PROJECT, DESIGN & MANAGEMENT
ISSN: 2683-1597

Cómo citar este artículo:

Adaniya Higa, B. J. (2019). Soft system dynamics methodology applied to the supply of liquefied petroleum gas (GLP). *Project, Design & Management, 1*(2), 41-60. doi: 10.35992/pdm.v1i2.244

SOFT SYSTEM DYNAMICS METHODOLOGY APPLIED TO THE SUPPLY OF LIQUEFIED PETROLEUM GAS (LPG)

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Abstract. This article contributes searching for a sustainable solution to the supply of LPG. A little research has been done in Peru regarding the supply of LPG; it is focused on the analysis of the energy matrix, LPG distribution for vehicles, Government pricing policy or supply sources. The lack of studies that carry out an analysis of the causes or the interrelation between different factors can affect the normal supply of this fuel. An analysis of the problematic situation following the soft system dynamics methodology allows an adequate definition of the problem and events generating of risks that are presented in the LPG Supply. As a result of its application, defining the unstructured problematic situation has included the situation description where events and circumstances are observed without having any kind of structure, arising as the occurrence of the LPG shortage without having a clear idea of the real factors that cause it. On the other hand, defining the structured problematic situation has involved concatenating all the elements that integrate the situation describing and analyzing the whole system, considering historical records of past situations and collecting needs, aspirations and expectations of the different stakeholders, contributing to form an image of the situation that shows the structure, processes, relevant events and interrelations between all the elements involved. Thus, it is observed how the variables in the phases of the value chain of the LPG are related and interact affecting their supply.

Keywords: Supply of LPG, system dynamics, soft systems, soft system dynamics methodology, structured situation, risk generators.

METODOLOGÍA DE LA DINÁMICA DE LOS SISTEMAS BLANDOS APLICADA A LA PROBLEMÁTICA DEL ABASTECIMIENTO DE GAS LICUADO DE PETRÓLEO (GLP)

Resumen. El artículo contribuye a la investigación sobre una solución sostenible para la problemática del abastecimiento del GLP. Hay pocas investigaciones realizadas en el Perú al respecto y se centran en el análisis de la matriz energética, el desabastecimiento de las plantas envasadoras o gasocentros de

GLP vehicular, la política de precios establecidas por el Estado y las fuentes de suministro. Ante la falta de estudios que realicen un análisis de las causas o de la interrelación entre los diferentes factores que pueden afectar el abastecimiento normal de este combustible, el análisis de la situación problemática siguiendo la metodología de la dinámica de los sistemas blandos permite una adecuada definición del problema y de los eventos generadores de riesgos o factores críticos que se presentan. Como resultado de su aplicación, definir la situación problemática no estructurada ha comprendido describir la situación donde se observa acontecimientos y circunstancias sin algún tipo de estructura, presentándose sin una idea clara de los factores reales que la causan. Por otro lado, definir la situación problemática estructurada ha implicado concatenar todos los elementos que integran la situación, describiendo y analizando todo el sistema, considerando los registros históricos de situaciones pasadas y recogiendo las necesidades, aspiraciones y expectativas de los diferentes grupos de interés, contribuyendo a formar una imagen que muestra la estructura, los procesos, los eventos relevantes y las interrelaciones entre todos los elementos involucrados observándose cómo las variables, en cada fase de la cadena de valor del GLP, se relacionan e interactúan afectando su abastecimiento.

Palabras clave: Dinámica de sistemas, sistemas blandos, metodología blanda de dinámica de sistemas, situación estructurada, generadores de riesgos.

Introduction

The article shows that; Using the energetic security concept and his provisional variation, is possible to contribute to the study of the establishment of fuels like Liquified Petrol GAS (LPG) Using the methodology of soft system dynamics. (Rodriguez-Ulloa, R. A., Montbrun, A. y Martinez-Vicente, S., 2011; Rodriguez-Ulloa, R. A., Martinez, S., Dyner, I., Pardo-Figueroa, J., Huaytan, V., Cardenas, W., Navarro, J. y Gonzales, A., 2015). This investigation contributes as a reference to other studies concerning fuel supply that guarantee the energy security In addition, it contributes to an analysis of the benefits of using a methodology that considers the thoughts of each stakeholder involved, directly or indirectly, and relates them to the different variables that act throughout the value chain.

The supply security of LPG, particularly in Peru, is a political and socio-economic issue that moves interests of economic agents and citizens. That seeks to have fuel with easy access at attainable prices. Residential and vehicular shortage generates social conflicts that motivate the study of its value chain by identifying the contribution of each variable involved.

The energy security, supply security or shortage, identifies the existence of criteria and focuses with a great conceptual diversity. In the study cases we see energetic security as the availability of energetics that satisfies the demand in a sustainable way at reasonable prices.

The number of scientific references and international agencies dealing with energy security is an indicator of concern over reliability and ease of access to energy considering price increases or supply problems. The interest, under this context, is to find medium and long-term strategies when studying the external and internal context of a country. The external context includes the possible interruption of access to energy due to geopolitical events as they are subject to risks that may arise at the place of production or on the way to the point of delivery. Thus, the interruption of the LPG supply can originate in the natural gas processing plant or during its transportation (ship or tanker). The challenge is to find means and interest groups that achieve a balance of energy and geographical locations that allow balancing minimum levels of security with adequate costs.

