



BULLETIN

FAL

FACILITATION OF TRANSPORT AND TRADE IN LATIN AMERICA AND THE CARIBBEAN

Energy consumption and efficiency: emerging challenges from reefer trade in South American container terminals

I. Introduction

This issue of the *FAL Bulletin* discusses the relevance of energy consumption as a basis for identifying energy efficiency potential and calculating the carbon footprints of ports and terminals in Latin America and the Caribbean (LAC), focusing on the Southern Cone countries of Argentina, Chile, Paraguay and Uruguay. More than 95% of South America's external trade is moved through ports (International Transport Database (BTI), 2012). It is therefore important to examine the energy consumption of port infrastructure and services, with regard to the competitiveness of infrastructure services, port performance and the goal of making transport and logistics sector activities more sustainable. The trade in reefer cargo, defined as refrigerated perishable goods, has led to a major increase in the scale of South America's container trade, as well as a change in its structure, since it accounts for a growing share of the region's exports. Not only does this young trade require different handling and logistics, it also consumes more energy. Yet despite rising energy consumption, energy efficiency measures and strategies are rarely present in ports and terminals. In a region where energy security is at stake and sits high on the political agenda, there is an emerging awareness in maritime trade of energy consumption, efficiency and associated costs.










This *FAL Bulletin* is the first worldwide publication on energy consumption patterns in South American container terminals. The results presented in this issue are part of a Latin America-wide study on energy consumption in terminals and ports of all kinds. Follow-up publications are under way, covering a larger set of countries and with specifications for bulk cargo, liquids and gas. Subregional and national seminars are also due

This *FAL Bulletin* analyses energy consumption patterns and provides a comparison of energy use in South American container terminals. It offers thoughts on how energy efficiency could be improved and how the current pattern might affect the competitiveness of the region, with particular emphasis on the role of reefer trade.

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The views expressed in this document are those of the author and do not necessarily reflect the opinions of the organization.

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to take place during the year, in order to present the study's results, to discuss these with the maritime and port industry, and to outline further steps to improve energy efficiency in ports and terminals.

II. Background

Economic development has traditionally been accompanied by a transformation of mobility. Mobility constitutes an ontological absolute for emerging societies. Nevertheless, the emerging demand for the mobility of goods and people comes at a cost, while at the same time raising the demand for energy. Since the 1990s, Latin American and Caribbean countries have engaged in a period of robust and sustained economic growth, which has also increased and altered the patterns of energy demand for freight logistics, both within the region and in its interaction with the global marketplace.

Until now, transport and freight logistics have been based inherently on the consumption of fossil fuels (Economic Commission for Latin America and the Caribbean (ECLAC), 2013). In recent years, the energy consumption of the transport sector in Latin America surpassed 2.0 billion tons of oil equivalent (toe), representing one third of the regional energy matrix. The transport sector's average share of overall energy consumption increased from 27% in 1990 to 35% in 2010 (Latin American Energy Organization (OLADE), 2013).

Port throughput in Latin America and the Caribbean increased from 10.4 million twenty-foot equivalent units (TEUs) in 1997 to 43.0 million TEUs in 2012. In addition to the expansion of container activity over the last two decades, Latin America and the Caribbean has experienced a changing geography of trade, in the form of a boom in trade with Asia. Volumes have had particular high growth rates in the reefer trade (BTI, 2012). In general, the containerized reefer trade has been one of the fastest growing market segments in the liner shipping industry to and from Latin America and the Caribbean. Reefer cargo requires constant refrigeration to maintain the quality of the product and thus consumes a significant amount of energy during movements in supply chain. As a result, reefer trade puts extra pressure on efficient energy consumption, in addition to the energy required for regular port activities and operations.

Despite the changes in the scale and structure of the container trade in Latin America and the Caribbean, energy efficiency measures and strategies are barely present in the region's ports and terminals. In fact, only one port, that of Arica (Terminal Puerto Arica- TPA) in Chile, has been certified with the ISO 50001 energy efficiency standard.

