RFID to enhance visibility in a Closed loop Supply chain:

Case of Cylinders Management in a Moroccan LPG distribution chain

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Abstract

The challenges highlighted in this paper relate to asset management, distributions performances and customer satisfaction. Emergence of new technologies such as RFID coupled with Vendor Managed Inventory processes gives big hope to success in dealing with these challenges especially in non-mature business environments such as the Moroccan one.

This paper illustrates also closed loop supply chain dynamics by a real world case. The case studied is related to distribution of packed LPG (liquefied Petroleum Gas) and discusses some general challenges companies evolving in this business face.

Cylinders management, called in some businesses "Metal management" makes LPG distribution business specific as the forwards physical flow is linked to the reverse flow. In fact at different layers of the distribution process from filling plants to customers, the forward quantity of delivered filled cylinders should be almost equal to the empty cylinders travelling upward.

As very scarce studies cover Cylinders management in LPG business, we aim to participate for more cylinders management comprehension and explore opportunities the use of information technology gives to enhance visibility through the distribution chain and improve distribution performances.

Keywords: RFID; Vendor Managed Inventory; LPG; Metal management; reverse flow.

1. Introduction

1.1 Background:

A key area in optimizing the distribution Supply Chain is the need for optimal and cost effective coordination among the various components of the SC. Improvements in order management, inventory management and purchasing functions using processes like VMI and CPFR are practices that successful SCs have adopted. These industry-leading processes have the potential to be fully complemented by technology enablers.

Implementing the proper technology infrastructure can create quantifiable advance in the time, cost and scale of purchasing and replenishment processes and creates competitive advantages by aligning the distribution processes to business objectives. These challenges are more accurate when dealing with reverse flows.

Reverse Logistics, called Closed loop SC have received increasing interest during the last twenty years for many reasons but essentially for regulatory environmental concerns but very scarce researches tried to explore business opportunities the optimal management of reused articles presents.

The term closed loop or reverse logistics refer to a variety of return flow types: production related returns, distribution returns, commercial returns, repair related returns, end of use returns or end of life returns. This diversity entails different levels of complexity and importance.

1.2 Closed loop and Reused Articles operations management review:

In our interaction with LPG distribution companies they expressed big concerns in dealing with cylinders control and operations. The reuse of cylinders in LPG SC has been all the time a core business disciplinary and was not linked

to the newest concerns of environmental and sustainability hype because of the high value of cylinders compared to the product itself. The cylinders procurement expenditures have always been considered by many LPG distribution company as capital expenditures rather than an operational ones.

Ruth Carrasco-Gallego, Eva Ponce-Cueto and Rommert Dekker defined RA as referring to "products that are used multiple times by different users [1;2]. This definition implies that the use by each user is of relatively short duration (compared with article lifetime) and does not deteriorate the product. It also implicitly states that the RAs require a reconditioning process which should remain short and simple, in order to enable quick utilization by the next user." In the same paper the authors identify 3 types of RA:

- Returnable transportation items
- Returnable packaging materials
- Reusable products

These products may flow in a star network linking one central depot with customers or in multi-depots network. In a previous paper Ruth Carrasco-Gallego and Eva Ponce-Cueto proposed a management model for closed-loop supply chains of reusable articles. The figure below illustrates the main cylinders management model components of CLSC:

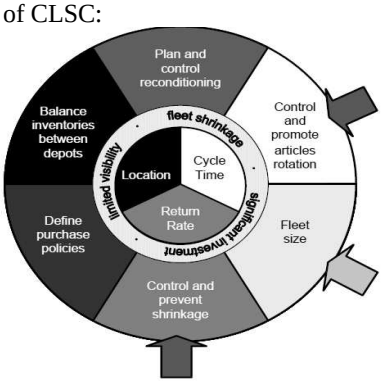

Fig. 1: Cylinders management components.

Daniel Hellström and Ola Johansson (2010) discussed the impact of control strategy on the management of returnable transport items and concluded that systems where the tracking system has inadequate data capture, data-analyzing and reporting capabilities, provide limited control thereby resulting in potentially high shrinkage. However, having a tracking system with decision- support features does not necessarily guarantee that firms are able to use increased information, or, more importantly, to use it efficiently. This research, however, illustrates that when tracking data are used properly, shrinkage can be controlled, but this requires continuous management attention.