Figure 1 shows that, from the Malvinas processing plant, located in Cusco, there is a dry natural gas (GNS) pipeline and a pipeline that transports natural gas liquids (LGN). On its way to Lima, the GNS undergoes a first compression at the Kepashiato station and a second compression at the Chiquintirca station to finally reach the City Gate located in the district of Lurín - Lima. It should be noted that, from the Chiquintirca station there is a branch that reaches the liquefaction plant of Pampa Melchorita (Chincha - Ica) from which liquefied natural gas (LNG) is exported. The LGN is processed at the Pisco fractionation plant (Ica), where LPG, Nafta and Medium Distillate for Blending Stock (MDBS) are produced. The LPG is transported to Lima by sea and to the south by tank trucks.

Figure 1. Path of dry natural gas and natural gas liquid pipelines
Notes: Source: Osinergmin

An important fact occurred in July 2010, when a partial shortage was generated, mainly in Lima, due to the strong waves that prevented the discharge of LPG at the terminals of two companies that supply this fuel. Another occurred during the first months of 2015, due to events related to the production of LPG, such as the rupture of the LGN pipeline on the route from Malvinas to Pisco; maintenance operations in one of the condensed natural gas production wells and the existence of anomalous swell periods that determined the closure of ports. These facts demonstrated that the existing storage capacity in the supply plants and the obligation to maintain average and minimum LPG safety inventories were not sufficient factors to guarantee their supply. Actions had to be taken to address this problem.

The study identified aspects that generate alternatives to solve a real problem and was framed in the applied and explanatory research. The design was quantitative, not experimental, longitudinal and trend when analyzing changes through the 2000-2015 period. External validity was achieved by generalizing the results to similar situations of energy supply assurance and internal validity was achieved when the results, properly analyzed and interpreted, showed the relationship between the variables and observing the effect of other variables not involved on the dependent variables.

From the complexity, a phenomenological, hermeneutical and systemic vision was adopted, analyzing the production, transport and processing of natural gas considering human participation, determining the decisions that affect the supply; finding how each part of the processes involved relates and interacts within the problem by proposing various dynamic structures that would explain the real anomalous behavior causing the shortage. All associated factors and risks that are constituted as variables, directly or indirectly, involved in the situation were identified.

In addition, a research horizon was opened using the Soft System Dynamics Methodology that analyzes scenarios of the behavior of the variables over time. The analysis that follows this methodology has adequately defined the problem, conflict situations or critical factors of LPG supply, as well as identified restrictions and alternative solutions. The study can complement the work done by the state officials in charge of developing policies; however, as a limitation, the study does not contemplate the evaluation of the requirements for the implementation of policies.

Method

The analysis of the LPG supply situation, following the methodology allows an adequate definition of the problem and the risk generating events presented. This methodology, used as support to expand and structure the ways of thinking when intervening in complex problems, allows us to observe how many elements interact with each other; considering that, the more elements and greater interactions, the greater the complexity increase Therefore, a methodology that was initially developed for the resolution of management problems in organizations has proven to be useful in the analysis of very complex problems that affect society.

The soft system methodology (SSM), first published in 1981, was developed by Peter Checkland since the early 1960s at Lancaster University in the United Kingdom; belongs to the group of soft operations research methodologies taking into account the world view of the different stakeholders identified in the problem (Rodriguez Ulloa et. al, 2005, Rodriguez Ulloa, et. al, 2012; Rodriguez Ulloa, et. al, 2015) . In the beginning, it was used as a modeling tool; subsequently, it was used as an instrument for learning and knowledge development. Through certain rules and principles of systems, thoughts related to the real world are structured and develop models that contain descriptive and normative elements that allow to manage processes to act in an organized way and react to any change in actions.

In the methodology, it is assumed that each person sees the world based on their culture, traditions, family environment, geographic environment, training and academic environment, among other aspects; Therefore, each one understands and evaluates each situation differently, generating different ideas and proposals for a solution to the same problem. These ideas are gathered and subjected to a discussion, negotiation, argumentation and validation, giving place to alternative solutions. His philosophy holds that people have different points of view, about the same situation generating the "problem" of knowing who is right; presenting the concept of plurality and the need to accept that there are relevant “problems” with the question of what should be done to evaluate the different points of view before making a decision and developing an intervention process.

The analysis Checkland carried out studying social systems and their dynamics led him to conclude that there are two paradigms in systems thinking; the hard paradigm, in which the real world is systemic, so that the methodologies used to investigate reality are systematic methodologies. The soft paradigm is the one that shows the real world as a world where the research process and methodologies can be systemic involving a transfer from systematization to research within the interpretive world of each involved in a given situation.

The soft systems methodology involves four important principles: learning, culture, participation and ways of thinking, so that a research process constitutes a learning system to achieve organized actions in a scenario of changing ideas and events that interact permanently. This learning includes the perception, analysis and evaluation of events before deciding and taking actions that then generate new perceptions, evaluations and emerging actions, constituting a continuous cycle where progress is decided in terms of importance, cultural feasibility and systemic convenience. That is to say, experience is gained by generating knowledge that leads to taking actions with defined objectives in various situations and whose results generate new experiences that, in turn, generate new knowledge reaching to establish a cycle of experience-action. This is replicated in the observed environment or, it is negatively or positively affected by the result of these actions, entering its own experience-action cycle.