Amid efforts to increase the sustainability of supply chains, energy consumption has been emerging as an important

topic, since it is directly connected to the social, economic and environmental dimensions of sustainability. Reducing energy consumption has a direct impact on emissions, cuts costs in the supply chain, and in developing regions contributes to energy security.

Acciario, Ghiara and Cusano (2013) argue that coordinated energy management not only leads to energy costs savings, but also its role as an energy manager can generate new businesses opportunities for a port. For this reason, port authorities and concessionaries should actively engage in the identification of energy flows and sources within their terminals (Acciario, 2013).

Governments are increasingly focusing on and pressuring for more climate-friendly strategies. However, these initiatives and policies usually focus on emissions as a symptom of industrial activity, rather than on the causes, of which energy consumption is one. As such, a detailed understanding of energy consumption in logistics supply chains is a necessary first step for engaging in strategies and policies towards more sustainable performance.

As Maria Belén Espiñeira (2013) of the Women's International Shipping and Trading Association (WISTA), pointed out:

It is good to know that there is an increasing awareness among private companies, and that they are taking action... We hope that as from now, there is also action from the public sector to provide guidelines. The government seems to have started taking some action now. Let's not forget that production and consumption of energy is a private interest due to the economic factors involved, but it is also an issue of general interest because, at the end of the day, what is seriously compromised is the environment, which belongs to all.

Hence the question arises: what are the sources of energy consumption in terminals? The authors argue that the main challenge is to identify energy sources and usage time, and assign energy consumption to certain port operations.

Whereas Fitzgerald et al. (2011) discussed the energy consumption of on-board reefer containers, this *FAL Bulletin* analyses the structure of energy consumption in 13 terminals in the Southern Cone, in order to gain, for the first time, a detailed understanding of the role of different container types in a terminal's energy bill. Discussions with terminal operators identified that within the industry there is actually a very limited understanding of energy consumption patterns in terminals. This new data is part of an effort to comprehend emerging production and consumption processes, in order to support and reflect upon new policy initiatives and instruments.

This *FAL Bulletin* presents a detailed comparative analysis of energy consumption patterns in container terminals, in order to identify the main sources of consumption and to

benchmark a set of terminals. The study provides a detailed insight into the different sources of energy consumption and costs, and relates them to the terminals' container handling processes. The work results in a calculation of energy consumption, differentiated by container type, as the basis for future energy efficiency measures and for potential solutions to reduce emissions at terminals.

The objective of this issue is threefold: first, to develop a detailed map of energy consumption sources in container terminals and to identify the role of reefer cargo in this context; second, to present a first benchmark of energy consumption in South American container terminals; and third, to calculate the differences between reefer and standard containers in the terminals' energy consumption matrix. Finally, a six-point action plan is proposed for ports and terminals to reduce energy consumption and enhance the transparency of energy efficiency achievements.

III. Understanding the concept of energy consumption and efficiency in ports

Deficiencies have existed until now in research on energy consumption and energy efficiency in ports. Strategies and programmes for comprehensively measuring energy efficiency and consumption by source are absent in the majority of ports and terminals, while the identification and implementation of strategic measurements for improving energy efficiency still do not include all process domains. Discussions with stakeholders in South America and in Europe, such as the European Union's Green

EFFORTS project, among others, have revealed the lack of a standardized method for measuring and allocating energy consumption and GHG emissions, and of energy efficiency key performance indicators. As a result, the benchmarking and control of energy consumption and efficiency is not possible at present.

Why are energy consumption and energy efficiency important for ports? Without the detailed tracking of energy consumption sources, energy efficiency measures cannot be implemented effectively. Furthermore, without understanding energy consumption in detail, even measuring or improving the carbon footprint of a terminal or port becomes a superficial and illusionary undertaking. The question of who needs the carbon footprint values of a container terminal is becoming increasingly relevant as end customers demand more transparency and information regarding the carbon footprint of the products they consume. In consequence, ports and terminals within the maritime supply chain should be accountable for the energy used in their processes. A set of measuring and reporting standards is available. These are: (a) the Greenhouse Gas Protocol (adopted by ISO 14064-1), (b) CEN 16258 and (c) ISO 50001. Each standard focuses on different aspects.