For LPG cylinders, the emergence of new IT solutions is making many business opportunities possible. Use of RFID tags to enhance visibility on cylinders control business seems to me a matter of time.

1.3 RFID in closed loop SC review:

The use of inventory tracking systems facilitates the design of profitable reuse systems (Flapper et al., 2005) and allows firms to realize new, innovative business opportunities in the area of closed-loop supply chains (van Nunen and Zuidwijk, 2004).

According to van Dorp (2002) tracking signifies the gathering and management of information related to the current location of items. The main function of tracking systems is that they connect physical material flow with information systems (Stefansson and Tilanus, 2001). Most tracking systems use automatic identification technology such as bar codes and radio frequency identification to identify the tracked item at different points in the supply chain (Hellström, 2009; McFarlane and Sheffi, 2003; Pålsson and Johansson, 2009; Ustundag and Tanyas, 2009). Tracking is a prerequisite for the wider concept of visibility. The Council of Supply Chain Management Professionals (2009) defines visibility as ''the ability to access or view pertinent data or information as it relates to logistics and the supply chain, regardless of the point in the chain where the data exists". For many businesses and organizations, asset visibility is as important as – or more important than – the visibility of its products" (Moore, 2007) [5].

Xiaowei Zhu, Samar K. Mukhopadhyay and Hisashi Kurata (2012) predicted that RFID has great potential for logistics, supply chain management and quick response systems and provided an overview of the current state of RFID applications in different industries and its impact on business operations. RFID can be used to identify and track location of shipping containers and items (like apparel, book, drug, and others) in warehouses and on the entire shipping route. RFID can also be used to make the inventory control system more efficient. Collins (2003) assumed that RFID will be the fastest-growing among all the smart label market segments in near future. He predicts that falling prices, technological advances and the establishment of uniform RFID communications standards would fuel this growth. Chao et al. (2007) gave a historical review of RFID research from 1991 to 2005 and explore RFID technological trends and forecasts. There paper can serve as a comprehensive literature review of contemporary RFID research and cites a number of real world RFID application examples.

The management of LPG cylinders would suffer without information systems which keep track of individual

cylinders and present timely, relevant information on their whereabouts. Studies have shown that visibility of where and how RAs are moving may save firms detention and demurrage charges for third-party-owned assets by as much as 80% (Angeles, 2005). Furthermore, the sizing and configuration of the RAs fleet can be minimized by fleet visibility (Frazelle, 2002) [6; 7].
The focus of most tracking literature has been on the flow of shipments (see Kärkkäinen et al. (2004) for a review), and to a lesser extent the management of the RAs which carry the goods. Similarly, most visibility literature focuses on information sharing concerning demand information and inventory positions (see Lehtonen et al. (2005) for an example). With the exception of Johansson and Hellström (2007), who show that asset visibility has the potential to reduce both investments and operational costs for RAs systems, little scientific work has addressed the visibility of RAs assets. Nevertheless, numerous firms have reported the use of RAs tracking systems. Marks and Spencer, for example, has announced that it tracks 3.5 million returnable food produce delivery trays throughout its supply and distribution network, thereby allowing the firm to speed up its supply chain and reduce errors. Volkswagen tracks 10,000 containers in order to achieve asset visibility and improve container availability (Roberti, 2005), and the Dutch retailer Hoogvliet tracks roll containers from distribution centers (DC) to retail outlets in order to reduce handling errors (LogicaCMG, 2004).

1.4 Research motivations

As we've seen, papers who studied RA tried to solve shrinkage issues challenges. In fact Inventory shrinkage is a common problem in the management of returnable containers. RFID-based container tracking systems have been proposed as a possible solution. Lars Thoroe, Adam, Melski & Matthias Schumann discussed the impact of RFID on management on returnable containers in a deterministic container inventory model. Many case studies: (Strassner and Fleisch2005) and (Foster et al. 2006) in automotive industry (Johansson and Hellström 2007) and Sectoral e-BusinessWatch 2008) in FMCG industry and (Lampe and Strassner 2003) illustrated the potential benefits of RFID use in container management and the majority highlighted shrinkage prevention as a major benefit.

