Chapter 5
Efficacy in Liquefied Petroleum Gas (LPG) Distribution in Urban Environments

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ABSTRACT

Companies distributing LPG in cities used to have two kinds of customers: gas stations that sell it to final users and commercial consumers that use the gas in their own operations. They have to manage the inventory of gas and the daily schedule of the vehicles that transport the gas to the customers. The objective is to meet customer demand, but they are producing low average vehicle loads and empty vehicle kilometers. The authors present a short-term horizon tactical planning system that includes forecasting of sales in gas stations, lower and upper limits of the daily requirement in each customer, and a binary goal programming that determines the life cycle of each vehicle. The slack of the limits allows meeting a service level in the demands, while working with full loads in the vehicles. The system includes a scheduler for the first day and for each chain. It uses a clustering of customers for each vehicle reducing the GPS time network and a shortest path algorithm to determine the routes to visit each customer. The largest fuel distributor of Peru has implemented the system.

INTRODUCTION

Liquefied petroleum gas (LPG) is a fuel derived from petroleum that is used in a gaseous state, but it is stored and transported in a liquid state, since it is cheaper: its volume is 250 times smaller. These functions are performed by placing the gas in containers with adequate pressure. The main uses of LPG are heating, cooking, transport vehicles, power generation and industries in general. The use of LPG has

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many advantages over other fossil fuels such as gasoline or petroleum, especially as regards environmental pollution and, as a result, its consumption in the transport and industrial sectors has increased exponentially in recent years. The need for clean energy in cities is highlighted by many organizations (Nations, 2017) and the use of LPG in replacement of gasoline and diesel is one solution. This demand increment requires an adequate infrastructure to supply customers, mainly located in cities. Service stations and special vehicles of great dimension, supplying them, are typical of this business. The LPG marketing format for these sectors is bulk: consumers have storage tanks that are replenished according to their needs by a distributor.

The take-off of the market has attracted various organizations that venture into the distribution of LPG in bulk, generating a scenario with its own characteristics, but the efficiency of its supply has not received sufficient attention.

This document deals with this scenario, identifies the problems of its distribution and presents a practical solution for them, based on principles of supply chain management. We present a complete solution, fulfilling the corresponding demands, seeks the greatest possible efficiency for the movement of the supplying vehicles within the objectives of urban logistics. The proposal includes strategic, tactical and operational planning of the distribution system, supported by mathematical models. These proposal proceeds from a solution developed for a real situation: one of the main distribution companies in Peru has implemented it.

BACKGROUND

The references of the literature review address three topics: those concerning urban logistics, those referring to gas transportation and those that exhibit vehicle planning and routing models. The proposal presented in this research is a mixture of these areas of knowledge as explained in the following comments.

Excellent compilations of everything that existed about Urban Logistics until that moment, are presented in (Teodor Gabriel Crainic, 2014) and (Gonzalez-Feliu J., 2018). It is emphasized that traffic and parking regulations, although necessary, are not sufficient and new organizational models are required for urban freight transport activities. Based on the fact that cargo transports within urban areas generate large numbers of vehicle movements with a low average load per vehicle and that many vehicles travel empty, it concludes that the only way to obtain significant improvements in these aspects is through a rationalization of the distribution activities that results in fewer vehicles circulating in the cities. The work discusses a two-layer model for an integrated logistic system presented in (Teodor Gabriel Crainic, Nicoletta Ricciardi, Giovanni Storchi, 2009), which proposes that, as in business systems, transport systems in urban logistics require planning at the strategic, tactical and operational levels. At the strategic level, it concerns the design of the system and the evaluation of the probable behavior and performance of the system under different scenarios. At the tactical level, a transportation plan is constructed to provide an efficient operation and an adequate use of the resources, satisfying the demand of the clients within the quality criteria. Finally, the operational level complements the above with the scheduling of terminals and vehicles with their respective drivers and personnel. Tactical level models can also be used to evaluate the project and the system planning mode. It is also highlighted that the important point in urban logistics is the volume of vehicles present in the city and not the assignment work of these vehicles. In the same direction, with the aim of reducing and controlling the number and dimensions of freight vehicles operating within the city, (Teodor Gabriel Crainic, Nicoletta Ricciardi, Giovanni Storchi, 2009) propose