Leticia Phillips
18-3-3

UNICA

BRAZILIAN SUGARCANE INDUSTRY ASSOCIATION

ETHANOL · SUGAR · ELECTRICITY

April 23, 2018

Mary Nichols

Chairman

Air Resources Board

1001 I Street

Sacramento, CA 95814

RE: UNICA's Comments on California Air Resources Board's (CARB) Proposed Amendments to the Low Carbon Fuel Standard (LCFS)

Dear Chairman Nichols,

The Brazilian Sugarcane Industry Association ("UNICA") appreciates the opportunity to provide comments on the California Air Resources Board's proposed amendments to the LCFS, which was posted for comments on March 6th, 2018.

UNICA is the largest representative of Brazil's sugar, ethanol and bioelectricity producers. Its members were responsible for 50 percent of Brazil's ethanol production and 54 percent of Brazil's sugar production in 2017/2018 harvest season. UNICA serves as a source for credible scientific and economic data about the competitiveness of sugarcane biofuels. UNICA also works to encourage the continuous advancement of sustainability throughout the sugarcane industry and to promote ethanol as a clean, reliable alternative to fossil fuels.

Brazil is the world's largest sugarcane producer and the second largest producer and exporter of ethanol with 22 percent of global production and 17% of exports in 2017.[1] Despite these volumes, sugarcane ethanol production uses only 0.6 percent of Brazil's territory[2] and reduces lifecycle greenhouse gas ("GHG") emissions by more than 100 percent[3] compared to conventional gasoline. Brazil's innovative use of ethanol in transportation and biomass for power cogeneration has made sugarcane a leading source of renewable energy in Brazil, representing 17.5 percent of the country's total energy supply, ahead of

[1] Percentages calculated by UNICA, based on LMC Ethanol Monthly Update (March 2018).

[2] Brazilian Institute of Geography and Statistics ().

[3] Seabra, J. E. A., Macedo, I. C., Chum, H. L., Faroni, C. E. and Sarto, C. A. (2011), Life cycle assessment of Brazilian sugarcane products: GHG emissions and energy use. Biofuels, Bioprod. Bioref., 5: 519–532. doi:10.1002/bbb.289

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hydroelectricity.[4] Brazil replaced nearly one-third of its gasoline needs with sugarcane ethanol last year.[5]

UNICA is committed to assisting CARB in meeting goals of the LCFS by providing one of the lowest carbon intensive biofuels to be added to gasoline in use in California. Reducing dependence on GHG generating fossil fuels, especially fossil fuels obtained from unstable and even hostile regions, benefits the entire world, including the United States and Brazil. That is why UNICA works with CARB staff to continue supporting implementation of the LCFS, and why its members have provided volumes of low-GHG-producing sugarcane ethanol to help California meet LCFS goals.

We recognize the effort of staff to try to make the pathway registration process more efficient and less complicated. We want to make sure that the amendments proposed will indeed have these consequences and will allow for a closer-to-reality carbon intensity number for sugarcane ethanol. We would like to see more volumes of low carbon Brazilian sugarcane ethanol entering the California market. For this reason, we would like to offer a few suggestions to the proposed amendments to the LCFS because we believe it will help the program better capture the reality of the domestic sugarcane ethanol industry and reap the benefits of this low carbon intensive biofuel.

Most of our comments are directed to the Carbon Intensity (CI) calculator for sugarcane ethanol, but we would also like to suggest a few comments on the verification process CARB is proposing to create. Please see our comments below:

I – Data analysis period

We understand that starting in 2021, by March 31st, fuel pathways holders will have to submit to CARB an Annual Fuel Pathway report that contains, among other things, 24 months of data. We have discussed with ARB staff in the past and would like to reiterate that official sugarcane harvest period in South-Central Brazil is from April thru March[6]. During this time, the majority of mills crush cane up until beginning of December when the intercrop season starts. For those months (December until March), production numbers will likely be zero, and we want to make sure that CARB has fully understood and accepted this nuance/ reality of Brazilian sugarcane ethanol production, without prejudice to the overall analysis of sugarcane ethanol pathway and its carbon intensity score.

II– Straw Emissions and Credits

As per previous conversation with CARB staff, we understand that the agency intends to discount electricity credits generated from straw (or sugarcane residues – leftover

[4] National Energy Balance – Base Year 2016 (2017).

[5] *Id.*

[6] South-Central region responds for more than 90% of Brazil's sugarcane crush. In North-Northeast region, responsible for less than 10% of national sugarcane crush, the harvest runs from September to August in some states (Alagoas, Bahia, Paraiba, Pernambuco, Rio Grande do Norte e Sergipe) and lasts from May to April in Amazonas, Ceará, Maranhão, Pará, Piauí and Tocantins states.

fibers, stalks and leaves) for all sugarcane ethanol pathways. Our understanding is that the technical basis for such move is the belief that straw removal from the field may influence the need for supplementary use of nitrogenous fertilizers (N-Fert).

We agree that this is an important issue for carbon footprint calculation considering the weight of N-Fert has in the overall GHGs emissions of biofuels. Given the importance of this issue for the LCFS program and for the Brazilian sugarcane ethanol producers, we would like to encourage CARB to do a detailed analysis that better reflect the practice in Brazil, accounting straw emissions and credits in a more complete and in-depth manner prior to making these amendments. In the following paragraphs, we provide an indication of the most relevant literature on the subject.

Vitti et al.[7] (2007) evaluated that Nitrogen (N) and Sulfur (S) stocks of root system are positively correlated with sugarcane yield in the next crop. Figueiredo (2011)[8] indicates that in green-harvested areas, 1619.8 $kgCO2e.ha^{-1}$ are emitted into the atmosphere each year, mainly due to fertilization and diesel use. However, it is worth noting that the results heavily depend on the site-specific characteristics. Fortes et al. (2012)[9] points out those sugarcane post-harvest residues is an important source of carbon and nutrients to soil-plant system. In a recent literature review, Carvalho et al. (2017)[10] argue that the indiscriminate removal of crop residues can reduce the environmental benefits of bioenergy. The same study indicates that benefits in soil carbon (C) stocks were reduced when total aboveground residue was removed while partial removal of sugarcane residues did not reduce soil C stocks.

However, it is recognized that nitrogen from plant residues goes through complex processes, involving several paths to N_2O, leaching to groundwater and surface water trapping, as well as direct emissions of the soil as N_2O, leaving a small fraction for effective use in the cultivation of the plant. Evidences from Vitti et al. (2008)[11] and Vitti et al. (2011)[12] show that nitrogen from straw does not contribute to sugarcane nutrition and that N from straw is below 1%.

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[7]Vitti, A.C. et al., (2007). Produtividade da cana-de-açúcar relacionada ao nitrogênio residual da adubação e do sistema radicular. Pesquisa Agropecuária Brasileira. Brasília, v.42, n.2, p. 249-256.

[8]Figueiredo, E.B. (2011). *Greenhouse gas balance due to the conversion of sugarcane areas from burned to green harvest in Brazil. Agriculture, Ecosystems and Environment* 141. p. 77-85.

[9]Fortes, C. et al. (2012). *Long-term decomposition of Sugarcane harvest residues in São Paulo state, Brazil. Biomass and Bioenergy* 42. p. 189-198.

[10]Carvalho, J.L.N. et al. (2017). *Contribution of above and belowground bioenergy crop residues to soil carbon. Global Change Biology - Bioenergy.*

[11] Vitti, A.C. et al., (2008). Mineralização da palhada e crescimento de raízes de cana-de-açúcar relacionados com a adubação nitrogenada de plantio. Revista Brasileira de Ciência do Solo. 32:2757-2762, Número Especial.

[12]Vitti, A.C. et al., (2011). Nitrogênio proveniente da adubação nitrogenada e de resíduos culturais na nutrição da cana-planta. Pesquisa Agropecuária Brasileira. V. 46, n. 3, p.287-293. Brasília – São Paulo, Brasil.

Recent literature corroborates that **there are levels for soil straw removal, with little or no impact on the need for nutrient replacement.** Neto (2015)[13] points out that the presence of different amounts of sugarcane straw did not change N_20 emissions relative to bare soil (control). In an extensive literature review, Carvalho et al. (2016)[14] verifies that crop residues remaining on sugarcane fields provide numerous ecosystem services including nutrient recycling, soil biodiversity, water storage, carbon accumulation, control of soil erosion, and weed infestation. Such agronomic and environmental benefits are achieved when 7 Mg ha^{-1} of straw (dry mater) is maintained on soil surface (about 50% of straw).

We should note that leaving about at least 40%-50% of sugarcane residues on the field leads to a mean annual C accumulation rate of 1.5 Mg ha^{-1} $year^{-1}$ for the surface to 30-cm depth (0.73 and 2.04 Mg ha^{-1} $year^{-1}$ for sandy and clay soils, respectively). It is caused by the conversion from a burnt to an unburnt sugarcane harvesting system, which is the case of the great majority of sugarcane fields in Brazil (Cerri et al, 2011)[15]. This is an additional safety level, once it seems not being captured in the mechanized credits in LCFS.

Considering the above, we suggest that **up to 50% of the straw could be safely removed from sugarcane fields to produce bioelectricity without affecting GHGs emissions in agricultural activities.** We, therefore, would like to suggest/recommended that the new calculator should have a place to input information of collected straw. This is an extremely important issue for the Brazilian producers and we will be glad to collaborate with CARB to ensure that all nuances of sugarcane ethanol production are captured in the calculator.

III- Mechanization

One input in the calculator that is of great importance to the Brazilian sugarcane sector is the mechanization input, given the advances and investments that the industry has made in this front in the last decade and the competitive advantages that set mills apart from their peers.