Our motivation in this research is to explore other benefits LPG empty cylinders tracking may present other than preventing shrinkage. We focus on this paper on benefits related to transportation cost saving and customer satisfaction opportunities. We aim also to help for more understanding of LPG cylinder management as the cylinders LPG business still grow in non mature markets and need for more academic research to help to optimize operation performances.

2. LPG Cylinders management Status of art review

2.1 General LPG distribution process description:

Field LPG results from processing natural gas and the stabilization of natural crud oil. Butane and Propane are also gases that result from the refining process. Vessels with maximum 50000 tons refrigerated, semi refrigerated or pressurized transport to customers' zones.
Large LPG storage facilities, often in an import terminal store product that is imported in large quantities by vessels. These products are often derived by train or road to intermediate storage areas.
LPG is then most often stored in spheres. The product is loaded in bulk on tank truck to supply the filling centers which fills bottles (cylinders) with butane or propane.
LPG can be used industrially in many ways. From the intermediary facilities LPG can be loaded in bulk on truck to be delivered to both private and professional customers.
The domestic uses of LPG are cooking, water heating and general heating. For these purposes, LPG is available at bulk and cylinders form.

2.2 Cylinders Management definition:

Intrinsically Cylinders Management covers tanks, cylinders, palettes and cages. However, this document will primarily focus on cylinders as it better fits the identified global risk profile for LPG i.e. 80-90% cylinder park is outside any direct control by LPG distribution companies (nearly 0% for tanks).
One definition which seems to describe Cylinders management is: Cylinders Management is a comprehensive management technique which focuses on what makes LPG unique in the supply chain management and very unusual generally in industry - the packaging is recycled.
Cylinders management embraces all the functions of a company, i.e. Marketing; Sales; Safety; Technical; Operations; Logistics; Legal; Fiscal; Economic & Financial. The financial and safety issues are generally the main drivers of a good Cylinders management policy and drive all other issues. However, other issues, such as marketing, can sometimes play a pivotal role in Cylinders management [8].

2.3 Cylinders Management importance:

Cylinders management is crucial to LPG business because of the facts that:

- Cylinder populations are usually large, and represent a significant proportion of assets.
- Cylinders are beyond companies control for most of the time, but still these companies are responsible for cylinder maintenance and safety.
- Cylinder management requires a complex, cyclical, logistical system.
- A large part of the logistical cycle is operated by third-party companies (distributors, retailers).

Cylinders management is at the core of an LPG business because as far as Cylinders management decisions have major consequences for all functions of the business. Also Cylinders management decisions are difficult to reverse - turning around unhealthy systems is often difficult and expensive in terms of time and resources.

2.4 Cylinders ownership issues

Cylinders can be owned by LPG companies, customers or may ne in an unclear situations.
In the current case, DC owns the cylinders (i.e. best practice). In this situation:

- DC makes them available on loan or on deposit to customers for them to use the gas.
- Customers swap an empty cylinder for a full one, paying only for the gas.
- The company is responsible for filling and supplying safely maintained cylinders to customers.
- Investment, replacement and working stock costs of cylinders can be covered by the deposit system.

2.5 Recovery of Cylinders:

Companies are not generally sure cylinders come back. Cylinders are mobile assets, which escape from company's direct control for most of their lifetime. Cylinders at the filling plant, on trucks, at distributors and retailers form the company working stock of cylinders and can represent a significant proportion of the cylinder pool. Companies should know about the gas sales potential of its cylinders: They should keep in mind that not only cylinders are used as a working stock, but also some cylinders held by customers are not "active". Customers often use a second cylinder as a spare reserve in order to avoid running out of gas. For all these reasons it is extremely risky to rely solely on gas margins to recover cylinder capital [9].