This methodology allows to study a problem of the real world, in an unstructured way, developing conceptual models that fit a situation with many objectives and multiple perspectives. Then, develop specific perspectives by building conceptual models to be compared with those of the real world. This comparison could initiate a debate that leads to a decision for an action with a defined purpose that improves the part of real life that is under analysis.

It is necessary to specify that structured problems, well defined and that can be formulated explicitly (the what) use a language that establishes the availability of a theory (the how), support of its solutions and on which it is agreed; whereas, an unstructured problem (problematic situation) cannot be formulated explicitly if a simple way of doing so is not found. This does not have clearly defined objectives with different points of view, it is not understood or it is not clear what the problem is (what); then, the what must be defined before the how can be found. This is where the soft systems methodology comes in to try to structure an unstructured situation and achieve that, from the multiple ideas about the situation, an agreement is reached in order to find a solution or an improvement of it.

In summary, according to Van Mullekom (2000), the methodology supports the objective of solving or introducing improvements in different complex situations by activating a continuous learning cycle among people involved in the situation. This learning is an iterative process, of trial and error, using concepts of systems to reflect and debate the perceptions obtained from the real world, carrying out an action on it and reflecting on the events that were produced by the use of these concepts. Reflection and debate are structured through the assumption of some systemic models because the problem situation is not fully known. The process can be represented according to figure 2.

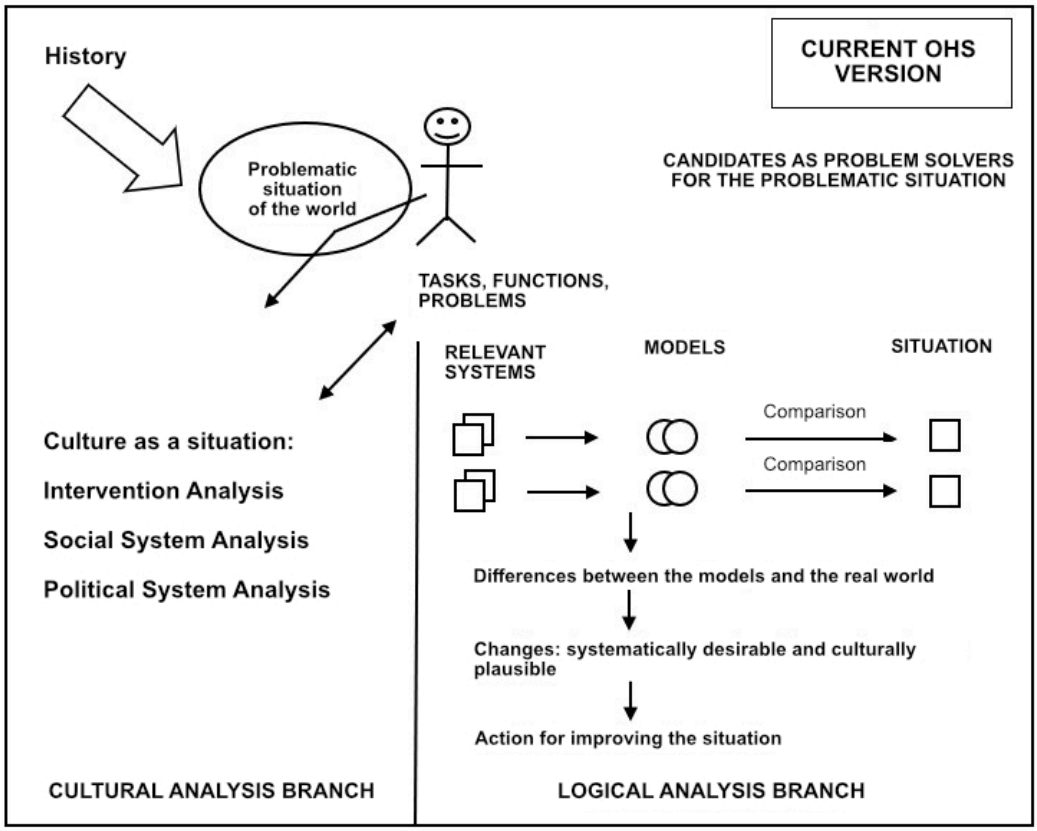

Figure 2. The Soft Systems Methodology process
Notes: Source: Methodology and Soft Systems M. Paz Acosta. Soft Systems Methodology Course. Rodríguez (2017)

The methodology is represented in seven stages that are not necessarily carried out in the order indicated, some are oriented to the real world and others, to the conceptual one. Figure 3 shows the model that, according to Van Mullekom (2000), in the first two stages an organized search is carried out to find situations in which structures, processes and their relationships must be established. In structural terms, power hierarchies, formal and informal communications, geographic environments or others are evaluated; In terms of processes, those basic activities that could be part of decision-making, results, effects and some type of corrective action that resulted were analyzed.

