environmental**: VMPA is used to calculate refinery emissions by combining the information it generates with TANKS software from the Environmental Protection Agency (EPA).
- **Finance**: VMPA is used to calculate costs. Information generated by the system is sent, via an interface, to the company's enterprise resource planning system and is one of the sources of information used to produce the accounting statements of the company.
- **Logistics**: Information generated by VMPA is used to determine the crude and refined products supply to the refinery and to the receipt and shipment terminals.
- **Maintenance**: Triggered by the group that run the VMPA system, which initially identifies malfunctioning instrumentation in the plant, the maintenance group adjusts and calibrates measurement instruments in the plant, the automatic level measurements in the tank farm, and the flowmeters used in receipt and shipment of hydrocarbons.
- **Audit**: By using VMPA's audit module, the audit group within ANCAP can verify the traceability, integrity and complete lifecycle of the data (see **Figure 3**).
- **Others**: VMPA is a source of information for the strategic planning group at ANCAP. It also supplies information to government offices in Uruguay.

Results

Once implemented and with daily use of the system, economic benefits were captured very quickly and this enabled the company to pay back its investment in the system. Here are some of the events arising from application of the system:

- **Leak detection in buried product lines:** La Teja refinery, due to its age, has many refined product shipment lines that are buried. The use of VMPA has made it possible to detect buried lines with leaks. During certain periods, the leaks represented losses for the company in the order of $20 000/month.
- **Detection of calibration errors in storage tanks:** La Teja refinery has expanded its tank farms several times. The companies that provide tanks deliver them together with a calibration table. Errors in these tables have been detected in several instances. As an example, a 25 000 m^3 tank of export gasoline had an inaccurate calibration table. In the critical zone this did not represent reality. The bill of lading is created from automated tank gauging measurements, which resulted in delivering more gasoline to the customer than the 'measured' amount when the tank level was in the critical zone.
- **Claims to suppliers for errors in the bill of lading of crude oils and refined products:** ANCAP buys crude oils and refined products based on measurements made at the cargo's loading port. It has become common to place claims, together with the foreign trade department of the company, for missing amounts of cargo upon unloading at the crude terminal and at the moor of La Teja refinery, based on the information generated by VMPA. These claims have resulted in reimbursements to the company for several hundreds of thousands of dollars.
- **Reduction of apparent losses:** Apparent losses make it difficult to carry out a loss analysis at the plant. An immediate result after implementing the production accounting project was a reduction in apparent losses and, although these type of losses are not real losses, they do affect the financial results of the company.
- **Real losses:** ANCAP had great variability in its loss index, which made it difficult to identify and reduce the losses. Once the majority of the apparent losses were eliminated, the company was able to identify the cause of the various losses and their amounts throughout the supply chain: refining, storage, receipts and shipments. A period of six months before implementation of VMPA was compared with the six months leading to the preparation of this article and it was concluded that the actual savings captured are an estimated $977 000 based on evaluation of losses at the middle distillate price (see **Figure 4**).

Conclusions

The decision made in 2006 to implement VMPA was correct. The

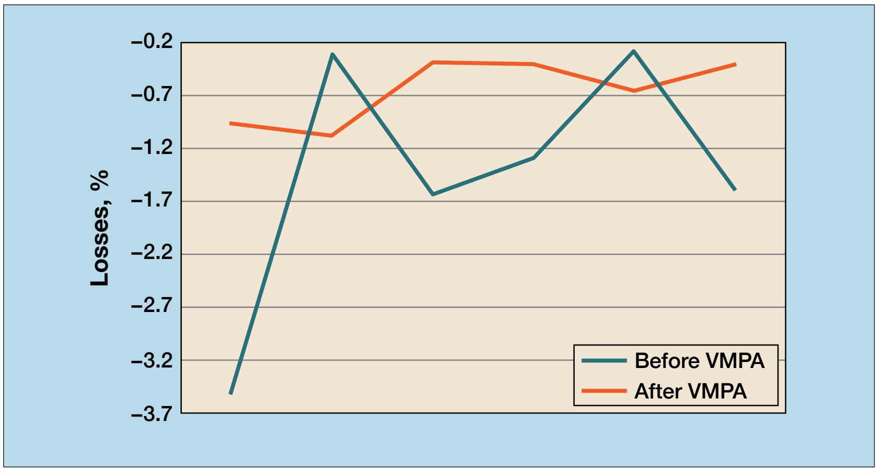

Figure 4 Semestral evolution of losses

direct economic impact of reducing the plant's losses is probably one of the most important benefits that this type of system brings. But we should not forget to take into consideration other types of indirect economic results, such as having all of the different areas within the company using the same reconciled and trusted information, shared and presented in a cooperative manner.

We have generated a change in communications dynamics between the different areas of the company. The active and integrated participation of process, maintenance, planning and logistics personnel in the analysis of the results generated by the VMPA system is an extraordinary change in the daily life of the company.

Tasks carried out by floor plant personnel have been given more hierarchy. This is another of the positive results that are not possible to quantify economically but in the medium term impact the company's productivity, mainly because the system is right there, at the plant floor, where individual opportunities for improvement exist by keeping in mind that 'every drop counts'.

The lack of a unified procedure or standard in the industry that would assist in the implementation and utilisation, in an effective and widespread manner, of a hydrocarbon accounting system is a barrier to obtaining immediate results. There are successful examples of development of procedures regarding a production accounting system in other industries. For example, in the mining/metals industry the following procedure exists: AMIRA P754 Code of practice for metal accounting. It would be of great help for downstream companies if a task force of experts could create a similar procedure that takes into account not only the quality of the information but also the use of the information at the highest levels of the organisation. This procedure could be submitted for approval to international organisations dedicated to establishing industry standards.

Further reading

1 *Apply System User Manual*, Process Plant Information and control system, Ch 2, Bonner & Moore Associates, Inc.

2 Los sistemas informáticos y la automatización en las empresas modernas, *Revista Ingeniería Química*, No. 20, 2001.

3 *S-TMS User Manual*, Soteica.

4 *IHM 31 Guide to Hydrocarbon Management in Petroleum Refinery Operations*, Energy Institute, London, 2nd ed, 2004.

5 Gaylard P G, Morrison R D, Randolph N G, Wortley C M G, Beck R D, Extending the application of the P754 Code of practice for metal accounting (www.saimm.co.za/Conferences/BM2009/015-038_Gaylard.pdf).

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