According to the State-owned Brazilian Food Supply Company (CONAB in Portuguese), from the Ministry of Agriculture, Livestock and Food Supply (MAPA), the South-Central region, where the majority of UNICA members operate, has reached 95.6% of mechanization level in 2017/2018 crop year, compared to 28,5% one decade ago[16]. Indeed, this index is even higher according the Sugarcane Technology Center (CTC). Following its data, the mechanical harvesting in areas owned by mills, located in South Central region, reached 98% in the named season.

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[13] Neto, M.S. et al., (2015). *Direct N_2O emission factors for synthetic N-fertilizer and organic residues applied on sugarcane for bioethanol production in Central-Southern Brazil. Global Change Biology – Bioenergy.* Piracicaba, São Paulo – *Brazil.*

[14] Carvalho, J.L.N. et al. (2016). *Agronomic and environmental implications of sugarcane straw removal: a major review. Global Change Biology – Bioenergy.* Campinas – São Paulo, *Brazil.*

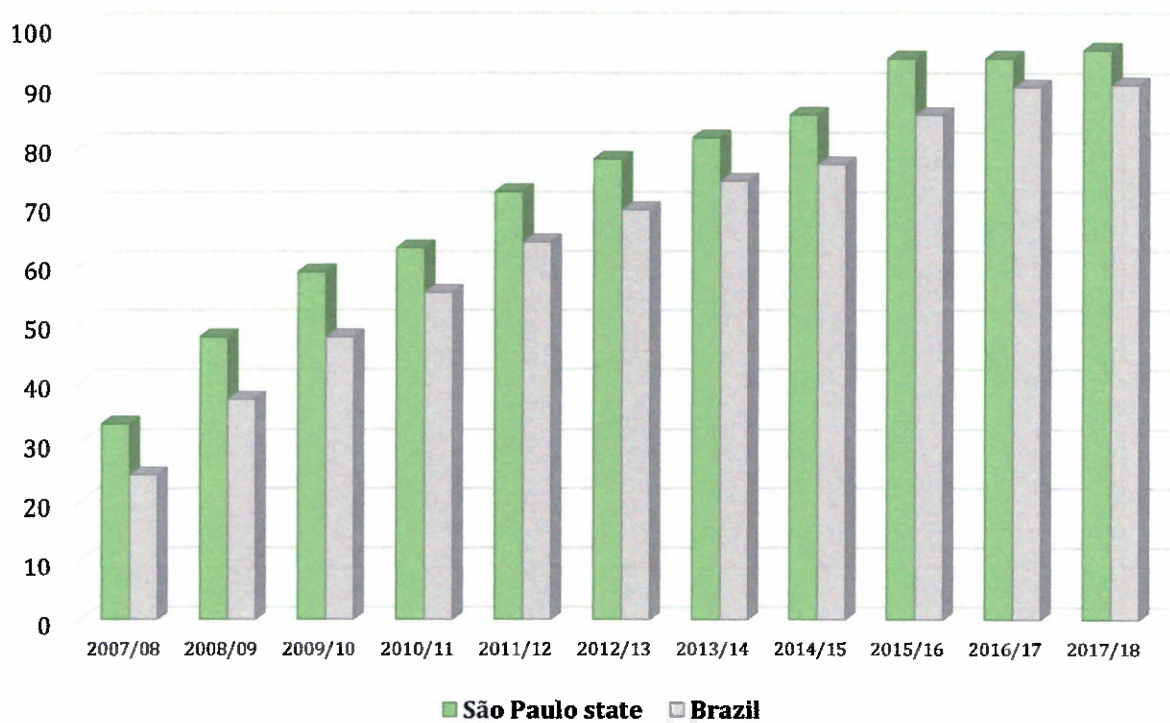
[15] Cerri, C. C., Galdos, M. V., Maia, S. M. F., Bernoux, M., Feigl, B. J., Powlson, D. and Cerri, C. E. P. European Journal of Soil Science; Special Issue: Soil Organic Matters; Volume 62, Issue 1, pages 23–28, February 2011

[16] http://www.conab.gov.br/OlalaCMS/uploads/arquivos/17_08_24_08_59_54_boletim_cana_portugues_-_2o_lev_-_17-18.pdf (page 60)

It is important to mention that this is the region responsible for all the ethanol exported from Brazil to countries such as the United States, Japan and the European Union.

As CARB is aware, São Paulo state government, in partnership with UNICA and sugarcane growers association (ORPLANA), created in 2007 a Green Ethanol Protocol, a pioneer initiative that, among other commitments, eliminated pre-harvest field burning in 2017. According to the Environmental Secretary, 95% of all sugarcane processed in the São Paulo state is under the management of certified parties.[17] Since June 2017 this commitment has entered into a new phase, now called More Green Ethanol Protocol, that continues to reiterate the pre-harvest field burning commitment, but includes the important commitment of restoring riparian vegetation around cane fields.

Sugarcane Harvesting– Fast Mechanization Process in Brazil



Source: CONAB (National Supply Company, from the Brazilian Ministry of Agriculture, Livestock and Food Supply

As previously mentioned, industry has invested a great deal in mechanization in the sector in the last decade. Investments that helped sector reach a level of 57% of GHG emissions reduction from harvesting over the past 10 years (from 4.8 to 2.1 g CO_2eq/MJ of eth-

[17] Slide 3 of the document: http://arquivos.ambiente.sp.gov.br/etanolverde/2017/06/etanol-verde-relatorio-preliminar-safra-16_17-site.pdf

anol), considering the parameters given in Table 1. We believe there is strong evidence that the soil carbon stocks increase due to unburned mechanized harvesting[18]. Estimations from Figueiredo and La Scala Jr (2011)[19] indicate that the emissions in the mechanized harvesting are almost 1500 kg CO_2eq ha^{-1} $year^{-1}$ lower than those for the burned harvesting, since it leads to a soil carbon sequestration of more than 1170 kg CO_2eq ha^{-1} $year^{-1}$.

Table 1: Parameters used for the estimation of emissions balance between burned and mechanized harvesting

Parameter	Value/source
% Mechanized harvesting	CONAB
Sugarcane production	UNICA[20]
Sugar and ethanol production	UNICA[20]
Straw burning emissions	2.7 kg CH_4/t dry matter burnt[21]
	0.07 kg N_2O/t dry matter burnt[21]
Straw to cane stalk ratio	140 kg (dry basis) per tonne of stalk[22]
Harvester's diesel consumption	74 L/ha [23]
Life cycle diesel emissions	83.8 g CO_2eq/MJ [24]

[18] Cerri, C. C., Galdos, M. V., Maia, S. M. F., Bernoux, M., Feigl, B. J., Powlson, D. and Cerri, C. E. P. European Journal of Soil Science; Special Issue: Soil Organic Matters; Volume 62, Issue 1, pages 23–28, February 2011

[19] Figueiredo EB, La Scala Jr N. Greenhouse gas balance due to the conversion of sugarcane areas from burned to green harvest in Brazil. Agriculture, Ecosystems and Environment 141 (2011): 77-85.

[20] http://www.unicadata.com.br/

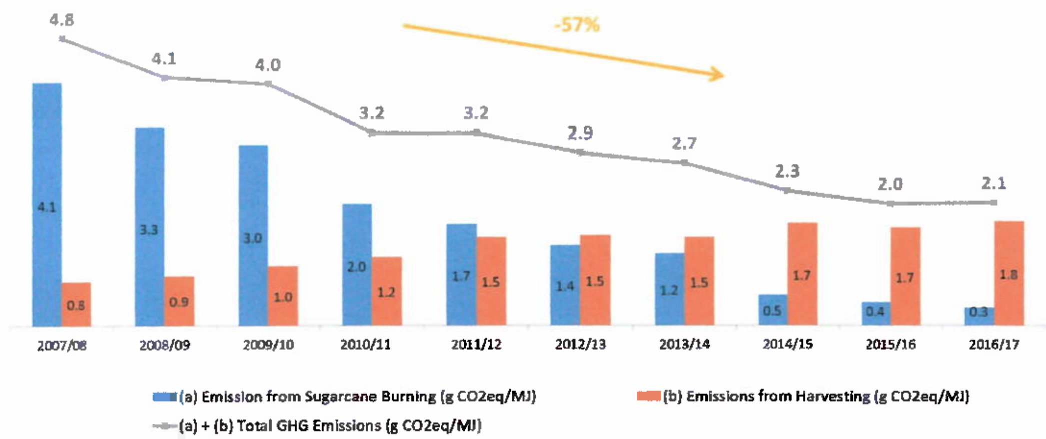
[21] IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

[22] Hassuani SJ, Leal MRLV, Macedo IC. Biomass power generation: sugar cane bagasse and trash. Piracicaba: PNUD Brasil and Centro de Tecnologia Canavieira; 2005.

[23] Adapted from Macedo IC, Seabra JEA, Silva JEAR. Green house gases emissions in the production and use of ethanol from sugarcane in Brazil: The 2005/2006 averages and a prediction for 2020. Biomass and Bioenergy 32 (2008): 582-595.

[24] European Parliament and Council of the European Union, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union of 5 June (2009).

Emissions Balance (Burning vs. Mechanization)



In the CI calculator for sugarcane ethanol, CARB proposes two default values for sugarcane mechanization for Brazil: 80% for São Paulo state and 65% for other states in the Center-South region. By choosing to use the default values, mills will not need to have this input verified. UNICA will probably have members who will be satisfied using the default value, however, the vast majority of our members located in Sao Paulo, who have nearly all of its sugarcane harvesting mechanized, prefers to prove that they are at highest level, as abovementioned reported by CONAB and CTC.

For this effect, UNICA would like to request that CARB includes an option for self-declared mechanization percentage in the CI calculator, and that mills opting for it will have its data and its mill audited by a CARB authorized third party verification body. In Exhibit A we suggest an outline for proving sugarcane mechanization levels in Brazil. In sum we propose that Brazilian mills be given three options: 1) using the default values proposed by CARB and forgo verification of this input; 2) self-declare and go through verification via auditing of its production record/mill; and 3) use of satellite imaging to show the levels of mechanization and go through the verification process of its records/mill. WE believe that any certification plan CARB develops for proving mechanization levels of Brazilian sugarcane ethanol mills should follow along these lines.