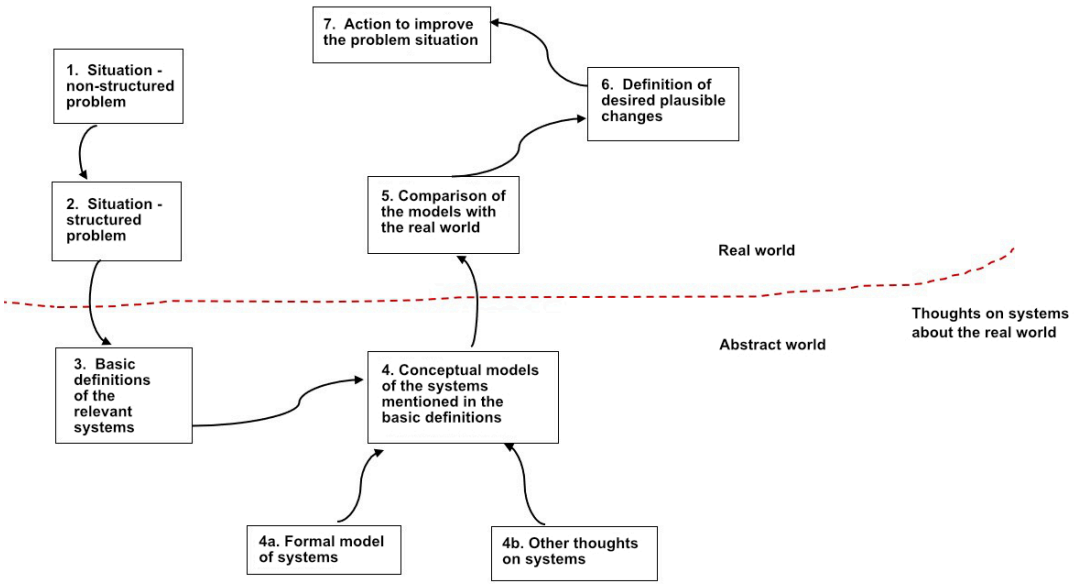

Figure 3 Conventional model for 7 stages of soft systems
Notes: Source: Systemics, Soft systems and the systems of information. Rodriguez (1994).

Figure 4 shows the pictographic chart that illustrates some risks, events and impacts involved in the LPG supply problem and that are collected during the first two stages.

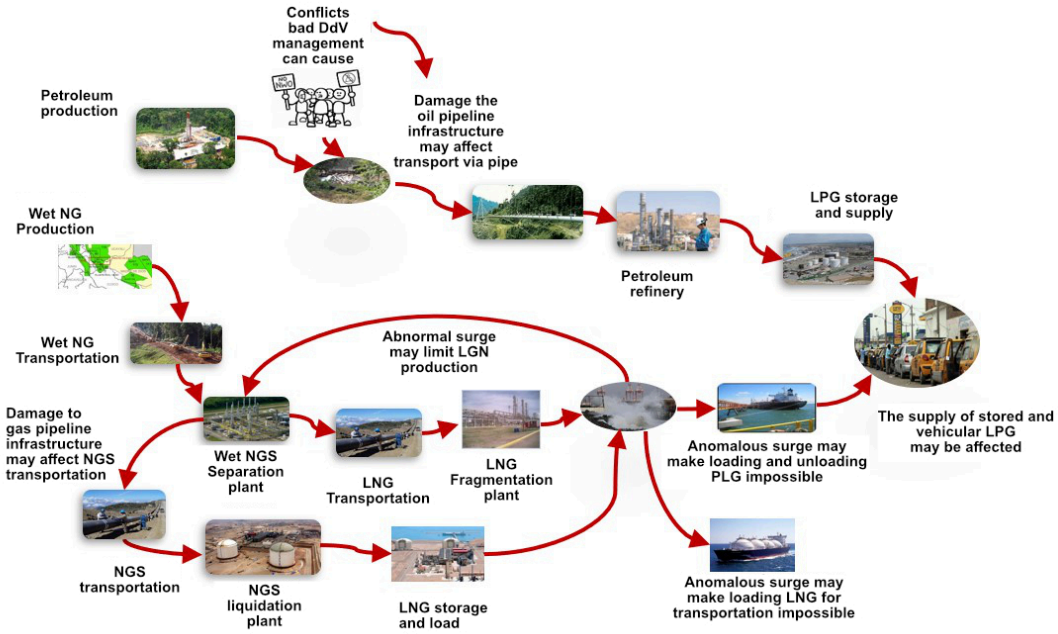

Figure 4. Pictographic chart of risks, events and impacts
Notes: Author's own creation

In stages 3 and 4, the basic definitions and their corresponding conceptual models are developed under an organized search for problematic situations and then

choose the one that will be resolved. This situation contains a model for each point of view observed and how it should be treated.
Each model constitutes a basic definition. These models do not represent the real world and generate a debate structure on how each interest group perceives reality. Then, these basic definitions are transformed into qualitative, conceptual models of activity systems with defined purposes.

