Optimization of Multimodal Connectors

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Abstract — *The use of multimodality in transport is a strategy that brings great energy, economic and environmental benefits, positioning itself as an essential tool in the search for diversification of Ecuador's productive matrix, for this reason this paper shows an analysis of the performed actions that can be applied in this process in order to ensure its efficiency in the energy sector. It is therefore necessary to have well identified the current stage of the process that needs to be optimized as well as each of its components, so that they can make improvements of all the elements, and the whole constitutes a multimodal logistics chain. Furthermore this paper compares specific consumption of various transport modes.*

Under these conditions, during the progress of the optimization exercise multimode connectors, measures, technical, technological and management are proposed, oriented towards greater effectiveness of each of the modes of transport, logistics infrastructure and global transport process , all applied to improving the energy efficiency of existing multimode connectors in Ecuador, as well as the multimodal transport logistics chain hydrocarbon.

Keywords — *transportation, energy efficiency, optimization, fuels, multimodality.*

I. Introduction

The implementation of multimode connector is a high presence strategy worldwide, as these help to improve transport logistics for large volumes of cargo, minimizing travel times and procedures.

Previously it was developed the report entitled: "Evaluation of current multimode connectors" which forms the basis to prepare this article. In the report mentioned information was collected about the Multimodal connectors set for Ecuadorian territory.

A Furthermore, the study evaluate capabilities multimodal transport network of a selected logistics chain. For this case the hydrocarbons logistics chain was selected because as this is a strategic sector in the national economy, it seeks to maintain a register to control the destinies of derivative products, ensuring the existence of data for correct Analysis.

During the development of this work is to seek improve the energy management of said multimodal transport chain. To this should be taken into account that the energy management systems typically involve three steps to develop: measuring and diagnosis of energy consumption, exploring systems to save energy and estimating the potential energy savings, later can implement an energy efficiency program for subsequent monitoring [1].

Many possible improvements can be derived by replacing old equipment with more efficient ones , verify unnecessary energy costs, improvement of process optimization, stricter legislation, among others. All these procedures involve investment that should be recovered in the short and medium term for its implementation is justified or otherwise must obtain environmental benefits which are not accounted for financial matters , ie savings toxic gases to health or dangerous, polluting the environment or causing serious environmental effects [1].

From this information some actions are suggested to help improve energy efficiency during the process, with its consequent reduction in energy consumption and emission of greenhouse gases (GHG).

As a result indicators of potential energy savings are obtained in this chain of multimodal transport.

II. Objective

Present proposals to improve the energy efficiency of multi-modal connectors, and assessing their impact if be applied, consequently optimizing the logistics performance in Ecuador.

III. Development

A. *Ecuadors´s Logistics Performance*

By 2016, the Ecuador is ranked 74th from a total of 160 countries in the ranking of Logistics Performance Index, LPI in English. This index developed by the World Bank, is defined as an interactive benchmarking tool created to help countries identify the challenges and opportunities they face in their performance on the trade logistics, and what they can do to improve this performance [2].

The LPI is the weighted average of six key dimensions used to assess the logistics performance of a country, these dimensions are:

- The efficiency of the clearance process (speed, simplicity and predictability of formalities) by border control agencies, also considering customs;
- Quality of trade-related infrastructure and transportation (ports, railways, roads, information technology);
- Easy ways to hire shipments at competitive prices;

- Competence and quality of logistics services (transport operators, customs brokers);
- Ability to track and trace shipments;
- Timeliness of shipments for arrival at destination within scheduled or expected delivery.

The letter rating, shown in Figure 1 shows the values of the indicators and the general LPI derivative.

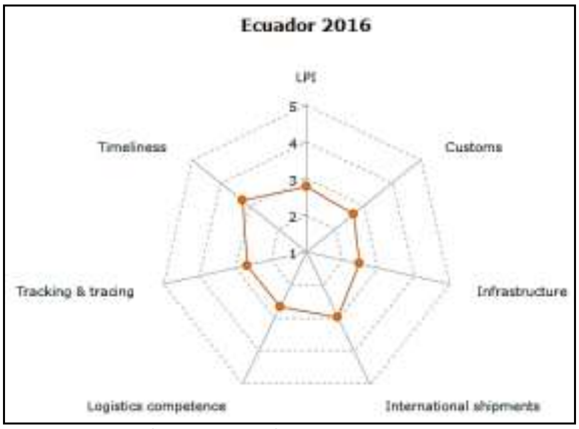

Fig. 1 LPI qualification letter for Ecuador 2016 [2].

B. *Optimization of the Multimodal Connectors Ecuador.*

In a previous report two existing multimodal logistics connectors were identified in Ecuador: Multimodal Corridor Manta - Manaus and Logistic South Corridor, both designed to connect the three regions of the continental Ecuador and seeking to establish greater trade relations through Amazon basin.