UNICA member mills are highly sophisticated enterprises who invest a great deal in the automatization of their agricultural and industrial processes. Third party verifying bodies in Brazil have for years audited mills' systems for certification schemes like the Bonsucro, EPA's RFS program and the LCFS in itself. We encourage CARB staff to continue to reach out to verification companies in Brazil in order to clarify doubts or misunderstanding regarding the automatized systems used by sugarcane mills.

We believe providing these options are not only the best way to capture the reality of sugarcane mechanization practices in Brazil, but it is also the fairest approach.

IV- Ethanol Pipelines

We would like to request CARB staff to include a pipeline transportation option in the CI Calculator for sugarcane ethanol. Although this modal of transportation is still less prominent than truck in Brazil, it is certainly a trend for the near future, as it represents a unique infrastructure that ensures fast, sustainable and low-cost transportation. We believe the addition of this option in the calculator is crucial in order to benefit mills who decide to use it to gain competitiveness in the California market.

Investments in integrated ethanol storage and distribution systems through pipelines, such those made by our member companies Copersucar, Raizen and Atvos in partnership with other stakeholders to create Logum Logística S.A., are a reality.

Ethanol transport through pipelines uses the LOGUM and Transpetro Pipelines systems which operate with hydrous and anhydrous ethanol, gasoline and diesel. In total these pipelines together can extend to 950 Km (590 miles).

Source: Logum System

We understand CARB is concerned with potential contamination of the product given that these pipelines are not for exclusive use of ethanol. For this same reason, and because ethanol producers need to guarantee the quality of their product to their buyer, quality control practices in pipeline transportation are extremely strict.

In summary, the process of ethanol transportation in pipelines occurs as following: fuels are transported in parcels; the flow is continuous and under pressure, allowing for the existence of a contact zone among the fuels, called "interface". The interface between hydrous and anhydrous ethanol does not impact the technical specification of the products, as per the National Agency of Petroleum, Natural Gas and Biofuels' (ANP) requirements.

In the case of ethanol and gasoline interface, ANP has particular requirements to protect the quality of both fuels. This control refers to a product certification in all phases of the transportation, and this is done via automated process, controlling the flows of fuels not to exceed the requirement's limits. It is important to clarify that, in order to guarantee quality control, ethanol fuel is inspected before leaving the port in Brazil and at arrival in the destination port.

When the pipeline moves diesel, it necessarily has to move gasoline in the sequence because this fuel works to seal the pipeline, allowing for the transport of ethanol without any modification. A small loss of 0,2% is allowed, which is normally due to evaporation. ANP exercises strict control and verification of product quality and specification and the flow of fuels have been taking place without any known quality control incident.

For illustration and clarification purposes we would like to share with staff, in Exhibit B, a paper that addresses the methodology of quality control in pipeline transportation in Brazil. We hope this gives staff a better understanding of how the process works in the country. We urge staff to provide this modal of transportation option in the CI calculator, and we remain at staff's disposal to answer any question and to connect CARB with the right people in order to provide better understanding of this issue.

V - Maritime Transportation

Unfortunately CARB has brought back the notion of back-haul penalties for maritime transportation of sugarcane ethanol to California. It is unknown to us that CARB has obtained data to support its assertion that ocean tankers bringing ethanol fuel from Brazil to California will necessarily return to Brazil, and empty. From conversations with staff we understood that this back-haul emission penalty is due to a conservative approach staff wants to take in case this happens in the future. We decided to verify our observations that ethanol ships from Brazil do not return empty and would like to present our findings to staff in Exhibit C.

In the past two years, nine ships have brought ethanol from Brazil to California, for a total of 10 trips (vessel High Valor has made the trip twice), from California these vessels called other ports to deliver other products. The tracking of these vessels confirmed our observations that ships do not necessarily go back to Brazil, and certainly not empty. Out of 10 trips, only one was back to Brazil, with the vessel carrying diesel. All other nine trips were to Asia, Europe and Mexico.

Maritime transportation would certainly not be efficient and affordable if vessels would travel empty around the world. Assuming that the energy consumption and associated emissions of the ocean tanker's round trip be attributed to sugarcane ethanol is highly speculative and arbitrary and causes a tremendous impact in sugarcane ethanol competitiveness in the California market. We would like to request that staff do not consider the emission of shipments returning to Brazil, since it defers from current market and trading practices. In the images bellow it is possible to compare the impact of the methodology change in terms of CI impact. If we consider the same distance parameter compared to CA-Greet 2.0 and CA-Greet 3.0, the CI impact is almost 4 gCO2e/MJ:

CA-Greet 2.0

Transportation and Distribution				5,88
From ethanol plant to port	HDD Truck			
Shares	100%			
Miles				
From ethanol plant to port	Pipeline			
Shares	100%			
Miles	0			
From ethanol plant to port	Rail			
Shares	100%			
Miles	0			
From port to CA port	Ocean Tanker			
Shares	100%			
Miles	8.953			
From CA port to blending terminals	HDD Truck			
Miles	40			
From terminals to fueling stations	HDD Truck			
Miles	50			

CA-Greet 3.0

Ethanol Transport and Distribution			**9,73**
From Ethanol Plant to Brazil Port	Mode: HDD Truck	68642343,2850547 dry gals	
Miles	0		
From Brazil Port to California Port	Mode: Ocean Tanker	100%	
Miles	8.953		
From California Port to Blending Terminal	Mode: HDD Truck	100%	
Miles	40		
California Blending Terminal to Refueling Station	Mode: HDD Truck	100%	
Miles	50		

Conclusion

We commend CARB for its efforts to simplify and make the LCFS registration process more efficient. We also appreciate the opportunity to have an open channel of communication with staff involved in this process. We urge CARB to consider our suggestions and ensure that sugarcane ethanol is fairly scored in the GREET-CA 3.0 modeling and that Californian consumers reap the benefits of sugarcane ethanol. We are at staff's disposal to work in any aspect of our suggested modifications, or to provide any additional data from the current experiences and anticipated trends in Brazil.

We hope this letter will contribute to improving the development of the LCFS in California and we remain at your disposal to answer any additional questions you or your staff may have.

Sincerely,

Elizabeth Farina
CEO

Leticia Phillips
Representative-North America

EXHIBIT A – Mechanization Percentage Credit Options For Sugarcane Ethanol

EXHIBIT B – Ethanol Pipelines in Brazil

EXHIBIT C – Sugarcane ethanol exports to California - Vessel Routes

PARAMETERS FOR MECHANIZATION METHODOLOGY

The following methodologies will be acceptable for applicants to apply for mechanization percentage:

1. **Default Values**

   a) **State of São Paulo:** standard mechanized harvesting level of 80%

   b) **Non – São Paulo States:** standard mechanized harvesting level of 65%

2. **Site Specific (Self-declared) – all options require third party verification**

   a) Mills with AUTOMATIC SYSTEM for sugarcane information registration should comply with the following parameters:

   - At least 80% of sugarcane volume should be automatically registered in the system.
     - If higher than 80%, mills should go through an audit process to validate the results from burned and raw sugarcane quantity registration.

Audit for mechanization verification to be performed by a third party verifier previously authorized and registered with CARB. Verification to include:

- Auditor to previously request automatically-generated cut orders (for both own and outsourced cane) for the time period in question
- Auditor to previously request all agricultural reports produced by the mills' automated system (PIMS, GATec, SAP, ERP, etc) for the time period in question
- For mills in the State of Sao Paulo, auditing team to request the Authorizations certificates for Legal Burning of Sugarcane from the Environmental Company of the State of Sao Paulo (CETESB), if any planned burning is reported
- Auditing team to request any information regarding accidental and/or criminal burning, and verify all documentation registered in the system

IBP2220_17

METHODS TO CONTROL THE PRODUCT'S QUALITY ON PIPELINES

Henrique Ho[1], Rafael Paes[2], Lauro Campos[3], Claudinei Amelio[4].

Abstract

The monitoring of product quality is fundamental in the non-continuous pipeline operation, especially when there are storage points throughout the system.

In this paper, we propose the main methods of controlling the quality of products from the origin (Collection Terminals) to the final destination (Distributors).

The use of statistical tools, monitoring of operations and automation of processes are extremely important for decision-making related to quality preservation, without detriment to other parameters.

The controls that were applied, allowed to advance in the cut-off interface, reducing the degradation of the noble product to the less noble, without the quality of the product being impaired.

1. Introduction

The LOGUM System is designed for operation with two types of ethanol: Anhydrous and Hydrated. The project to supply the domestic and export markets considers the capture of ethanol, in collection terminals and transportation and distribution by pipelines.

LOGUM's collection terminals consists of TTRP (Terrestrial Terminal of Ribeirão Preto) and TTUBE (Terrestrial Terminal of Uberaba). The product captured at these two terminals is pumped to the TTPLN (Paulínia Terrestrial Terminal). From there, through TRANSPETRO pipelines, the product is shipped to distributors in Barueri, Guarulhos and Duque de Caxias, as shown in figure 1.

Figure 1 – LOGUM System

[1] Industrial Engineer – Logum Logística S.A.
[2] Pipeline Engineer – Logum Logística S.A.
[3] Mechanical Engineer – Logum Logística S.A.
[4] Electrical Engineer – Logum Logística S.A.

The TTUBE consists of 4 discharge Skids, and its annual capacity of receiving is 2.0 MM m / year. The storage is carried out in 4 tanks with a capacity of 6 thousand m each and the shipment is carried out from auxiliary and main pumps. Figure 2 explains the simplified flowchart of TTUBE operations.