To verify that a basic definition has been properly prepared, it is contrasted with a CATWDE analysis, in which C represents customers, who are negatively or positively affected by the transformation; A, represents the actors who carry out the transformation; T identifies the transformation to be performed; W, is the Weltanschauung or world view, the way each person perceives things based on their cultural patterns, training, environment or other aspects that influence each individual and that justifies the transformation; that is, each observer has an interpretation; D, corresponds to the owners who have the power to authorize or stop the transformation and, finally, E refers to the environment. Table 1 shows some examples of relevant systems generated by each Weltanschauung.

Table 1
Basic Definitions

Interest Groups		Weltanschaung	Relevant problem-oriented system
Clients	Indigenous communities	Belief that energy exploration and exploitation projects damage the ecosystem of their communities within the areas of influence and their properties	Belief that energy exploration and exploitation projects damage the ecosystem of their communities within the areas of influence and their properties
Stakeholders	Osinergmin	The belief that Osinergmin is not responsible for regulations in the Natural Gas industry, so it does not have to propose appropriate regulations for the supervision, control and regulation of GN.	Human activity system aimed at maintaining regulatory proposals regarding safety and quality of service in the Natural Gas industry, which do not allow adequate supervision, control and regulation.
	Perupetro	Belief that Perupetro should supervise contracts and evaluate the forecasts of GN and LPG production in addition to the useful life of the deposits from the continuous evaluation of the level of GN reserves	Human activity system aimed at getting new investments in GN projects, based on production forecasts and stock assessment.
	Operating companies	Belief that the levels of exploration and exploitation of the GN are adequate to take advantage of the integral and sustainable exploitation of the GN.	Human activity system aimed at maintaining exploration and exploitation levels.
	State	Belief that the current level of investment in the supply of GN is convenient, although the demand for GN will increase in the coming years.	Human activity system aimed at maintaining levels of investment in GN, without considering that the demand for GN will increase in the coming years, under the program of massification and the needs of

			economic growth of the country.
Owners			
	Operating companies	Belief that the regulations should be updated to promote investment in exploration and ensure GN reserves for the future.	allow greater investments in the exploration phase in GN lots.

Notes: Author's own creation

The basic definition developed will lead to the mapping of the events and their risks involved. For the case investigated, the relevant system is: "Meet the national LPG requirement in an efficient, safe and sustainable way", with its Basic Definition: "An efficient and effective human activity system, which aims to meet the national requirement of LPG in a safe and sustainable way through a policy of prices and incentives for production and investment." This basic definition is performed CATWDE analysis.

In the fifth stage, the conceptual models are compared to the real world, resulting in proposals for changes that generate actions to improve, alleviate or resolve the problem situation. In the sixth stage, the actions (changes) to be implemented (culturally feasible and systemically desirable) will be defined and proposed; and, in the seventh stage, the implementation is carried out.

Results

The SSM based on systems engineering for the solution of technological problems of great complexity, in its beginnings was oriented to hard thinking systems in which the problem is clearly defined to be resolved without questioning about the raised; nevertheless, when the solution of problems related to policies is required, it is not very adequate when not considering the subjective and interpretative elements of the individuals; developing the soft thinking approach when considering that each individual has a personal perception, a particular vision of what is going on around them.

In this study, the occurrence of LPG shortages is presented without having a clear idea of the real factors that cause it. The structured problem situation implies concatenating all the elements that make up the situation, describing and analyzing the entire system, considering the historical records of past situations and collecting the needs, aspirations and expectations of the different interest groups. This will help to form an image of the situation on which the structure, processes, relevant events and interrelations between all the elements involved can be visualized.

A systemic view shows how each variable in the LPG value chain is related and interacts. Within this context and making use of causal relationships, the risk-generating events (human and non-human) were first identified in each of the stages of the natural gas value chain and that of some stage of another value chain interrelated with that of natural gas, such as that of liquid hydrocarbons; Second, causal relationships were determined.

Among the dangerous events that generate human-type risks are those of the internal context or of the environment in which these events have been presented. Those of the internal context may be related to breaches of standards and procedures, good practices, quality of service, state of supplies and materials, infrastructure, technology, information and / or knowledge, financial resources, among others. These events can be casual or intentional, as well as being the product of certain failures causing impacts of various kinds. Events from the environment can be the result of attacks, social conflicts, lack of monitoring of market behavior, impact on the institutional image, among others. These events can be casual or intentional and cause social, economic and political impacts.

Among the dangerous events that generate non-human risks are those that occur due to natural effects and cause major impacts. Once the risk generating events have been identified, the soft system dynamics methodology is used. In a first stage, the unstructured situation of the problematic situation is defined by collecting all possible information to carry out the actions to define the structured situation, in stage 2.

As a result of the analysis of the sources of information collected in the form of an unstructured situation, a series of variables related to the problem of LPG supply were identified. Then, we proceeded to represent all the information collected in a pictographic chart showing the relationships between dangerous events (risk generators), variables and risks. Figure 5 shows a pictographic chart illustrating the effects and impacts generated by events related to the transport of natural gas, GNS and LPG.