Three systems can be used to recover Cylinders costs:

- Deposit fee (between the end customer and LPG company)
- Rental (between the end customer and LPG company)
- Sales (between the end customer and LPG company, with LPG company owning the Cylinders at least up to POS)

Before a new cylinder is lent/rented/sold to the end customer, it remains in the channel custody. During this temporary period, a cost recovery mechanism has to be put in place to cover the (financial) risk associated with this transit of companies' assets in the distribution channel. The three above systems should therefore be associated with a mechanism to cover the (financial) risk associated to cylinders within channel custody (Guarantee or 'Upfront' Deposit mechanism).

2.6 The Deposit System:

When customers get their first cylinder, they pay the LPG company that owns this cylinder an amount of money, i.e. the deposit, for the use of this cylinder or of any subsequently exchanged cylinder from the same LPG company, for as long as they intend to use LPG from that company. When customers no longer want to use this company's cylinder, they can recover the deposit by returning their cylinder and deposit voucher to the retailer. The deposit is used:

- To encourage customers not to lose the cylinder.
- To recover the cost of continuing cylinder investment and replacement.
- To recover the cost of inactive cylinders.

The deposit should preferably be above 130 % of the delivered, valved cylinder cost, in order to recover the investment. This is not an absolute rule and the actual value of the deposit fee is dependent on market practices. At least this is not the case in Moroccan environment where the deposit is less than 20% of the delivered valved cylinders cost despite in the Moroccan market, cylinders need a lot of maintenance and frequent replacement due to the hostile cylinders handling, transportation and storage conditions. The low value of the deposit encourages the emergence for second-hand cylinders market and inactive cylinders can accumulate in back gardens, investment in inactive cylinders increases and customer loyalty is lost - in addition to the safety problems that this creates.

2.7 The closed loop

A cylinder will go through different complete cycles in different locations before being eventually scrapped, as shown below.

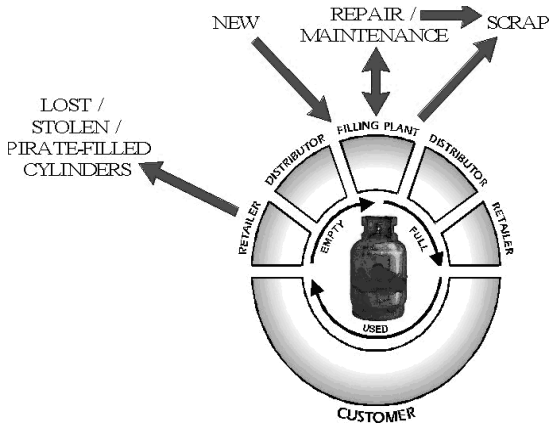

Fig. 2: LPG Cylinders stock flow

- **Cylinders at Customer Sites**

These are the most difficult to control and the size tend to grow all the time. Generally there are more cylinders than customers and the more mature the LPG market, the more cylinders per customer (2nd spare cylinder, multi-use of cylinders, etc.).

- **POS Stock Movements**

Assumptions: Initial POS Working Stock = ten 9-kg cylinders

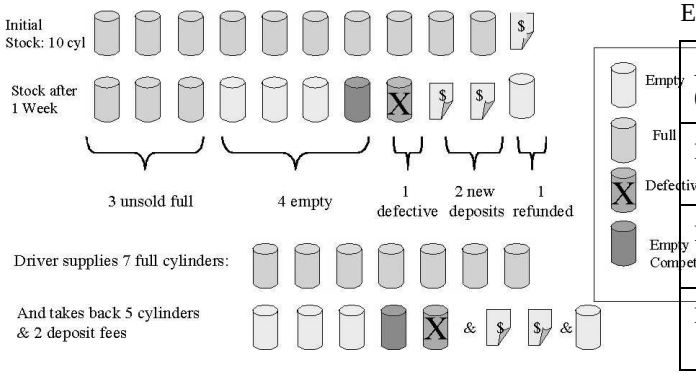

Fig. 3 POS Stock movement illustration.