The ISO 50001 energy management framework has a slightly different angle, as it focuses on measuring energy consumption rather than emissions. Starting from an energy baseline, areas for improvements are identified together with appropriate energy performance indicators and targets. These are then used to develop and implement an energy action plan.

Table 1
COMPARISON OF THE GHG PROTOCOL WITH CEN 16258

Target users	GHG Protocol	CEN 16258
	All types of companies	Transport services
Boundaries	<ul style="list-style-type: none"> - Direct emissions (scope 1) - Indirect emissions (scope 2 and 3), including office buildings, maintenance, lighting, cold store, handling equipment, staff commuting and third-party services 	<ul style="list-style-type: none"> - Direct emissions from transport mode/ vehicle - Indirect emissions, including production and transportation of fuels for transport mode/vehicles
GHG emissions sources	<ul style="list-style-type: none"> - Scope 1, 2 and 3 	<ul style="list-style-type: none"> - Well-to-tank/WTT (energy processes) - Tank-to-wheel (vehicle processes)
Measurement methodology	<ul style="list-style-type: none"> - Direct measurement, published emission factors, default fuel use data 	<ul style="list-style-type: none"> - Specific measured values - Transport operator vehicle-type or route-type specific values - Transport operator fleet values - Default values
Activity data	<ul style="list-style-type: none"> - Scope 1: fuel consumption - Scope 2: purchased energy and supplier-specific, local grid or other published emission factor - Scope 3: reported energy use or published third-party emissions 	<ul style="list-style-type: none"> - Fuel consumption - Actual distance - Weight of shipment - Energy and emissions conversion factor

Source: GHG Protocol, ISO 14064-1 and CEN 16258.

By way of example, a European terminal handling 1.6 million TEUs was estimated to consume about 12 million kilowatt hours (kWh) of electricity and 3.1 million litres of diesel per year¹ (Froese and Toeter, 2013). The former is equivalent to the energy generated by two 1.5 MW wind turbines per year. In order to create a basis for subsequent carbon footprint calculations, energy consumption needs to be differentiated by type of energy (fossil fuels and electricity) in order to calculate emissions for scope 1: emissions from diesel engine of owned-handling equipment, and scope 2: emissions from purchased electricity.

To understand the sources of energy consumption, container port operations need to be split in process clusters. According to Froese and Toeter (2013), the authors differentiate between the following clusters: quay cranes, lighting, buildings, cooling (reefers), horizontal operations in container handling, and others.

However, greater disaggregation is necessary in order to fulfil customer expectations regarding the calculation of a carbon footprint. Lin et al. (2011) recommend an activity-based cost (ABC) approach focusing on calculating the costs of individual activities and assigning those costs to cost objects such as products and services on the basis of the activities undertaken to produce each product or service (Horngren et al. 2000). In this sense, the authors define the container type and size as reference units, which would ideally enable differentiation between: full/empty, size (20", 40" or 45"), type (reefer, frozen, chilled, ambient temperature) as well as between the type of reefer (import, export, transshipment), for the purposes of discussion on the different container types handled in ports (Monios and Wilmsmeier, 2012). In an ideal scenario, differentiation between full and empty would also include the specific weights of the container, since this can influence the energy actually consumed in handling processes. Most importantly, the comparability of the data should be maintained when controlling for various characteristics of cargo.

Thus any measurement of energy consumption and efficiency calculation requires a thorough understanding of the processes and cargoes handled in a terminal or port.