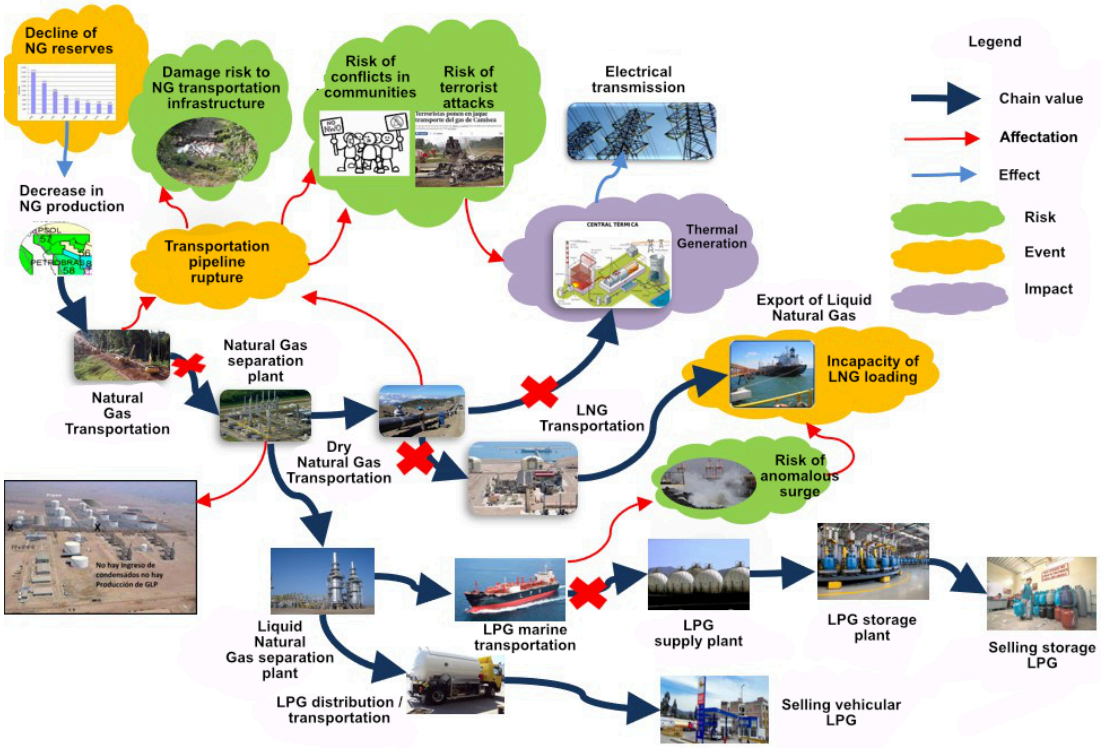

Figure 5 Pictographic table of events and risks in the transport of natural gas
Notes: Author's own creation

Once the analysis of the events was completed, the basic definitions oriented to the problem were elaborated; performing the analysis of the stakeholders and defining the Clients, the Actors and the Owners. Then, they proceeded to identify their worldview (worldview or Weltanschauung), the level and type of power relations existing between them, cultural issues, how they perceive the problem and how they propose a solution. These are the aspects that make the problem situation difficult to understand and establish proposals for solution or improvement. Table 2 presents the interest groups, identified as those most related to the problem of LPG supply, and their respective worldviews.

Table 2
Cosmovision or Weltanschauung of the Interest Groups most related to the supply of LPG

Interest group	Worldview or Weltanschauung, belief that
Ministry of Energy and Mines of Peru. Minem	The current investment level of operators in the liquid hydrocarbons sector is insufficient despite the fact that the greatest need is for natural gas due to the potential increase in LPG demand.
Supervisory Body for Investment in Energy and Mining. Osinergmin	Osinergmin is not responsible for the regulations in the natural gas industry and, therefore, does not necessarily have to propose adequate regulations for the supervision, control and regulation of natural gas.
Companies operating the natural gas lots	The levels of exploration, exploitation and processing of natural gas are adequate to take advantage of the integral and sustainable development of this industry
Companies operating the natural gas and natural gas liquid transport pipelines	by increasing natural gas transport operations, with current systems, the risks and losses due to natural gas and natural gas liquid pipeline ruptures will increase
Natural gas processing plants	Natural gas liquid processing levels are adequate to take advantage of the integral and sustainable development of LPG
Refineries that produce LPG	oil processing levels are adequate to take advantage of the integral and sustainable development of LPG supply
LPG supply plants	LPG storage capacity of plants is insufficient for the integral and sustainable development of LPG supply
LPG Importers	Oil and natural gas processing levels are insufficient to meet national LPG demand
Power Generation Stations	maintaining traditional sources of electricity generation, Peru can maintain sustainable growth and development.
Ministry of Environment Minam	the exploration and exploitation of Natural Gas generates social and environmental conflicts
National Investors	there is no adequate legal and social framework to increase investments in natural gas exploitation and LPG production
Foreign investors	there is no adequate legal and social framework to develop investments in natural gas exploitation and LPG production
Indigenous communities	Oil and natural gas exploration and exploitation projects impact natural areas affecting agriculture and fisheries, the main source of food and income.
LPG end users	Oil and natural gas processing levels are sufficient to meet national LPG demand

Notes: Author' own creation

The problematic situation requires that each interest group propose a transformation process, as illustrated in Table 3.