Elements that determine the Points Of Sales Cylinder Stocks are:

- Local regulations to set maximum number of cylinders.
- Desirable frequency of delivery based on weekly sales.
- Seasonality
- Compromise to be made between stocks (costs for POS or LPG Distribution Company) and frequency of delivery (cost for Distributor).
- Precautionary ratio in case of rapid growth or specific periods.
- Ratio to be higher for "slow-moving" cylinders (large ones for instance).
- Example1:
  - 1 POS selling 150 12-kg cylinders per month (peak) and 50 50-kg cylinders - Maximum number of cylinders by law = 30.
  - Desirable frequency of delivery: twice per week.
  - Stock calculation for 12-kg cyl.: 150/8 = 19 + precaution ratio 20% : Total = 23) 32 – 2 = 30
  - Stock calculation for 50-kg cyl.: 50/8 = 6 + precaution ratio 50% : Total = 9)
  - Total final number: 22 12-kg & 8 50-kg if sales stable - when sales are growing, move to 3 deliveries per week.
  - If so, new calculations: 12-kg = 150/12 + 20 % i.e. 15 and 50-kg: 50/12 + 50 % = 6 – Total number: 21.

Example 2:

Average daily sales (during peak season)	Delivery schedule	Stock at POS
Less than 5 cyl /day	Once a week	8 days of sales (7+1)
From 5 to 15 cyl /day	3 X a week	3 days of sales (2+1)
More than 15 cyl / day	Daily	2 days of sales (1+1)

- POS should NOT be allowed to get additional cylinders even when paying for it.
- Rules to be set up by LPG company and monitored by Sales Reps at Distributors' level.

- **Cylinders at distributor Sites**

Cylinders at retailers and distributors form a population that is much smaller than the Customer Cylinder Pool (usually 10 to 30 times smaller). They are often outside direct control.

Elements that determine Distributor Cylinder Stocks are:

- Total stock requirements at POS level (see above process) AND operational needs at Distributor's depot.
- The frequency of delivery from the FP: Set number of days of precautionary stock - When daily (usually): 1 day + 1 = 2 - If every two days: 2 days + 1 = 3.
- Maximum capacity for 2nd distribution truck.
- Seasonality
- Precautionary ratio in case of rapid growth.
- To be set separately for each cylinder type (precautionary ratio for "slow-moving" cylinders, e.g. large ones).
- Example:
  - 1 distributor selling 2000 tonnes per year in 12-kg cyl. - Peak month + 20 %.
  - I.e. peak daily sales = 2000 / 0.012 x 1/320 days x 1.20 = 625 12-kg cylinders.
  - Delivered every day from the FP with 700-cylinder truck.
  - Operational need = 700 + 625 x 2 = 1950 cylinders.
  - Has a network of 90 POS (based on above slide): Total POS requirements = 90 x 23 = 2070.
  - Additional need for specific events / issues? - Say nil.
  - TOTAL DISTRIBUTOR "ALLOCATED" STOCK = 2070 + 1950 = 4020 12-kg cylinders.

2.8 Cylinders Tracking and Monitoring: How Many Cylinders Do company Have and Where Are They?

Cylinders with customers are by far the largest population. They are also the population over which companies have the least control.

- To achieve more control customer behaviour should be understood.
- For example, a population of 300,000 cylinders could be split between either…
  - 30,000 commercial or industrial customers - or.
  - 100,000 domestic customers who either have spare cylinders for cooking or have multiple uses for the gas - or.
  - 300,000 customers, who have only 1 cylinder of company's brand (but they might have cylinders from other brands).

This question is further complicated by the possibility that distribution companies do not deal directly with a lot of there customers - e.g. those served by distributors, dealers or retailers - so how to know who the end customers are?

In the studied case deposits do not directly finance working stock, this requires careful management. If it is:

- Too Small - DC may trigger stock-outs, lose potential gas sales, gain a reputation for unreliability, and possibly provoke an illegal brand swap, resulting in the loss of cylinders and the loss of customers.
- Too Large - the Capex will be unnecessarily high and deposit could not be sufficient to cover the extra stock investment.

Good monitoring tells:

- Whether working stock of cylinders is too large or too small at each layer of the distribution chain and then improve delivery performances
- How to reduce cylinder Capex.
- How many new customers the company gets.
- When to react against cylinder swapping or stealing.

A cylinder will go through different complete cycles in different locations before being eventually scrapped, as shown below.