IV. Looking beyond energy consumption

Comprehensive work related to port and terminal environmental issues has been carried out on ballast water, waste, scrapping/recycling, and emissions (SO_x, NO_x, PM, VOCs), but the CO₂ footprint now is pre-eminent on the regulatory and political agenda. However, port and terminal operators are still trying to understand the details and the patterns of energy consumption in their installations. Continually rising energy costs increasingly have come to

the attention of terminal and port operators, as these can have significant impacts on their competitiveness. This provides a good opportunity to raise awareness of energy consumption and to discuss possibilities for achieving lower carbon footprints and lower energy bills, while at the same time achieving greater competitiveness by becoming greener and more efficient.

From the terminals' point of view, the state of the art in the development of benchmarking concepts for energy consumption must be clear that there is no simple means of comparing terminals with one another. Even if container logistics are comprehensively standardized on a global level, the operational conditions can differ widely (climate, equipment, etc.). Sometimes all processes take place at the same site (e.g. in case of a big transshipment terminal with no space restrictions), while in other cases processes are regionally distributed, causing additional transport operations (e.g. off-site empty container depots or dry ports). In this first approach, container terminals must focus on understanding their energy consumption pattern and sources.

V. Methodology

The research is based on a semi-structured questionnaire that was sent out to terminals in four Southern Cone countries, namely Argentina, Chile, Paraguay and Uruguay. The data was collected during personal interviews and in the form of email responses. Thirteen terminals, representing around 70% of container throughput in the Southern Cone excluding Brazil, participated in the research.

An initial finding was that terminal operators had very little knowledge on the subject of energy consumption, or of records of historic energy consumption in their terminals. In several cases, specific energy consumption source monitoring was not installed. This was particularly the case in smaller ports and terminals, which were not acquainted with energy consumption measurements. While collecting the data, significant time had to be invested in explaining to the terminals the relevance of the topic and the way in which to record the necessary data. This meant that some questionnaires were not completely filled out in the first round, however in most cases the required data was obtained during personal follow-up discussions.

VI. Analysis of energy consumption in container terminals in the Southern Cone

A. Energy sources and general pattern of consumption

In recent decades, the Latin American and Caribbean region has shown increased demand for transport based on fossil fuel energy, resulting from increased income per capita, a

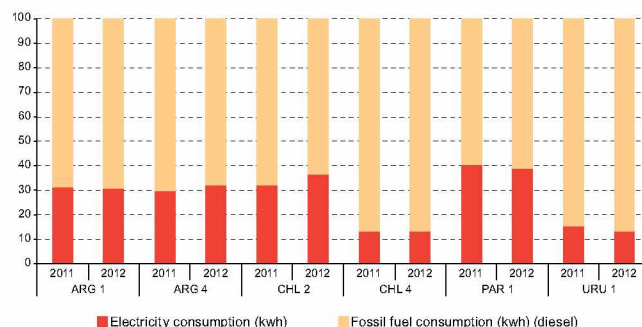
¹ A reference container terminal was developed as part of the Green EFFORTS project.

technological lock-in effect and conventional transport policies. Given the need to maintain the energy security of the region, as well as further economic and population growth, research is needed on possible measures and policies to decouple transport demand from conventional energy sources and economic development.

Reducing fossil energy consumption through improved efficiency and electrification in ports has been perceived as part of the solution for reducing dependence on fossil fuels, both in Latin America and the Caribbean and in other parts of the world. Currently, most of the energy used in Latin American and Caribbean ports is generated from fossil fuels. The survey analysis revealed that on average less than 30% of the energy used in container terminals comes from electricity (see figure 1). On the one hand, these findings show a huge potential for switching from fossil fuels to electricity and thus reducing scope 1 emissions. On the other hand, they present a significant challenge, since such a conversion would have to be mitigated through investment in the energy grid and production, in order to accommodate the new demand and demand peaks in particular. At the same time, the results illustrate that the share of electricity is slowly starting to increase in the majority of the terminals under study. Additionally, the distribution of energy consumption clusters can vary considerably, mostly depending on the share of reefer trade, which during the fruit season can easily rise to up to 60% of the total electricity consumption of a terminal.