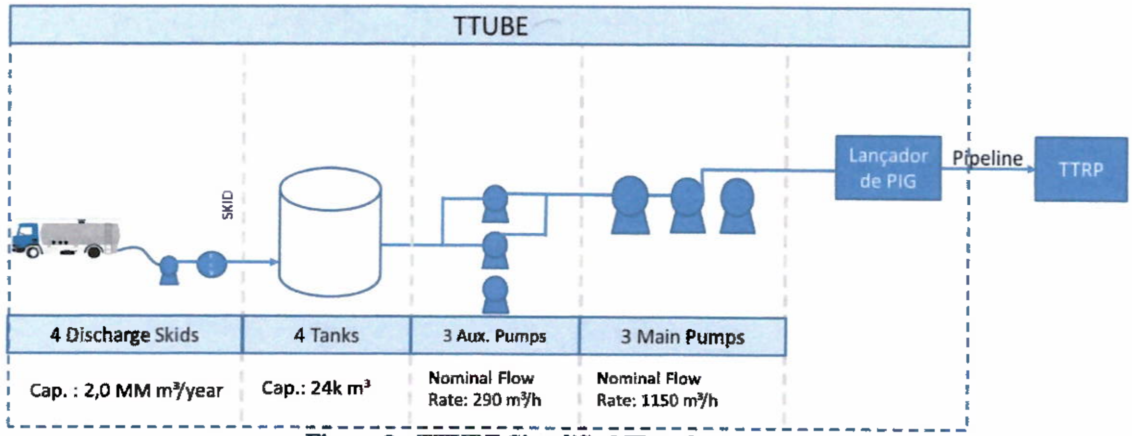


Figure 2 - TTUBE Simplified Flowchart

The TTRP has 18 unloading Skids, capable of receiving 4.3 MM m / year. The storage is carried out in 5 tanks with a capacity of 10 thousand m each and the expedition is carried out from auxiliary and main pumps. It is possible to store product from TTUBE. Figure 3 shows the simplified flow of TTRP operations.

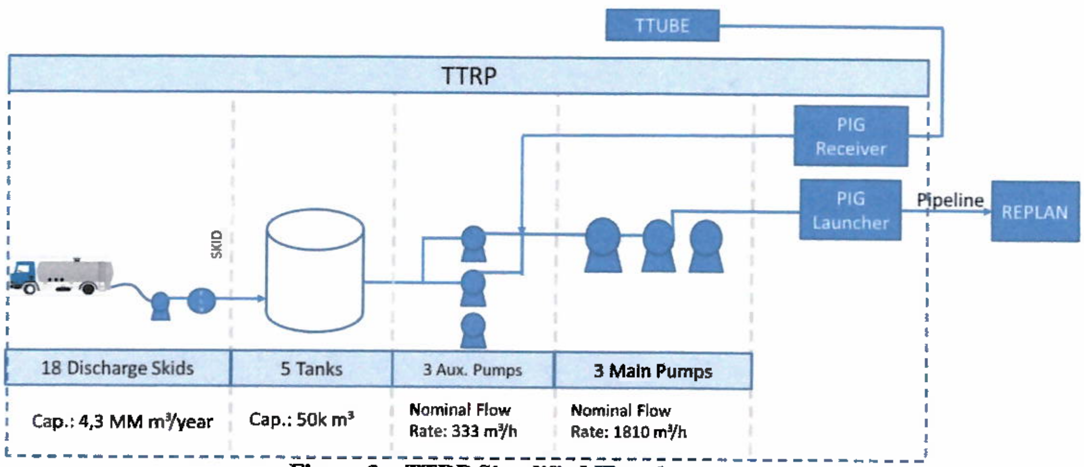


Figure 3 – TTRP Simplified Flowchart

2. Methodology

Ethanol quality control becomes even more important as the product runs through a complex pipeline system, through intermediate terminals and having interfaces cut-off, which can extend up to 950 km of pipeline, if the product is shipped from TTUBE to Duque de Caxias. In this way, it is necessary to have rigor in the control of the products received in the Collection Terminals.

The study on the quality control of Ethanol allowed us to advance in knowledge about the degradation of Anhydrous Ethanol to Hydrated Ethanol, and followed the methodology below:

- Historical survey of test results from tank trucks prior to unloading at the collection terminals;
- Historical survey of results of the certificates of the storage tanks, before dispatch, for calculation of the quality clearance of Anhydrous Ethanol, in the origin;
- Data, from online instruments, of the actual volumes of the interfaces generated in the LOGUM pipelines (TTUBE-TTRP and TTRP-TTPLN);
- Calculation of the degraded volume of anhydrous ethanol to hydrate;
- Implementation of automation tools that help reduce degradation and quality control.

2.1. Assumptions

The specifications of Ethanol, Hydrated and Anhydrous, is governed by the Agência Nacional do Petróleo, according to Resolution number 19/2015.

2.2. Analytical results of the Ethanol in Trucks and Tanks Dispatchers

The process of transporting ethanol through pipelines is susceptible to contamination, mainly through the interfaces generated along the pipeline. For this reason, the quality control at the collection terminals must be strict.

Since the beginning of operations, all the trucks that were discharged were subjected to a previous analysis of the ethanol parameters, specified by the ANP. In addition, during discharging, in-line instruments (densimeter and conductivity meters) follow the quality parameters and in case of non-compliance, the discharge system interlocks, interrupting the discharge.

As the product stored in the tanks of the collection terminals will still pass through several terminals and ducts, the trucks arriving at the terminal with product out-of-specification are refused, to maintain a minimum quality clearance necessary for efficient interface cut-off.

The control chart below shows the clearances of the Anhydrous ethanol tanks (the noblest product) of the tanks of the terminals from the origin, and shows a statistically controlled process, confirming the effectiveness of the qualitative sanitation upon receipt and maintaining a minimum clearance for accomplishment of more aggressive interface cuts.

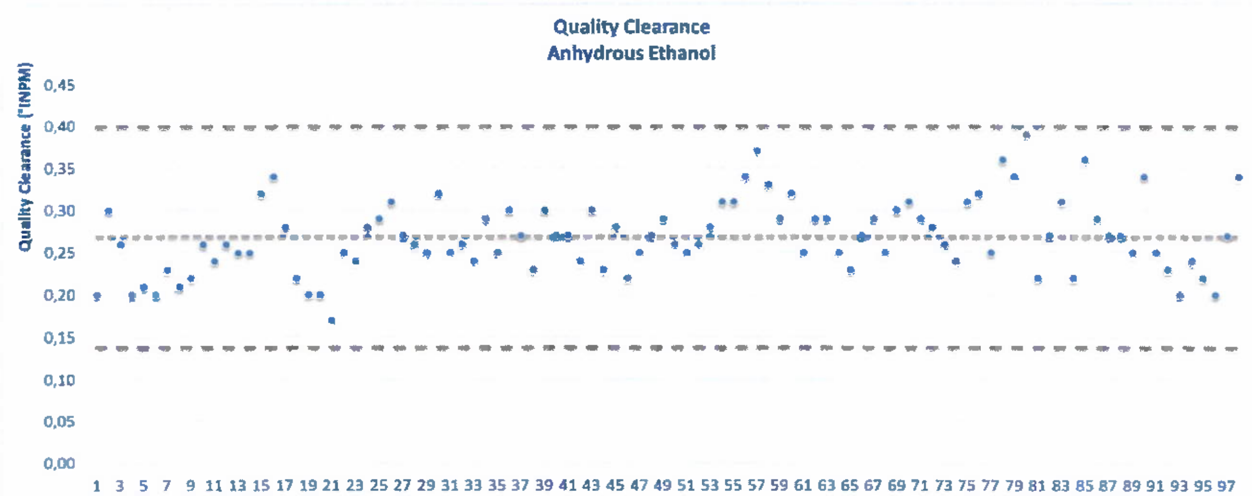


Figure 4 - Results of the Certificates of Quality of the Tanks in the Collection Terminals

2.3. Impact of Interfaces on the Quality of Anhydrous Ethanol

The LOGUM pipelines have the following characteristics:

Table 1 - Features of LOGUM's Pipeline

Stretch	Length (km)	Diameter (pol)	Thickness (pol)
TTUBE – TTRP	143,68	20	0,281
TTRP – TTPLN	207,16	24	0,344

The batches are pumped volumes of Anhydrous and Hydrated Ethanol, in a subsequent way, and the interfaces generated in the poliducts come from the interaction between the different products, as shown below:

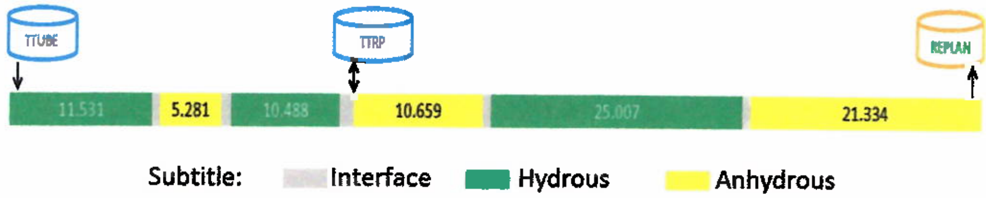


Figure 5 - Representation of the pipeline LOGUM I

In the initial phase of the project, the LOGUM pipelines were idle, causing several pump starts and stops, which end up impacting the increase in interfaces. Among other factors that reflect in the interfaces volumes, it is possible to highlight:

- Flow velocity;
- Duct length;
- Duct profile;
- Diameter of the duct.

Figure 6 represents the theoretical behavior of the batch in a duct. The curve in red represents the specific mass of the product, the area below the curve represents the volume of Hydrous (Green) and the area on the curve represents the volume of Anhydrous (yellow).

The mixture between the batches generates interfaces and, from the cut-off interfaces, a certain volume of Anhydrous is destined for Hydrous, just as a certain volume of Hydrous is incorporated into the Anhydrous, in which case Hydrous acts as a "contaminant" of Anhydrous. Depending on the cut-off point of the interfaces, we may have degradations (transformation of a nobler product into a less noble product) or even contamination of the product with greater purity.