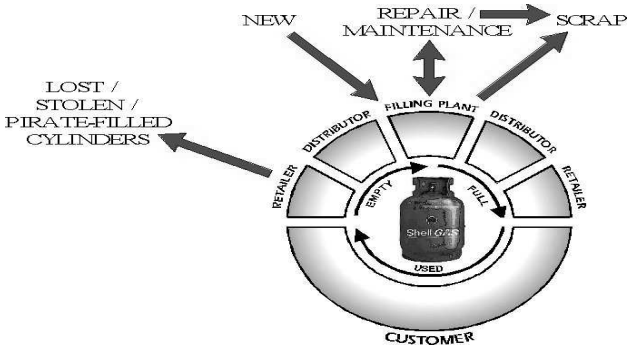

Fig. 4: LPG cylinders flow

2.9 Cylinder utilisation Indicators:

Cylinder Turnaround Ratio (CTR or CT) - also known as "Rotation Index" (RI). The Cylinder Turnaround Ratio (CTR) is a traditional measure of cylinder pool efficiency. CTR is an asset utilisation ratio for cylinders. The higher it is, the better.

$$\text{CTR (i.e. the Cylinder Turnaround Ratio)} = \frac{FR}{CP}$$

FR (the Filling Rate - i.e. the number of cylinders filled per year)

CP (the Cylinder Pool - i.e. the total number of cylinders)

A CTR of 5 will mean that on average a cylinder is filled 5 times per year. BUT, it cannot be used to tell you the efficiency of cylinders held at each of the following:

- Customers.
- Depots and filling plants.
- Distribution and retailers.
- Repair shop.

CCT: Cylinder Cycle Time

The lower it is, the better ("unproductive" cylinders)

$$\text{CCT (i.e. the Cylinder Cycle Time Ratio)} = \frac{1}{CT} \times 365 = \frac{CP}{FR} \times 365$$

CP = the Cylinder Pool - i.e. the total number of cylinders

(the Filling Rate - i.e. the number of cylinders filled per year)

A CT of 5 will have a CCT of 73 days, which means an average cylinder will take 73 days between 2 fillings. It also corresponds to 73 calendar days of sale.

A useful aspect of the CCT ratio (as opposed to the CT) is that you can split it into different sub-ratios to reflect the stages of the cylinders' life cycle : for example, the CCT can be a combination of :

- The customer CCT (CCTcus).
- The CCT of working stock cylinders at your own premises, filling plants, depots, (CCTows).
- The CCT of working stock cylinders at distributors, retailers (CCTdws).
- The CCT of cylinders under maintenance (CCTmain).

CCT: Cylinder Cycle Time

$$CCT = CCT_{cus} + CCT_{ows} + CCT_{dws} + CCT_{main}$$

Where:

$$CCT_{cus} = \frac{\text{Customer Cylinder Pool}}{FR} \times 365$$

$$CCT_{ows} = \frac{\text{Own Cylinder Working Stock}}{FR} \times 365$$

$$CCT_{dws} = \frac{\text{Retailer / Distributor Cylinder Working Stock}}{FR} \times 365$$

$$CCT_{main} = \frac{\text{Cylinders Under Maintenance}}{FR} \times 365$$

Taking the previous example, the 73 days of a cylinder cycle can be split between:

- 60 days at customer premises (CCTcus = 60)
- 10 days at retailer/distributor premises (CCTdws = 10)
- 3 days at your plants and depots (CCTows = 3)

WSR: Working stock ratio

The lower it is, the better ("unproductive" cylinders)

$$\textbf{WSR} = \frac{\textbf{Nb of cylinders at FP/Distributor/}}{\textbf{Total cylinder pool}}$$

$$WSR = \frac{\text{Nb of cylinders at FP/Distributor / PoS}}{\text{Total Cylinder pool (CP)}}$$

3. Case Study

3.1 Business Overview:

The case is about, Butagaz a Multinational LPG (liquefied petroleum gas) division of Shell Group in Morocco. The LPG division holds a market share of roughly 20%.

While LPG consumption declines and is being substituted by safer and cleaner alternatives such as natural gas or renewable energies in advanced economies, it still grows in developing countries.

In this case study we focus on LPG for domestic uses delivered in cylinders. The unitary process of each LPG cylinder is estimated at 22 Euros. LPG cylinders are periodically tested for vessels resistance to working pressure's stress in specialized plants.