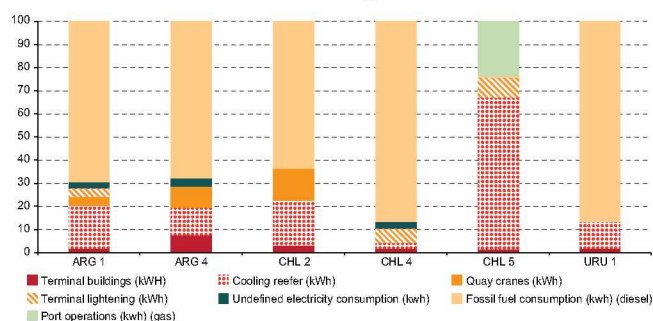
In a common container terminal, electrical energy consumption is on average distributed as follows: (a) reefer containers, i.e. refrigerated containers carrying deep-frozen or chilled cargo (40%), (b) ship-to-shore cranes (40%), (c) terminal lighting (12%), and (d) administration buildings and workshops (8%). Fossil fuel consumption (diesel or gas) is distributed, on average, as follows: (a) stacking operations (68%), (b) horizontal transport of boxes, for example by tractor (30%), and (c) other vehicle and equipment operations such as those using terminal cars and forklifts (2%). Analysis of the set of terminals under study yielded varying results. It seems that most electricity in terminals is consumed by reefer containers for the purpose of cooling, followed by ship-to-shore cranes (in the terminals where applicable). Unfortunately, using the current data it is not yet possible for the use of diesel fuel to be differentiated by process cluster. Therefore the next step in the investigation will be to differentiate the use of fossil fuels by process cluster, a necessary measure when moving towards identifying areas for energy reduction. One key issue was identified in that one of the sample terminals makes substantial use of gas in its operations (see figure 2).

Figure 1
ENERGY CONSUMPTION BY TYPE OF ENERGY SOURCE
(Percentages)



Source: Prepared by the authors based on the ECLAC/ISU Energy Consumption and Efficiency Survey.

Figure 2
ENERGY CONSUMPTION DISTRIBUTION AS A PERCENTAGE OF TOTAL TERMINAL ENERGY CONSUMPTION IN 2012
(Percentages)



Source: Prepared by the authors based on the ECLAC/ISU Energy Consumption and Efficiency Survey.

B. The reefer challenge in energy consumption

Between 2010 and 2011,² the East Coast of South America (ECSA) exported more than 700,000 TEUs of refrigerated containers (APL Logistics Ltd., 2013). Argentina accounted for 19% of the exported TEUs, or 135,000 containers. Uruguay exports 7% of the region's containerized reefer exports, with almost 50,000 TEUs (Drewry, 2012).

During 2010-2011, 78% of the containerized reefer exports from the subregion were meat products, more than 400,000 TEUs. Chicken (whole and breast) is the largest meat category exported, constituting 73% of all meat exports from the subregion, followed by bovine meat (14%) with 57,000 TEUs. Swine meat accounted for 5% of meat exports, with 19,000 TEUs (APL Logistics Ltd., 2013).

Fresh fruit made up 10% of the containerized reefer exports, with 53,000 TEUs (APL Logistics Ltd., 2013)³.

² (November 2010-November 2011).

³ In comparison to APL Logistics Ltd. (2013), Drewry (2012) reported that fruit exports accounted for a higher share of maritime reefer exports. Fruit, nuts, citrus peel and juice constituted 20% of total reefer shipments (TEUs) in 2010.

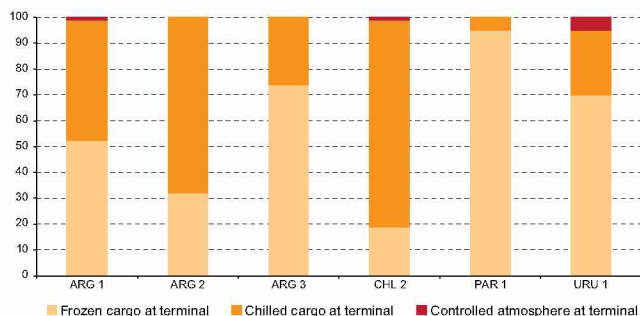


Between 2009 and 2011, Chilean containerized reefer exports of fresh and frozen fruits and fish increased from around 240,000 TEUs to more than 300,000 TEUs, an increase of more than 25% (Foreign Trade Data Bank for Latin America and the Caribbean (BADECEL), 2012).