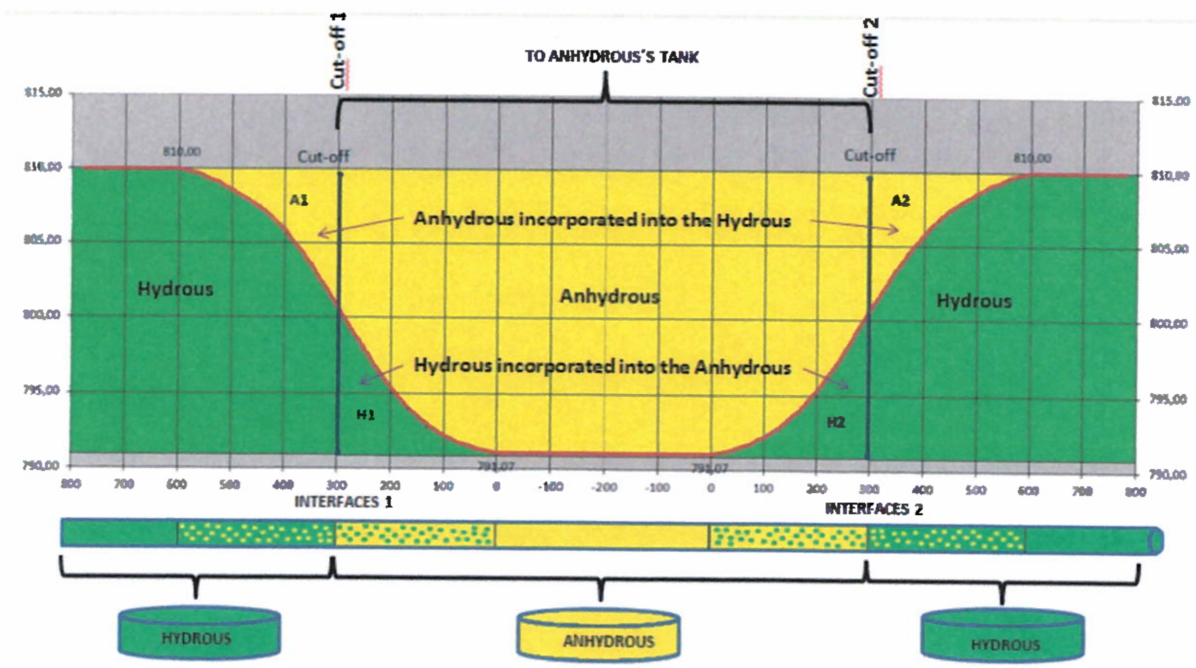


Figure 6 – Batches in a pipeline

Figure 7 details the view of the operator when performing an interface cut, which is focused on reading the density of the products. In this case, the end of the batch of Anhydrous is being received and will start receiving Hydrated. In the example, when establishing such a cut-off point, it is possible to observe Hydrous being destined for Anhydrous (green) and Anhydrous being destined for Hydrous (yellow). This cut-off point prioritizes the preservation of quality to the detriment of degradation (lower volume of contaminant destined for the noblest product and higher volume of Anhydrous destined for Hydration).

The degraded volume is the difference between the volume of Anhydrous destined for Hydration (yellow) and the volume of Hydrate destined for Anhydrous (green).

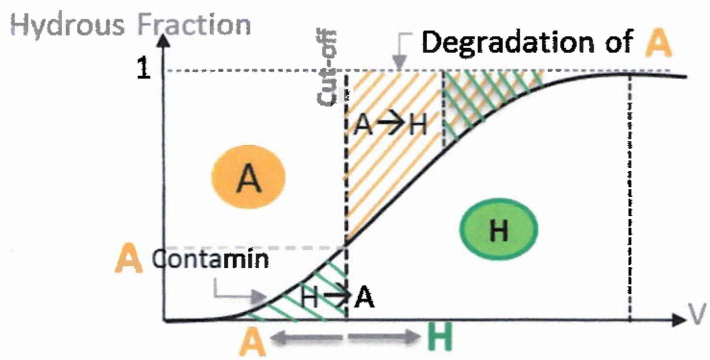


Figure 7 - Theoretical Interface

As degradation, by transforming a higher value product into a lower value product, generates financial losses to customers, it is necessary to seek a cut-off point that preserves the quality - maintaining a gap and having the knowledge that the product will pass through other terminals and will have other interface cuts - and reduce the degradation to minimum values.

Figure 8 shows a theoretical interface being cut with 50% of the variation of Hydrous density. It is possible to verify that the volumes of a product being destined to the other are equivalent, thus reducing degradation, but with the increase of the cut-off point, the risk of contamination of the product also increases.

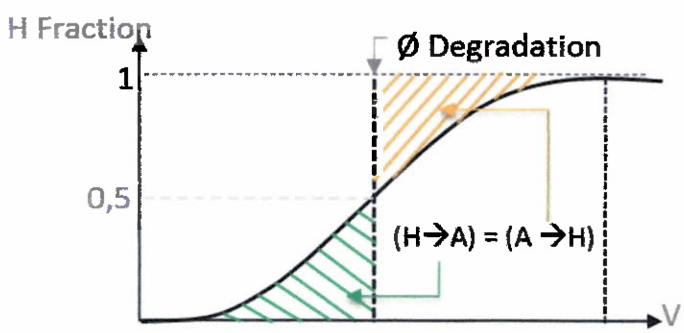


Figure 8 - Theoretical Interface Cut to 50%

2.4. Calculating the degraded volume

It is possible to verify that the quality of the product is directly related to the degraded volumes, thus the monitoring of the batches as regards the service of the quality and the results of degradation is of paramount importance. To follow the degradation results, a calculation is performed according to figure 9.

The volumes shipped at the origin and the volumes received at the destination, of Anhydrous and Hydrous are known. The difference between these volumes of Anhydrous, represent a joint share of P&S (Loss and Gain Results) and

Degradation. Since the P&S portion is known, it is possible to calculate the degradation from the highlighted equation.

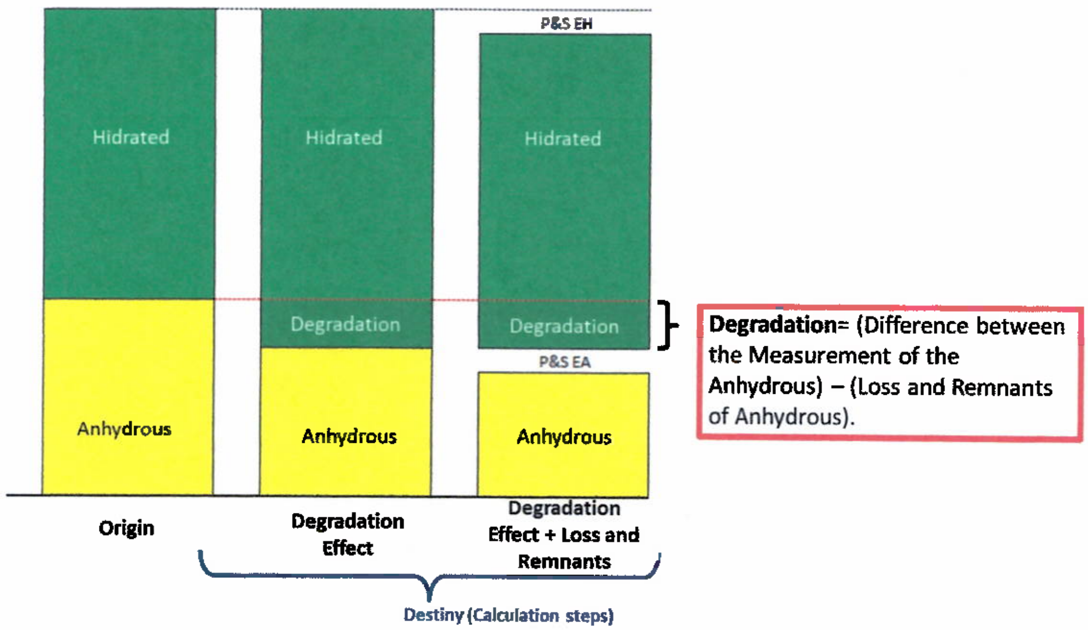


Figure 9 - Calculation of Degradation

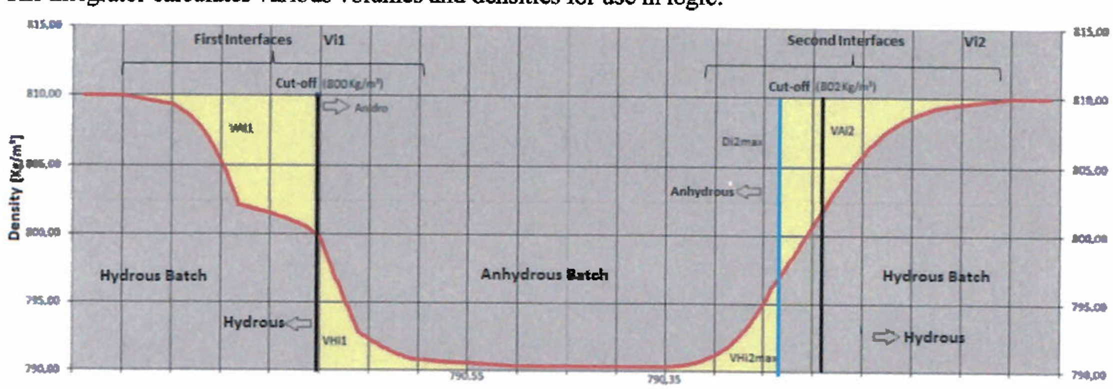
2.5. Automation of processes for preservation of quality and reduction of degradation

The implementation of automation tools to the processes have become great allies to achieve the established goals of reducing degradation along with preservation of quality. So, an interface integrator tool was developed, which allows to calculate, in real time, the volumes of Hydrous destined for Anhydrous in each interface and the volumes and the specific mass of the anhydrous batch, so that the volume of contaminant does not exceed the established maximum quality limit.