Table 3
Worldview of the Interest Groups most related to the supply of LPG and Relevant Systems Oriented to the Problem

Interest group	Worldview or Weltanschauung, belief that	Relevant Problem Oriented System. Human activity system oriented to,
Minem	The current investment level of operators in the liquid hydrocarbons sector is insufficient despite the fact that the greatest need is for natural gas due to the potential increase in LPG demand.	increase the levels of investment in liquid hydrocarbons, although the greater need and demand for LPG will increase the need for GN in the coming years due to the country's economic growth needs
Osinergmin	Osinergmin is not responsible for the regulations in the natural gas industry and, therefore, does not necessarily have to propose adequate regulations for the supervision, control and regulation of natural gas.	maintain regulatory proposals regarding the safety and quality of service in the natural gas industry, which do not allow adequate supervision, control and regulation.
Companies operating the natural gas lots	The levels of exploration, exploitation and processing of natural gas are adequate to take advantage of the integral and sustainable development of this industry	wasting the integral and sustainable exploitation of natural gas
Companies operating the natural gas and natural gas liquid transport pipelines	by increasing natural gas transport operations, with current systems, the risks and losses due to natural gas and natural gas liquid pipeline ruptures will increase	Increase losses of natural gas and natural gas liquids as a result of breaks in transport pipelines.
Natural gas processing plants	Natural gas liquid processing levels are adequate to take advantage of the integral and sustainable development of LPG	Maintain natural gas liquid processing levels in the belief that there are sufficient reserves of natural gas liquids.
Refineries that produce LPG	oil processing levels are adequate to take advantage of the integral and sustainable development of LPG supply	Maintain oil processing levels in the belief of contributing to meet the demand for LPG in a high percentage.
LPG supply plants	LPG storage capacity of plants is insufficient for the integral and sustainable development of LPG supply	increase the storage capacity of LPG in strategic points of the country.
LPG Importers	Oil and natural gas processing levels are insufficient to meet national LPG demand	increase import levels of LPG, by sea and land.
Power Generation Stations	maintaining traditional sources of electricity generation, Peru can maintain sustainable growth and development.	use the GN for electric power generation.
Minam	Natural gas exploration and exploitation generates social and environmental conflicts.	increase socio-environmental conflicts produced by activities related to natural gas.
National Investors	there is no adequate legal and social framework to increase investments in natural gas exploitation and LPG production	increase socio-environmental conflicts produced by activities related to natural gas.
Foreign investors	there is no adequate legal and social framework to develop investments in natural gas exploitation and LPG production	maintain the absence of a legal and social framework that allows developing investments in exploitation of the GN

Indigenous communities	Oil and natural gas exploration and exploitation projects impact natural areas affecting agriculture and fisheries, the main source of food and income.	negatively affect agricultural activities, the main source of income and survival, through exploration and exploitation of oil and GN.
LPG end users	Oil and natural gas processing levels are sufficient to meet national LPG demand	Acquire more LPG than necessary for fear of running out of fuel.

Notes: Author's own creation

At this point, basic definitions of the processes of transformation of the real world were elaborated, from each worldview of the stakeholders. See table 4

The correct elaboration of the basic definitions is based on the CATWDE analysis, improving through permanent feedback processes.

Table 4
Basic definition and the elements that define it

Interest group	**Worldview or Weltanschauung, belief that**	**Relevant Problem Oriented System, human activity system oriented to**	**Basic definition. Human activity system**
Minem	The current investment level of operators in the liquid hydrocarbons sector is insufficient despite the fact that the greatest need is for natural gas due to the potential increase in LPG demand.	increase the levels of investment in liquid hydrocarbons, although the greater need and demand for LPG will increase the need for GN in the coming years due to the country's economic growth needs	Del Minem and Perupetro, aimed at promoting investments in hydrocarbons, especially in natural gas. This process, executed by Minem and Perupetro, occurs under the belief that the increase in investments in exploration and discovery of new natural gas deposits condensed with subsequent exploitation will cover the growing demand for LPG for the benefit of the Peruvian community and of the native communities for a greater distribution of the gas canon reducing social conflicts.
	Osinergmin is not responsible for the regulations in the natural gas industry and, therefore, does not necessarily have to	maintain regulatory proposals regarding the safety and quality of service in the natural gas industry, which do not	Belonging to the Presidency of the Council of Ministers, Minem and Osinergmin oriented to propose norms regarding the security and quality of service in the Natural Gas industry, to allow adequate supervision, control and price regulation. This process, executed by Osinergmin, considers the belief that the goals of covering the national LPG