One of the challenges presented by containerized reefer cargo is its seasonality (Vagle, 2013), which causes significant variations and peaks in energy consumption, with the peaks determining the number of reefer plugs required for an efficient operation at the terminal. The peak fruit season lasts only three months and thus creates an oversupply of reefer infrastructure during the rest of the year.

A further characteristic of reefer cargo is that it is not uniform and, as mentioned above, requires differentiation between frozen, chilled and controlled-atmosphere cargo, with energy consumption patterns that vary considerably. Contrary to the general belief that frozen cargo consumes less energy than chilled and controlled-atmosphere cargoes, the authors argue that the latter two categories require a constant energy supply because even the slightest temperature variations can impact negatively on cargo quality. Figure 3 illustrates that chilled cargo accounts for a significant share of reefer cargo at some of the terminals under study. A detailed understanding of the energy requirements of these cargoes is necessary in order to estimate energy consumption.

Figure 3
REEFER CARGO DIFFERENTIATED BY TYPE
(Percentages)

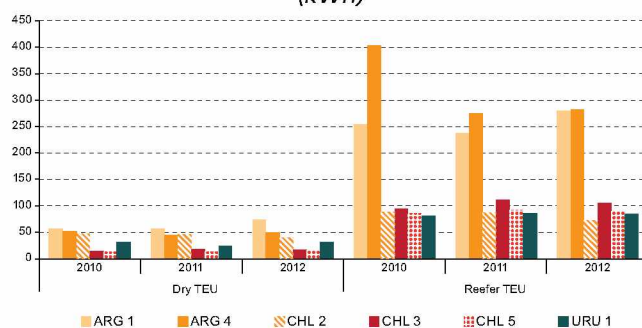


Source: Prepared by the authors based on the ECLAC/ISU Energy Consumption and Efficiency Survey.

The authors also asked the question: what is the actual difference between the energy levels consumed by reefer and by dry TEUs, when all terminal processes are taken into account?

Figure 4 illustrates the difference in energy consumption between these two types of containers on a macro scale, without taking into account the different types of reefer cargo. In this particular case, energy consumption from fossil fuels and electricity was taken into account for refrigeration, terminal lighting, buildings and cranes. The calculations are based on an equation adapted from the methodology used in Buhaug et al. (2009) on the comparison between reefer and dry containers.

Figure 4
COMPARISON OF THE ENERGY CONSUMED
BY REEFER AND DRY TEUS
(kWh)



Source: Prepared by the authors based on the ECLAC/ISU Energy Consumption and Efficiency Survey.

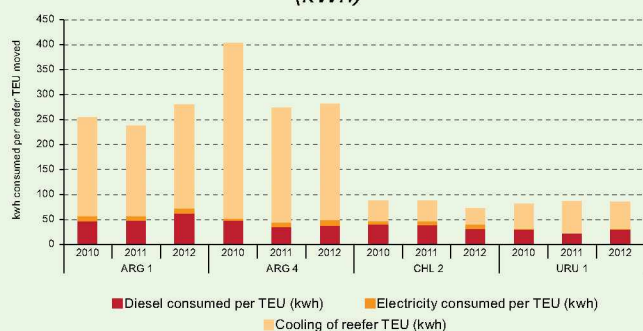
The results demonstrate immense differences in the energy consumed when comparing dry and reefer cargo handling in all the ports and terminals surveyed. The difference resulted from the energy consumed in cooling, as opposed to not cooling the respective cargo.