According to the item 2.2, the Anhydrous Ethanol is dispatched with an average purity of 0,26 ° INPM. A maximum loss of quality of 0.10 ° INPM has been established to maintain reasonable slack for the following terminals.

The use of this tool will allow to control the parameters of quality, reducing the degraded volumes of Anhydrous in the Hydrated.

The integrator calculates various volumes and densities for use in logic:



The density of Anhydrous is calculated in real time using the following formula:

$$Df = \frac{DHm*(VHi1+VHi2)+(DAm*VA)}{VA+VHi1+VHi2}$$

Where:

Df = Final density of the anhydrous batch when cutting at the second interface, without loss of quality;
DHm = Average density of the hydration batch read by the densimeter, not considering the interface;
DAm = Average density of the batch of Anhydrous read by the densimeter, not considering the interface;
VA = Total Anhydrous batch volume;
VHi1 = Hydrate Volume in the batch of Anhydrous when cutting at the first interface;
VHi2 = Hydrate Volume in the batch of Anhydrous when cut in the second interface.

From this information, it is possible to verify how much Hydrous can still be destined for Anhydrous in the second interface.

For example, upon reaching the second interface, the maximum volume of Hydrated Ethanol is known to be incorporated into the Anhydous so that the established limit of quality loss is not reached. If the volume of Hydrous approaches this limit, the logic of the tool will generate an alarm so that the interface cut-off is performed.

3. Results

3.1. Real interface monitoring

At the beginning of the operation, the cuts were performed with the first density variation, that is, 0% of the contaminant was incorporated into the Anhydrous. This form of operation would guarantee the quality of the product, but would bring negative degradation results.

In order to achieve the objective of reducing degradation combined with preservation of quality, it would be necessary to understand the process of generating interfaces in 20 inches and 24 inches pipelines that work with a certain amount of idleness. The monitoring of all the interfaces that arrived at the TTPLN was carried out, in order to have a concrete data base to allow the change of the cut-off point of the interfaces.

With this monitoring, it was possible to verify that the behavior of the real interface (represented in blue, in figure 10), was directly related to the pipeline stops and was more impacted when the interface stopped in the duct, in order to keep the product more dense at the top and the less dense product at the bottom, according to the detail indicated as an example in the pipeline elevation. The comparison between the actual interface (blue) and the theoretical interface (orange) indicates an increase in the interface due to this factor.

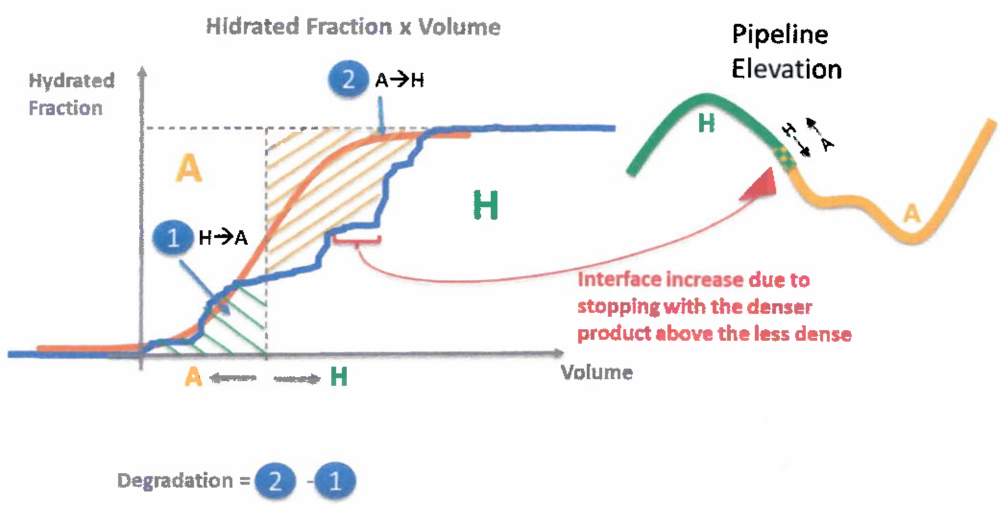


Figure 10 - Real Interface x Theoretical Interface

After monitoring the quality of some Anhydrous batches, the average of the volumes of the interfaces, the theoretical volume of contaminant destined for an average batch of Anhydrous and, consequently, the impact on the quality of Ethanol Anhydrous if the cut-off point was changed to 50% of the variation of the interface density, in TTPLN, were verified. According to table 1, the theoretical impact, considering historical and theoretical data would be 0.09 ° INPM.

Table 2 - Impact on Anhydrous quality

Hydrous effects in Anhydrous	
INPUTS	
Anhydrous Average Density in Origin (kg/m³)	790,63
Initial Alcoholic Degree (°INPM)	99,56
Average Quality Clearance (°INPM)	0,26
Anhydrous Average Batches (m³)	18000
Hydrous Average Density (kg/m³)	810,0
Interfaces Average Volume (m³)	690,0
Hydrous Theoretical Volume Incorporated to Anhydrous per Batch (m³)	248,0
OUTPUTS	
Final Density (kg/m³)	790,90
Final Alcoholic Degree (°INPM)	99,47
Final Quality Clearance (°INPM)	0,17
Qaulity Loss (°INPM)	0,09

Figure 11 shows a sampling of the monitored interfaces before changing the breakpoints of the interfaces.

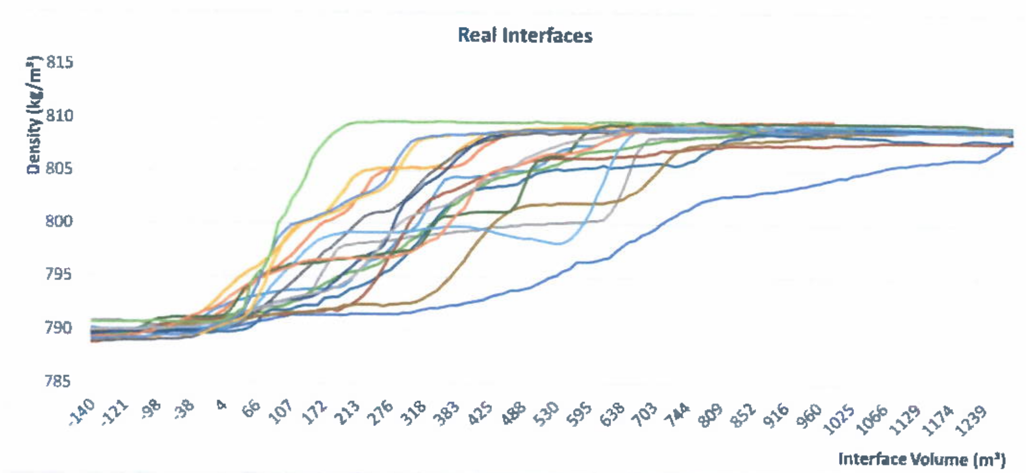


Figure 11 – Sample of monitored Interfaces

Even with the change of cut-off point to 50%, variations in volumes and behavior (generation of levels due to prolonged duct stops) of the interfaces could lead to high degradations, or even, high contamination. Figure 12 shows a real case in which the interface cut was performed at a density of 800 kg / m 3, but the volume of degraded Anhydrate to Hydrate was high.

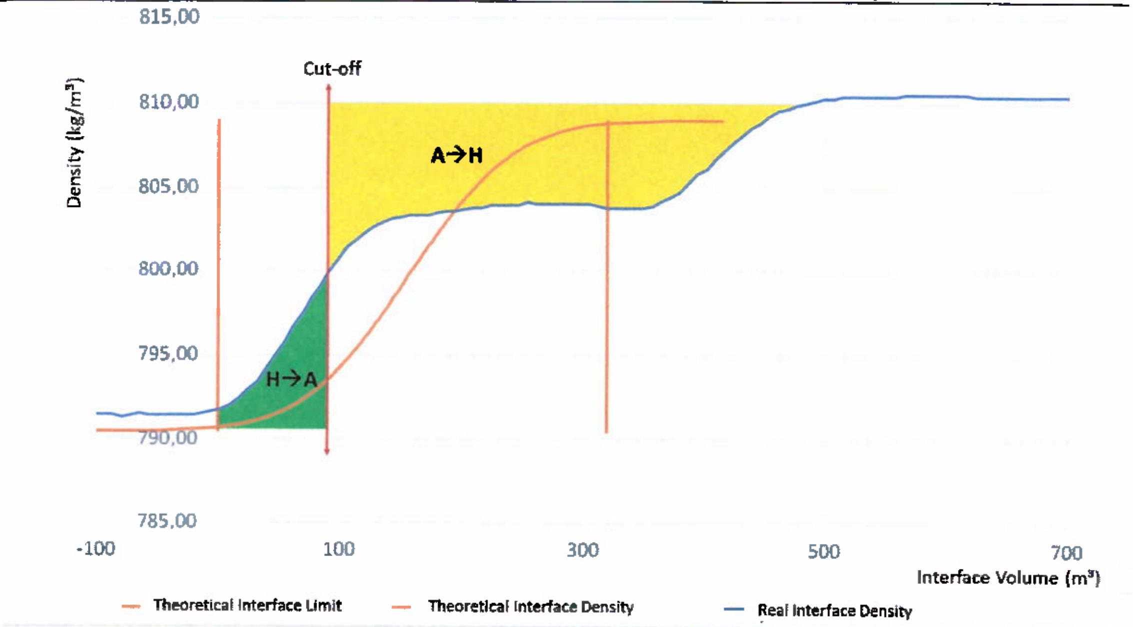


Figure 12 - Real Interface with High Degradation

3.2. Implementation of interface integrator tool

The interface integrator tool presented the following results, according to figures 13 and 14, after implementation.