For serving its customers Butagaz holds a pool of 5 million cylinders which has an equivalent value of 110 million Euros. Butagaz management acknowledges that their pool size is under-dimensioned compared to there competitor and is a barrier to business growth. Operation manager should strive to maximize cylinder utilisation and keep Butagaz market share stable without having the luxury of introducing new cylinders in the Moroccan growing market due to the group investment policy.

The agents in the SC are the filling plant, the distributors, the POS and the customers. The testing and maintenance centres are not discussed in the research assuming that the cylinders loss and failure are low compared to the business volume.

Empty cylinders recovery follows the same logistic circuit used for cylinders delivery. The full-for-empty swapping or equal exchanges policy applies for cylinders exchange between filling plants, distributors, POS and end customers. As cylinders are heavy packing elements, it is important to reduce transportation cost by using equal exchange policy. Cylinders may return to the same filling plant or to other Butagaz filling plants.

Cylinder pool shrinkage is not part of the research scope but we should note that cylinders are scrapped when they can't be economically repaired or when they are age due.

The cylinder pool owned by Butagz is under-sized for Butagaz market share and filling and distribution operations starve to keep smooth but in many occasions filling plants are short of empty cylinders or vehicles keep waiting for hours to recover for cylinders at distributor premises. Management is concerned about filling plant capacity usage and vehicle fixed rate cost. For this Butagaz looks for efficient tracking solution to keep empty cylinders moving and utilization rate high.

Butagaz suffers from high costs of poor quality (COPQ) within the "order to cash" (OTC) process related to packed distribution gas from filling plants to dealers.

It delivers full cylinders to its dealers who take in charge the distribution process to Point Of Sales (POS). Butagaz transports cylinders to more than 50 dealers in morocco. The distributed LPG volume is Appx. 300.000 tons the travelled distance by distribution trucks is Appx 3 million km. Cylinders are filled in 3 company-owned filling plant and 6 JVs filling plants. Packed gas is delivered in 3 cylinders sizes, 3 kg, 12 kg and 35 kg. For simplification, exposed figures are related to 12 kg market. The issues for the two other markets are similar.

3.2 Cylinders flow:

The flowchart below describes the physical flow of cylinders throughout the distribution chain. If mapping cylinder pool at a particular time, we will find cylinders:

- At customer sites
- At retailer/distributor sites
- At depots
- On trucks
- At filling plants
- Under repair, maintenance, requalification

- In unknown places (stolen, pirate filling, lost)

We also find that the cylinder pool is "alive", with cylinders moving in and out of the system - i.e. new cylinders which feed the pool, and scrapped cylinders that leave the pool.

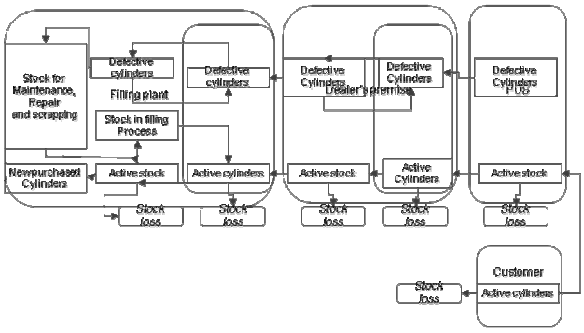

Fig. 5: LPG cylinders stock movements

3.3 Cylinders management and Distribution process:

Butagaz receives orders for full cylinders from the dealers who bases there demand on their own sales forecasting. Trucks used in packed gas delivery to dealers are rented from a local hauler. The rental is made of fixed rate and distance variable rate. Each trip is related to one drop, multi-drop deliveries occur very rarely. Once full cylinders delivered to the dealer the truck should take back the equivalent quantity of empty cylinder back to the filling plant.

Demand planning issues:

Forecast errors make this fulfilment process causing trucks waiting time in dealers' depots for empty cylinders availability once the full cylinders unloaded. Dealer's trucks in charge of delivery to POS may not be back to depot on time or may not deliver the predicted quantity of full cylinders and then can't collect the forecasted empty cylinders.