Unfortunately these corridors are not yet fully operational, and therefore is not possible to assess its performance; however, actions can be suggested in order to help to achieve a more optimal operation and less need for adjustment once the corridors are used at its maximum capacity.

The actions to be taken into account have an impact on infrastructure, regulations and use of technology; all of they focused on the search for multimodal logistics efficiency by leveraging the efficiencies of each of the transport modes [3].

Examples of actions to be implemented are:

- Modernize existing infrastructure and build new facilities.
- Formalize the freight service providers.
- Determine and establish timely modal interchange points.
- Ensure efficiency by the service providers.
- Use specialized technologies in automation and control of logistics processes for transporting heavy loads.

C. *Optimization of the Multimodal Network for Selected Logistic Chain*

III.C.1 Transport Modes Involved

Throughout the report "Evaluación de conectores multimodales actuales" [4] was determined that in the process of transporting products of the public oil company "Petroecuador", the modes of transport with significant participation were:

- Ground transportation by tankers
- Poliduct
- Maritime, using oil tankers

The first mode of transportation (Land), is used for the clearance of the terminals and depots to service stations. It has a fairly high turnout, especially in the Coast and Andean regions are those that offer the greatest number of consumers.

The poliduct network was designed seeking to connect terminals and oil deposits located throughout the Continental Ecuador, starting with the largest capacity and lately also considering to lower participation.

In the case of maritime transport, this has presence in cabotage activities that occur along the Ecuadorian coast to dispatch clean the ports of traditional fisheries products, as well as for the provision of fuel to the Archipelago Galapagos. The release in these islands is made by the Tanker of petroleum called "Isla Puna", which departs from Terminal of Liberty (in Santa Elena-Ecuador), reaches the tank Baltra where calculated reserve tanks , from there it moves to make the offices in Puerto Baquerizo Moreno and Puerto Villamil, finally returning to unload the remaining freight in the Baltra station.

The distribution route by the petroleum ship "Isla Puna". It can be seen in Figure 2.

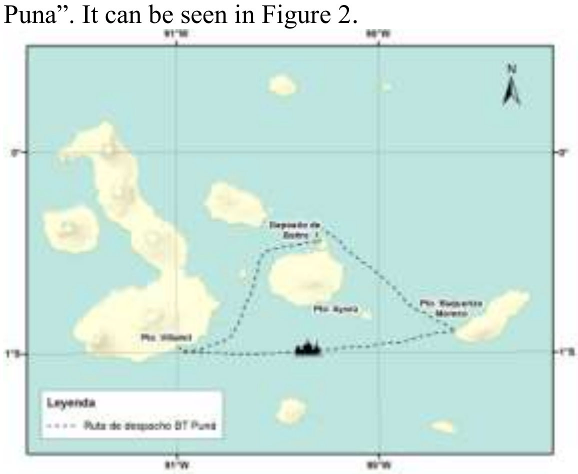

Fig. 2 Fuel distribution route by sea in the Galapagos Archipelago

III.C.2 Proposals for Optimization

Two approaches can be considered in order to improve the energy efficiency of the multimodal logistics chain for the hydrocarbon transport:

The first considering the system as a whole, and can thus increase the participation of a more efficient mode of transport and reduce other less efficient, improve logistics characteristics of the mode change nodes, reduce the necessary procedures, among others.

In this regard, the bar graph shown in Figure 3 shows the specific consumption in KJ / ton-km for different modes of transport. It is noted that on average the consumption of shipping is equivalent to one tenth of the consumption of road transport and a fifth of rail´s consumption [5].

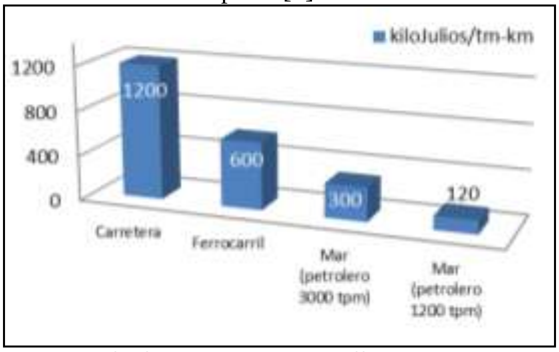

Fig. 3 Specific fuel consumption in different transport modes [5].

The second approach is given by the application of independent actions on each of the modes of transport used; these actions are detailed below.