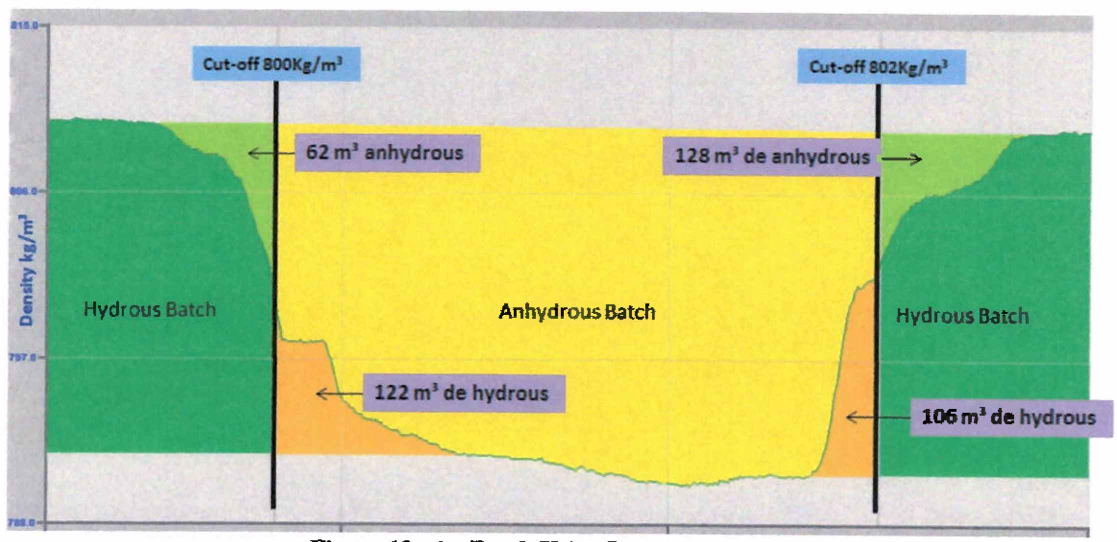


Figure 13 - 1st Batch Using Integrator

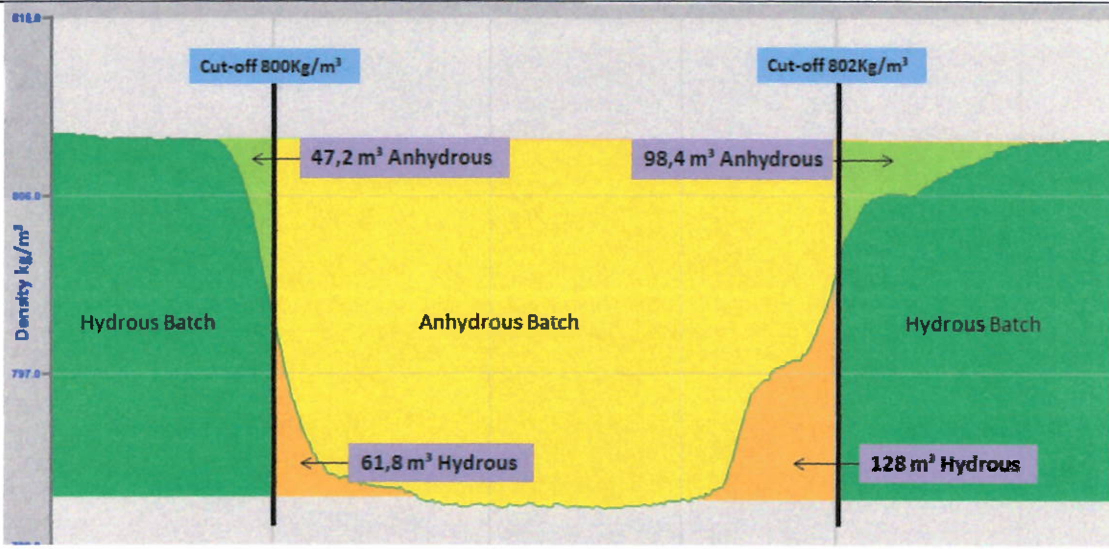


Figure 14 - 2nd Batch Using Integrator

It is possible to verify that, in both operations, the quality of Anhydrous Ethanol remained preserved, and the degraded volumes of Anhydrous to Hydrate reduced.

4. Conclusions

As shown in the previous items, the continuous learning and monitoring of the receiving and dispatch operations, from the collection terminals to the final destinations, brought benefits in terms of quality preservation - since there were no such contaminations during the operations of the LOGUM System - and to improve the results of degraded volumes, as detailed in figure 15.

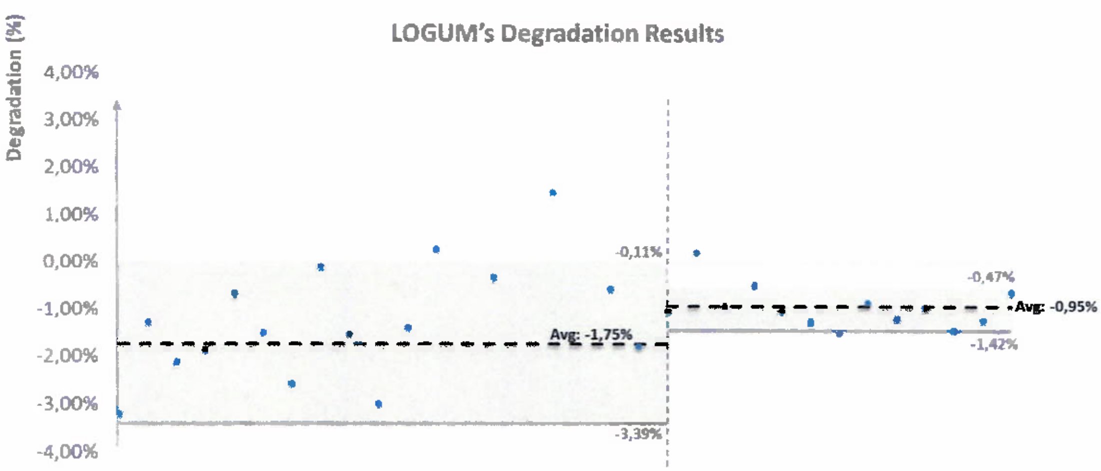


Figure 15 – Degradation Results

Brazilian Ethanol Exports to California

Vessel: Silver Ellie
ETS Santos: 20.05.2016
ETA California: 22.06.2016
Next Destination: Shanghai, China

Source: Bloomberg

Brazilian Ethanol Exports to California

Vessel: Silver Euplecta
ETS Santos: 26.06.2016
ETA California: 24.07.2016
Next Destination: Rosarito, Mexico

Source: Bloomberg

Brazilian Ethanol Exports to California

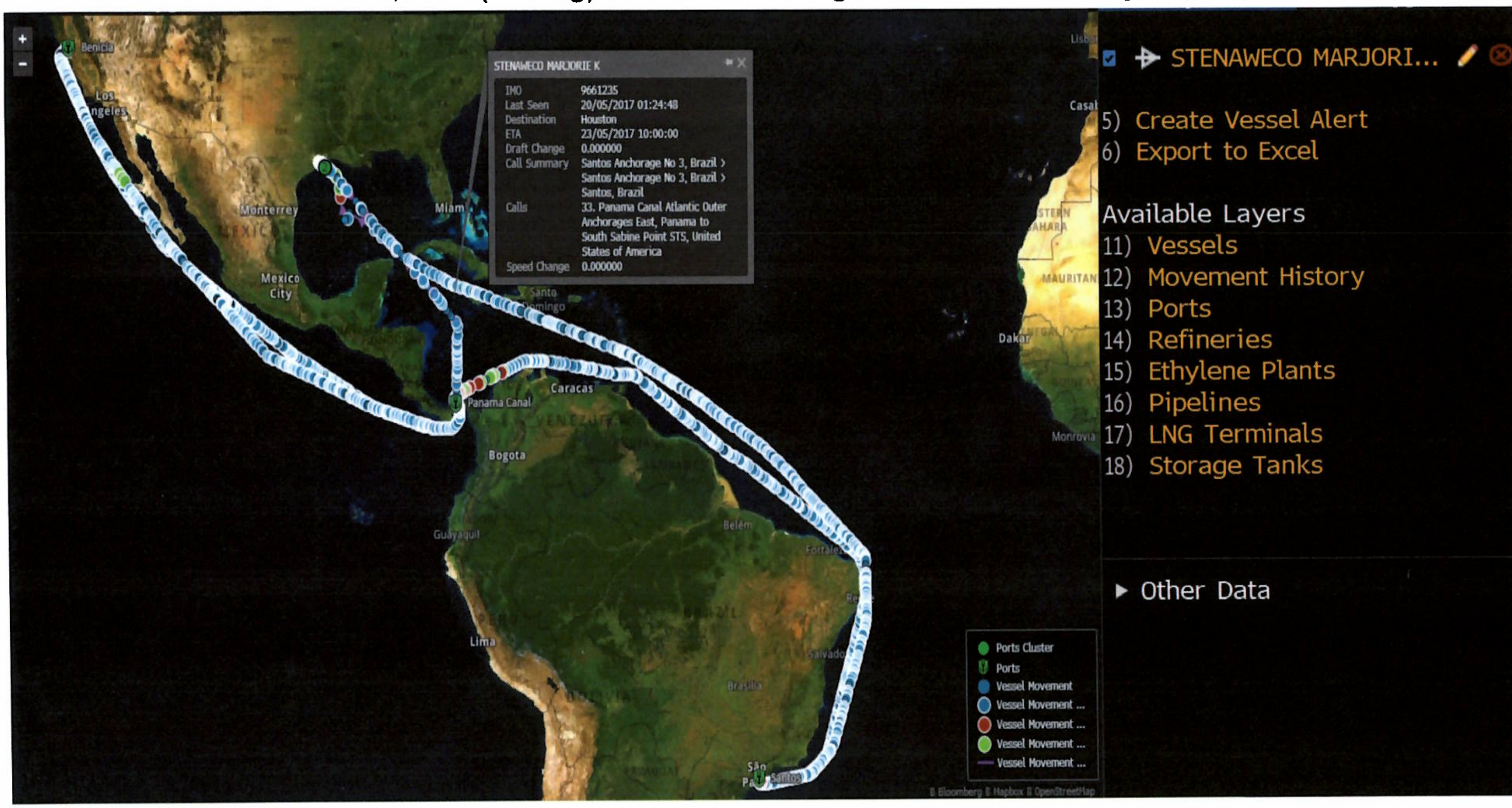
Vessel: High Valor
ETS Santos: 27.04.2017
ETA California: 02.06.2017
Next Destination: Vancouver, Canada and Busan, South Korea