A COPQ computing of the OTC process conducted for 6 months by the company showed that the waiting time for empty cylinders availability in the dealers' premises costs to the company the equivalent of 2 trucks working hours per day which is equivalent to k$ 80 per annum.

The cylinders inventory in dealer depots is managed by the dealer but the distribution company still owns the cylinder and is responsible for delivery to end customer reliability. The high cost of empty cylinders (Appx. $30) compared to the deposit price (Appx. $6) or to the unit margin ($1) makes the company starving to reduce dramatically the empty cylinders inventory. Poor visibility on dealers' stock was noted as a root cause of the issue as the ordering process is based on there daily demand forecasting.

3.4 Customer satisfaction concerns:

This lack of visibility affects also the customer satisfaction as other dealers may not be delivered on time because trucks are waiting in the wrong dealer's location. A 5% of sales here estimated to be lost because of unreliability and cylinders stock-out at dealers depots and then at POS. Cylinders in morocco are branded and filling companies are forbidden to fill cylinders related to other brands. Once a customer can't find in the POS full cylinders for the same brand of the empty cylinders he owns he decide to switch to other brand. Once a customer is loosed it is generally very difficult to get him back as he becomes physically linked to the brand through the empty cylinder he will bring to the POS in the next cycle.

3.5 Automatic Identification and Data Capture (AIDC) to enhance SC visibility:

Coupled with RFID technology the vendor-managed inventory (VMI) function may be a solution to enhance visibility en stock. The APICS Dictionary, 13th edition defines VMI as a means of optimizing supply chain performance in which the supplier has access to the customer's inventory data and is responsible for maintaining the inventory level required by the customer". An RFID architecture proposition for packed LPG distribution proposition:

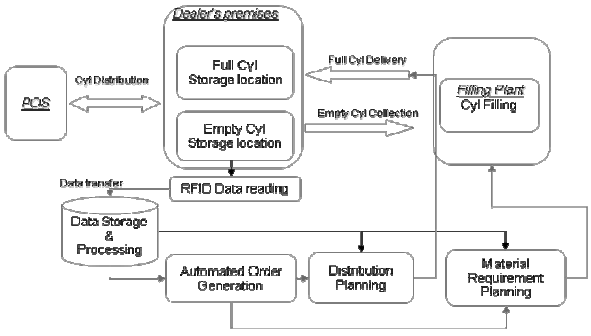

Fig. 6 LPG cylinders movements

For all these reasons a solution that may provide on time visibility is worthy to be explored for use. RFID (Radio Frequency Identification) solution seems to meet such a need.

4. Conclusion

RFID and bar codes (called Automatic Identification and Data Capture devices) helps to identify items and track the movement of goods across the SC automatically, leaving employees to handle just the physical movement of goods with key benefits of faster information visibility and increased transaction accuracy and processing speed.

In fact RFID tags would help to track at least in distributor's premises the exact amount at any time of cylinders. Separate locations for empty and full cylinders with the right FRID readers may help planners in the LPG Company to have a full visibility on stocks. Combined with Vendor Managed Inventory process, this should prevent gas shortage, extra stocks and truck waiting for empty cylinders availability.

An RFID solution may also alleviate the reduction of full cylinders stock out and vehicles waiting for empty cylinders at dealers depots because the inventory information of empty and full cylinders is more accurate and available to DC planners. This means that supply is matched closely to demand, leading to added profits because fewer sales are lost and better assets and trucks usage.

Automated replenishment signals can occur as inventory will be tracked accurately enabling functions such as vender-manager inventory (VMI). RFID use improves also quality assurance by tracking where problems have occurred.

To help to move the company to take advantage from such technology, process optimisation should precede. Both DC and its agents should accept on time data sharing. Mixed team should work to gather to make data flow effectively. The planning process should also evolve from forecast based to data based process.

It is also important to assess the solution cost compared to the COPQ. For this, other COPQs should be taken into consideration such as shrinkage costs, lost sales and empty cylinders inventory cost. Many experiences showed that even projects cost (which is continuously decreasing as the technology continue to develop) and COPQs comparison may not justify a "Go" decision, this kind of project generally helps companies to review its operation process and then reduce unknown poor quality.

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