- ***ENERGY EFFICIENCY MEASURES IN GROUND TRANSPORTATION (ROAD TANKERS)***

As part of the development of "Informe Final de escenario energético actual base de la Red Logística Nacional" [6], different strategies for energy optimization in the logistics chain for hydrocarbon transport by road were determined. Below is performed a summary of the description of the strategies made in that report:

Clearance Optimization: This is done by solving a linear optimization problem of transport networks. The parameters considered in this strategy are the volumes shipped by the terminals and the distances traveled by road tankers. In this case the canton demands and terminal capabilities are met. The purpose of this strategy is that under such restrictions each canton receive product of the terminal whose road distance is the least.

Reallocation of shipments by tanker's category: Regarding this suggestion, it was determined that greater energy efficiency is achieved when the share of tankers with capacity greater than 6000 gallons is higher. This is explained taking into account that despite the greater the capacity, the greater the specific consumption (gal / km) of vehicles; its energy intensity (i.e. the volume of fuel consumed by the quantity of product transported) is lower. Besides, the use of larger vehicles minimizes the number of vehicles required for the process, reducing traffic on roads.

Implementation of efficient driving programs: Based on train fleet drivers to make them aware and encourage the use of more efficient driving techniques. Efficient driving is a set of techniques that help to reduce the fuel consumption, environmental emissions and improve driving safety. It is a comprehensive procedure for the operation of a vehicle, aimed at achieving a minimum consumption of fuel, tires and spare parts in any type of road and traffic conditions [7]. This is the technique that requires less investment, nevertheless presenting great potential for energy savings.

- ***ENERGY EFFICIENCY MEASURES IN HYDROCARBONS PUMPING SYSTEMS BY POLIDUCTS***

Like roads, rivers, power lines, railways, among others; the pipelines are means of transport, in the case of Ecuador, are a mean of transport for hydrocarbons. Pipeline systems and other modes of transport require some energy source to operate and mobilize the load.

In Figure 4 an oil fuel pumping unit is observed, which is made up of a 1800 RPM pump and flow of 660 GPM, with an efficiency of 70%, the driving source is a diesel group [8].

Fig. 4 Pumping group P100-A Pascuales - Tres Bocas [8]

Implementation of electric motors: One of the most practical and fast to improve the efficiency of the pumping action, is the substitution of electric motors by combustion engines, taking into account the efficiency of electric motors exceeds 90% efficiency while diesel engines do not exceed 60% [9].

Thus improving efficiency of energy consumption is immediate; however, the main drawback is economic, because the investment for such infrastructure goes from the coupling system for pumping up the power supply.

Frequency converters: Normally pumping systems operate at constant speed. The frequency inverters are electrical instruments for speed control of electric AC motors; thanks to these devices it is possible to adjust the frequency of the grid to change the rotation speed of the electric motor. The following expression indicates as speed depending on the supply frequency varies [9].

$$RPM = \frac{60 * f}{p}$$

Where RPM is the angular velocity of the engine, f is the frequency of the AC supply and p is the number of motor poles CA.

These drives allow deliver the required energy for work and power needed at that moment, so many components are saved as gearboxes, Figure 5.

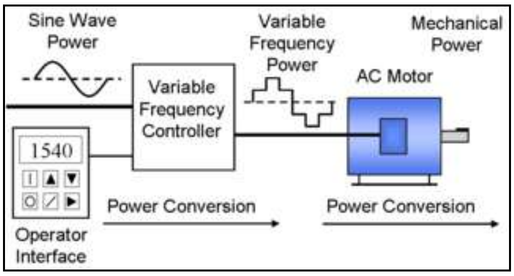

Fig. 5 Diagram of variable frequency and electric motor [10].

Use of more efficient pumps: The pumps are responsible for moving fluid through the pipe, in that sense pump allows more efficient use less energy to mobilize fuel.

Multistage Centrifugal normally for this type of application, where the main function is to move the fluid pumps are used. The pump efficiency is given by the ratio between the hydraulic power delivered by the pump and the power absorbed by the shaft [10].

$$n = \frac{Ps}{Pa}$$

The range of efficiencies of this type of pump, is between 70% to 85%. However the implementation of more efficient pumps has the disadvantage economic investment.

Improvements in the delivery system: The measures that capacity improvement in energy efficiency has are those which would apply to the entire supply network, that is to say, these measures should be considered even from the design stage, it is difficult to make improvements once built network of a pipeline [11].

Energy efficiency criteria have to do with; pipework, dimensioning of pipes, functionality adapted to the actual demand and appropriate control strategies.

- ***ENERGY EFFICIENCY MEASURES IN MARITIME TRANSPORT (SHIPS TANKERS)***

The shipping companies in general are aware of the benefits of energy efficiency and many of them are still good practice to save fuel and reduce emissions of polluting gases. It is detailed below measures where tankers can focus to generate energy savings and GHG reduction.