Source: Bloomberg

Brazilian Ethanol Exports to California

Source: Bloomberg

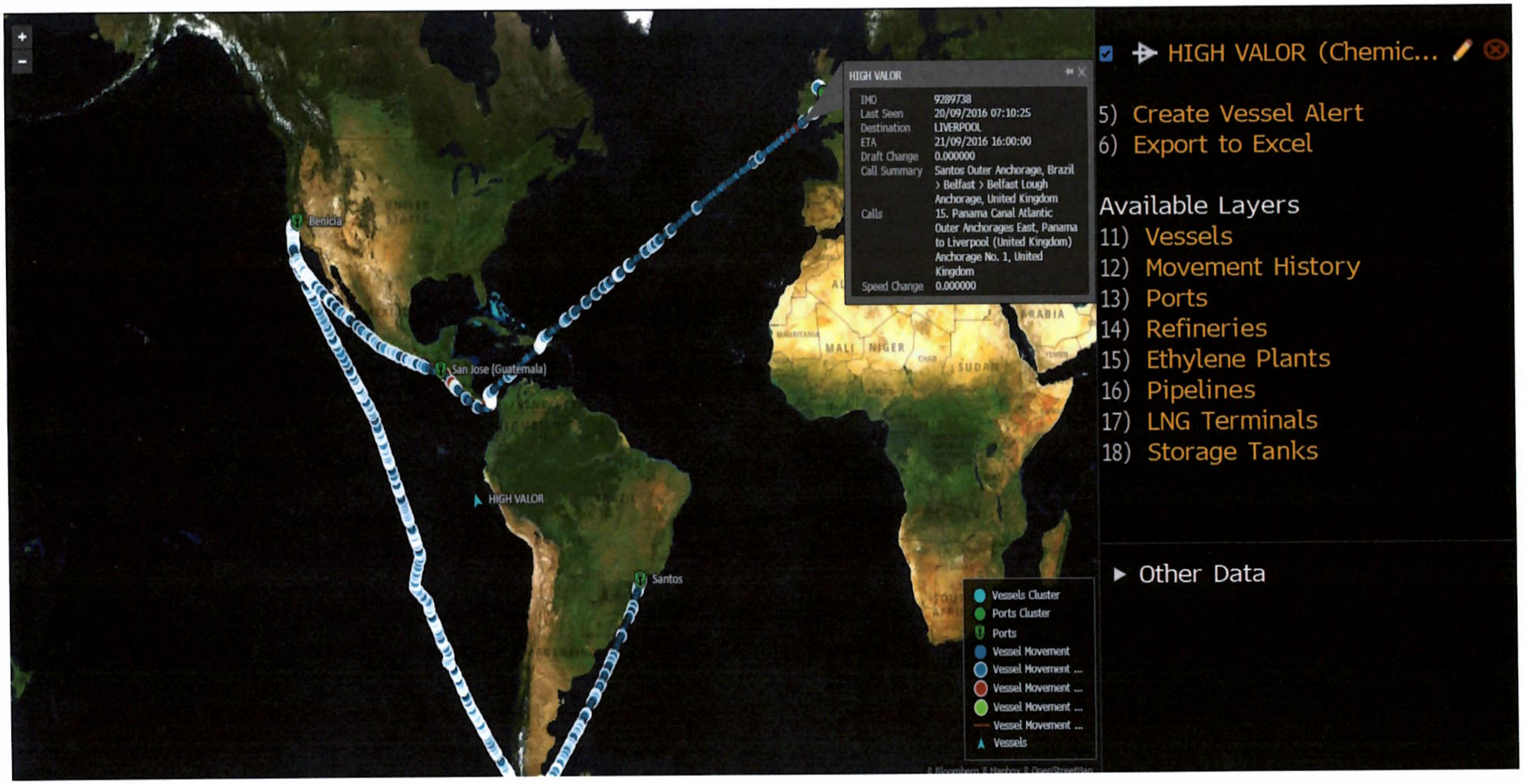
Vessel: Stenaweco Marjorie K
ETS Santos: 04.04.2017
ETA California: 04.05.2017
Next Destination: Houston, USA (loading) and then returning to Santos to discharge liquid products (diesel)



Brazilian Ethanol Exports to California

Vessel: High Valor
ETS Santos: 15.07.2016
ETA California: 13.08.2016
Next Destination: Liverpool, England

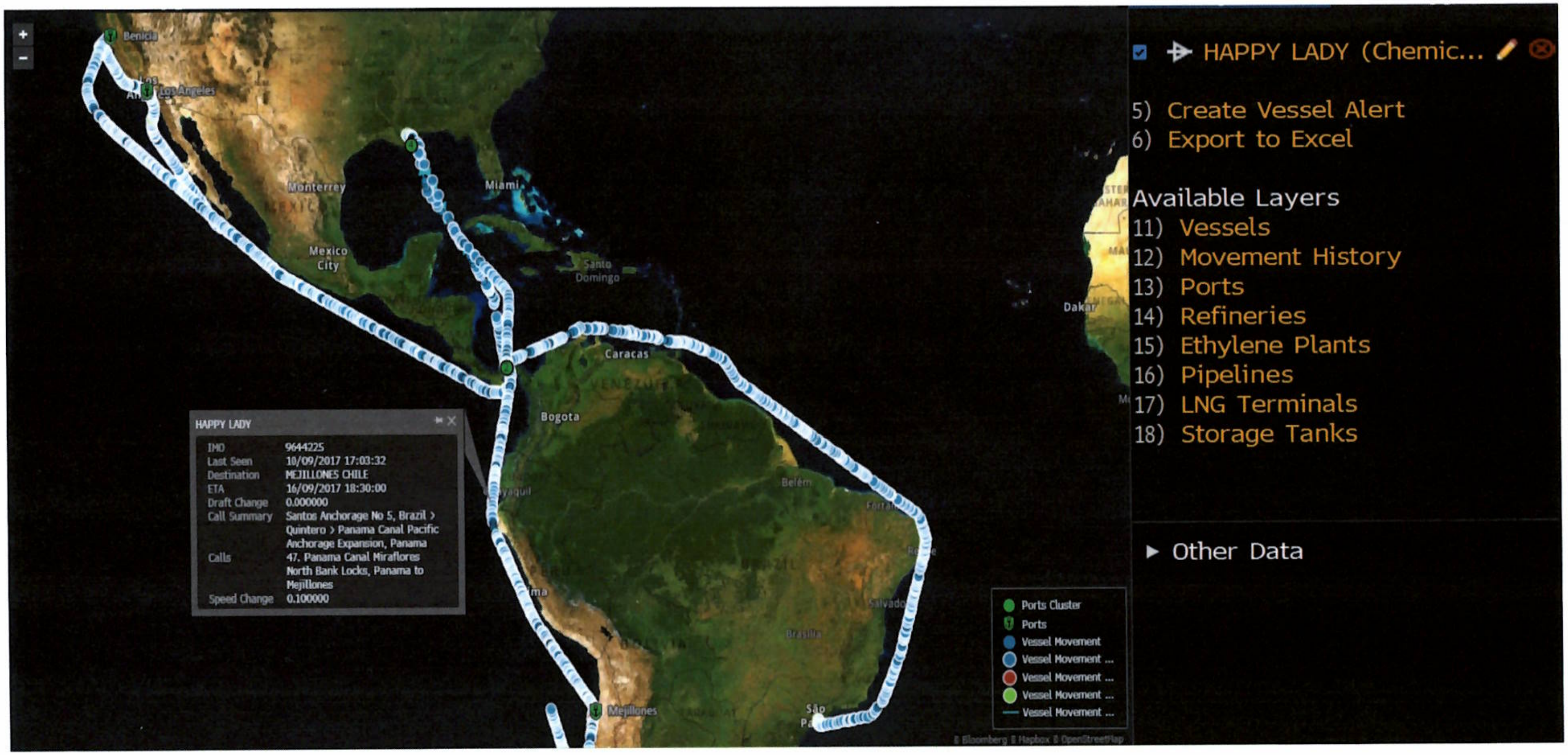
Source: Bloomberg



Brazilian Ethanol Exports to California

Vessel: Happy Lady
ETS Santos: 01.07.2017
ETA California: 02.08.2017
Next Destination: Los Angeles, Houston and Mejillones, Chile

Source: Bloomberg



Brazilian Ethanol Exports to California

Vessel: Orwell
ETS Paranaguá: 09.07.2017
ETA California: 05.08.2017
Next Destination: Daesan, South Korea

Source: Bloomberg

Brazilian Ethanol Exports to California

Vessel: Torm Helvig
ETS Santos: 08.08.2017
ETA California: 06.09.2017
Next Destination: Antwerp, Belgium

Source: Bloomberg

Brazilian Ethanol Exports to California

Vessel: Silver Sawsan
ETS Santos: 06.10.2017
ETA California: 02.11.2017
Next Destination: Taijin, China

Source: Bloomberg

Brazilian Ethanol Exports to California

Vessel: Madha Silver
ETS Santos: 29.10.2017
ETA California: 31.11.2017
Next Destination: Manzanillo, Mexico

Source: Bloomberg