To gain a deeper understanding, total energy consumption was estimated per reefer TEU handled in each terminal, considering all processes and energy sources (figures 5 and 6). The results show significant variations between the terminals. While the terminals ARG 1 and ARG 4 decreased their total energy consumption per reefer TEU between 2010 and 2011, at the other terminals consumption stayed the same or increased slightly. However, between 2011 and 2012, ARG 1 and ARG 2 increased their total energy consumption per reefer TEU, while the other terminals maintained or decreased their consumption.

Despite the fact that the differences between the terminals declined in this regard, they nonetheless remained notable. The indicator employed leaves room for interpretation, since reductions and differences in

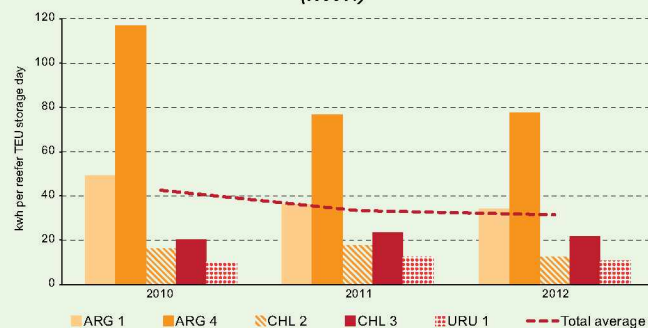
consumption can stem from various causes. One key aspect that needs to be taken into consideration is the terminal dwell time of the reefer units, which is not considered in this measurement. Terminals with shorter dwell times will therefore have significantly lower energy consumption per reefer TEU.

Figure 5
ENERGY CONSUMED PER REEFER TEU,
BY ENERGY SOURCE
(kWh)



Source: Prepared by the authors based on the ECLAC/SU Energy Consumption and Efficiency Survey.

Figure 6
ENERGY CONSUMED IN COOLING, PER REEFER
TEU PER STORAGE DAY
(kWh)



Source: Prepared by the authors based on the ECLAC/SU Energy Consumption and Efficiency Survey.

Neither does the measurement account for the potential differences in technology used in each terminal. In order to advance towards a more accurate measurement, the total energy consumption per reefer TEU (figure 5) and energy consumption for cooling per reefer TEU was estimated. On average the results show a similar positive trend in terms of energy consumption. However, the reasons for these reductions need to be investigated at individual terminal level to determine whether they stem from an increase in operational efficiency or are the result of technological change (for a general discussion on advances in terminal productivity and technological change in Latin America

and the Caribbean, see Wilmsmeier et al. 2013), the type of reefer cargo or even the conditions in which the cargo is delivered.

This factor emerged from the interviews with the terminals. Operators stated that reefer cargo is often packed and delivered to the terminal in containers that are not pre-cooled. A significant amount of energy is therefore required to first cool down the units to the specified temperature. However, besides the greater need for energy, this habit also increases the supply chain risk to the cargo, potentially jeopardizing the quality of the products and thus creating extra logistical costs at a later stage of the cold chain.

Figure 6 presents the actual energy consumption of cooling per reefer TEU per storage day (dwell time) for a selection of three terminals, thus controlling for longer or shorter dwell times. It is interesting to observe that energy consumption per hour can exceed a tenfold variation between the best and the worst terminals, and indicates significant potential for energy savings and efficiency measures. Additionally, ports and terminals are required to cater for peaks in reefer demand, and therefore terminals exposed to the export of products with higher seasonality will not be able to use reefer plugs at high efficiency rates over the whole year.

C. Ship-to-shore cranes

It is generally perceived that the electrical operation of cranes at container terminals is the more environmentally friendly than using other power sources (read fossil fuels), and many terminals are working to electrify their operations. While electrification presents no challenge in terms of the technical and operational aspects of the terminal, full terminal electrification can have significant impacts and repercussions on the grid the terminal is connected to. Energy consumption per move using a ship-to-shore crane is estimated to be around 6 kWh.