Reducing vessel speed: Reduce the speed of ships reduces fuel consumption. Compared to other forms of transportation, navigation at low speeds it is more efficient and less polluting. According to the International Maritime Organization (IMO), navigate at low speed is about ten times more efficient than trucks and at least a hundred times more efficient than air transport, if the ship speed increases, it loses much of this efficiency (Sánchez, 2016). In addition, the IMO calculate that a 10% speed on all ships in the world would reduce emissions by 23.3%.

When it comes to transport petroleum products, slow down, it may be beneficial to the environment and more economically profitable.

Clean fuels: The use of cleaner fuels such as Marine Diesel Oil (MDO), containing 0.5% sulfur, Marine Gas Oil or (MGO) containing 0.1% sulfur reduces emissions of fine particles dioxide carbon and nitrogen oxides. In addition, the use of MDO and MGO eliminate the need to use purifiers, heating fuel tanks and burn sludge, which would reduce economic costs [12].

Technical Measures: is possible to apply several measures focus in energy efficiency such as; Set up a rout map according meteorology, improve planning of travels and logistic efficiency, optimization of ships and engines and use other technologies and methods to reduce fuel consumption, like better design of hulls and improve boat's hydrodynamic [12].

- ***ENERGY EFFICIENCY MEASURES IN LOGISTIC INFRASTRUCTURES – HARBORS***

Logistic Infrastructure is a group of physic facilities available which allow movement of freight between different logistic nodes of transportation. Currently we know that costs on logistics around of world vary from 10 – 5% of world gross domestic product (GDP), however in Latin America this quantity in average is over 20% (18-32%) [13], for this reason logistic cost in the most of countries, there are bigger than fees in total cost.

Exist a concept within energy efficiency in infrastructure, which energy use is gaining importance in total efficiency and sustainable of services of infrastructure, logistics and harbors.

Currently, global trends, is focusing to aims complete electrification of port operations because at least in South America, 70% of energy consumption comes from fossil fuels and 30% remaining is electric energy [14]. Whit this, sis possible to use automatic systems of container transportation, such as: AGV-ACT (Automatic Guided Vehicles – Automatic Container Terminals), LMCS (Linear Motor Condutions Systems), GR (Grid Rail) or AS/RS (Automatic Systems Storage and Recuperation).

Furthermore, to obtain an efficient logistic chain is necessary to have a direct connection with whole of logistic infrastructure (transport road grid), this one of solutions is to create ports with concentration of logistic activity zones and internal transfer centers.

Improving energy efficiency is a goal that should be focused on tangible assets (equipment and infrastructure used in business processes) and intangible (human resources, data).

In Figure 6 it shows a model designed with the factors that will improve the energy efficiency.

Fig. 6 Model Energy Efficiency Improvement.

The model proposes to focus improvements in operational management processes and processes of learning and development. The first is focused on the implementation of new equipment and / or technologies to provide better energy efficiency and to automate and control the various activities within the business process. The second is focused on optimizing, planning and organizing the various activities carried out by staff, through, monitoring and control of activities, staff training and use of best practices in different areas of work.

IV. *RESULTS*

In this section the savings that can be achieved as a result of the implementation of the above detailed proposals are presented.

Regarding to land transport, combining the three proposed strategies for energy optimization, based on the data reported in (Diaz et al., 2016), it has been determined that approximate savings of 37,489 equivalent gallons of diesel per month can be achieved , amount equivalent to the energy consumed by 2,687 average Ecuadorian households.

In respect of the pipelines, it is more complex to quantify the potential savings, since the configurations of pumping stations can vary greatly from one to another, and even the systems installed within a single station could have very different characteristics, however, in general terms the implementation of frequency converters can be suggested.

The use of frequency converters for electric engines driving the pumps would achieve savings of up to 30% of energy, depending on the load and power of the plant [15]. However, these savings are not subject to direct implementation of systems of varying frequency and speed of electric motors, but must carry out the determination of in what working ranges is necessary to reduce the speed of rotation of the pumping systems.

V. CONCLUSIONS

Energy efficiency measures are based in good practices of success cases on an international level, and these can be the starting point for implementations within Ecuador.

The implementation of energy efficiency measures should be supported in a model or methodology to achieve the objectives of improvement and reduction of energy consumption in business processes.

The best way to determine the energy savings achieved in the implementation of improved energy efficiency is by measuring the rate of decline in energy demand.

Reduce ship's speed and use of clean fuels, will decrease energy consumption and greenhouse emissions.

Although in design phase is where ensure pumping energy efficiency in a pipeline, exist improvements for failures in performance, to reduce energy consumption of a pumping fuels plant, among we have: replace engines for electric motors, implementations variable frequency drives, more efficiency pumps.

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