Comparing the energy consumption of ship-to-shore cranes revealed major differences between the terminals studied. In the case of cranes, the level of the deployed technology is highly relevant in terms of energy consumption. In order to gain a full understanding of whether technological change could be economically viable, the results of individual terminals were compared against the equipment actually deployed in the port, and a strong positive correlation was discovered between age of the equipment and energy consumption. As such, significant savings could be achieved where technological change is implemented as part of an integrated long-term strategy.

Figure 7
ELECTRICITY CONSUMPTION PER OPERATING HOUR
OF A SHIP-TO-SHORE CRANE
(kWh)



Source: Prepared by the authors based on the ECLAC/SU Energy Consumption and Efficiency Survey.

VII. Proposed actions for ports and terminals

The findings in relation to the current energy consumption of container terminals show the need for action, and are highly relevant for industry and policymakers given the urgent need to address competitiveness, energy security and climate change. Therefore the following six action points have been developed in order to help discover energy efficiency solutions for ports:

- 1 **You can only improve what you measure**
Ports and terminals should install an energy monitoring system to assess current energy consumption and its costs.
- 2 **Identify energy consumption sources**
Ports and terminals should identify their energy-consumption sources to discover energy reduction potentials.
- 3 **Formulate an energy efficiency and reduction plan at the process level**
Ports and terminals should formulate an energy efficiency and reduction plan at the process level to coordinate energy efficiency actions.
- 4 **Implement energy efficiency measures and strategies**
Ports and terminals should implement energy efficiency measures and strategies as a coordinated action, especially focusing on processes with high energy reduction potential.
- 5 **Obtain energy efficiency certificates to demonstrate your success**
Ports and terminals should apply for energy efficiency certificates to demonstrate their success and to gain competitive advantage.
- 6 **Formulate a long-term sustainability strategy to meet future energy needs**
Ports and terminals should formulate a long-term strategy to meet future energy needs, especially if an expansion or electrification of the port or terminal is planned.

VIII. Conclusion and outlook

This FAL Bulletin discusses the relevance of energy consumption as a basis for identifying energy efficiency potential and carbon footprint calculations in the Southern Cone. Research and field experience when gathering data

disclosed the urgent need to create more awareness of this topic, while very strong interest was received from terminal operators and stakeholders, who are becoming aware of the unused potential of measures for improvement.

The findings also underscore the importance of a detailed understanding of energy consumption patterns and sources, and show how much more research is required to gain a full understanding of these issues. Aside from identifying consumption, this first research on energy consumption and efficiency in South American container terminals illustrates not only the environmental, but also the economic dimension of the energy discussion and how this can help turn container terminals into more sustainable infrastructures. The presented results are not only relevant for the terminal operators, but also to policymakers, port authorities and transport and logistics operators, since these figures provide details to benchmark different terminals and countries.

By way of example, policymakers and port authorities should support the ports and terminals in reducing energy consumption and emissions in various ways. These include helping terminals and other operators to establish green technologies; developing differentiated port and terminal charges related to energy consumption, implementing energy management for ports as a whole to enable load shedding and smart grid (macro grid) applications, energy brokerage to allow for environmentally friendly and economical contracts with providers, and developing an energy mix including own energy production using wind farms, solar panel installations, tidal energy, and others.

Further investigation on this topic is ongoing and aims to include terminals of all kinds across the whole Latin American and Caribbean region, as well as to further specify energy efficiency indicators. At the same time, dialogue with the terminals has been intensified, based on these first results, so as to engage in discussions regarding the underlying factors and determinants influencing past and present energy consumption patterns. The ultimate goal is to determine appropriate energy performance indicators and targets for container terminals, both for benchmarking purposes and to provide the basis for comparable carbon footprint calculations in the future.

A. Acknowledgements

We would like to express our sincere gratitude to all the port and terminal operators in Argentina, Chile, Paraguay and Uruguay that are supporting our initiative and that have provided us with relevant and detailed data. We hope to continue to deepen our dialogue. We would also like to thank Eric Petri from the System for State-Owned Companies of the Chilean Government for supporting our research by facilitating communication with the Chilean ports.

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