Osinergmin	propose adequate regulations for the supervision, control and regulation of natural gas.	allow adequate supervision, control and regulation.	demand will not be met, due to the maintenance of regulations that discourage investments in expansion and modernization of plants and expansion of LPG storage capacity unless the regulatory entities cover the existing legal gaps.
Companies operating the natural gas lots	The levels of exploration, exploitation and processing of natural gas are adequate to take advantage of the integral and sustainable development of this industry	wasting the integral and sustainable exploitation of natural gas	Oriented to avoid wasting the full and sustainable exploitation of natural gas. This process will be executed by companies operating the natural gas lots
Companies operating the natural gas and natural gas liquid transport pipelines	by increasing natural gas transport operations, with current systems, the risks and losses due to natural gas and natural gas liquid pipeline ruptures will increase	Increase losses of natural gas and natural gas liquids as a result of breaks in transport pipelines.	Oriented to increase the volume of natural gas transport operations for the benefit of the communities of Camisea (Cusco) or by harming communities within the area of influence of the right of way. This process will be executed by natural gas transport companies; it is carried out under the possibility of increasing sabotage and conflicts with the communities; the granting of tenders without an adequate prior study of soils generating poor work when installing the transport pipelines of the GN and LGN; increased landslides due to natural phenomena; environmental pollution and considering the belief that increasing the volume of natural gas transport operations can increase losses due to breakage or taking of facilities.
Natural gas processing plants	Natural gas liquid processing levels are adequate to take advantage of the integral and sustainable development of LPG	Maintain natural gas liquid processing levels in the belief that there are sufficient reserves of natural gas liquids.	Oriented to avoid missing out on the opportunity to expand its facilities to raise the levels of processing of natural gas liquids from other sources. This process will be executed by national or foreign investors under the supervision of Osinergmin.

Refineries that produce LPG	oil processing levels are adequate to take advantage of the integral and sustainable development of LPG supply	Maintain oil processing levels in the belief of contributing to meet the demand for LPG in a high percentage.	Oriented to increase the levels of heavy oil processing due to the belief of contributing to meet the demand for LPG in a high percentage. This process will be executed by national or foreign investors under the supervision of Osinergmin.
LPG supply plants	LPG storage capacity of plants is insufficient for the integral and sustainable development of LPG supply	increase the storage capacity of LPG in strategic points of the country.	Oriented to increase the storage capacity of LPG without considering other strategic points of the country. This process will be executed by national or foreign investors under the supervision of Osinergmin
LPG Importers	Oil and natural gas processing levels are insufficient to meet national LPG demand	increase import levels of LPG, by sea and land.	Oriented to increase the levels of LPG import by sea and land without considering the possibility of consuming national production. This process will be executed by domestic or foreign investors.
Power Generation Stations	maintaining traditional sources of electricity generation, Peru can maintain sustainable growth and development.	use the GN for electric power generation.	Oriented to use GN for the generation of electrical energy. Este proceso será ejecutado por los inversores nacionales o extranjeros bajo la supervisión de COES y Osinergmin.
Minam	Natural gas exploration and exploitation generates social and environmental conflicts.	increase socio-environmental conflicts produced by activities related to natural gas.	This process will be executed by Local and Regional Governments, Indigenous Communities and the Population of the area of direct influence, environmental NGOs, Minam. It is carried out under the implementation of free market policies with rigorous environmental studies, in state contracts of GN avoiding the creation of social conflicts due to the contamination of flora, fauna, air, rivers, land; and considering belief that the

			exploitation of GN generates social and environmental conflicts.
National Investors	there is no adequate legal and social framework to increase investments in natural gas exploitation and LPG production	increase socio-environmental conflicts produced by activities related to natural gas.	Oriented to promote the existence of a legal and social framework that allows a more fluid investment in the exploration of GN. This process will be executed by the Minem.
Foreign investors	there is no adequate legal and social framework to develop investments in natural gas exploitation and LPG production	maintain the absence of a legal and social framework that allows developing investments in the exploration of the GN	Oriented to promote the existence of a legal and social framework that allows greater investment in NG exploration avoiding the use of regulations from a different context to Peru. This process will be executed by the Minem.
Indigenous communities	Oil and natural gas exploration and exploitation projects impact natural areas affecting agriculture and fisheries, the main source of food and income.	negatively affect agricultural activities, the main source of income and survival, through exploration and exploitation of oil and GN.	Oriented to avoid negatively affecting agricultural activities, the main source of income and survival, through the exploration and exploitation of oil and GN. This process will be executed by the Ministry of Culture, Ministry of Agriculture, Minem, Minam.
LPG end users	Oil and natural gas processing levels are sufficient to meet national LPG demand	Acquire more LPG than necessary for fear of running out of fuel.	Oriented to satisfy the demand of LPG avoiding hoarding and speculation.

Notes: Author's own creation

Once these aspects have been defined, problem-oriented conceptual models are established that indicate how to perform the transformation required to solve the problem. This implies generating activities for the achievement of the transformation for each type of interest group. Concluded the task of developing the models identifies the verbs that will define the central activities of the groups involved. These verbs, with their respective activities, are grouped in accordance with similar meanings and in unique activities, established by consensus, producing a tentative primary task model in which the human activity system is established oriented to generate a transformation, identifying the owner of the process, as well as the actors, victims and beneficiaries.

Discussion

A tentative model of primary task would be the human activity system oriented to natural gas, involving exploring a lot, confirming a finding, exploiting the

reservoir, producing wells, transporting natural gas to processing plants, producing and distributing LPG and other products derived from natural gas or transform it into higher value products; negatively affecting the ecological balance of the regions where the exploitation of natural gas takes place; with wasted opportunity to advance the integration, security and welfare of communities through an agile, proactive, creative, rational, ethical and sustainable management of this industry. This would lead to an inefficient and inefficient use of the gas canon in addition to the breach of other goals related to the development of this energy and the progress in road infrastructure, education and health works. Also, the appearance of bureaucratic barriers due to inappropriate regulations; low levels of investment required in the exploitation of natural gas and its impact on electricity generation.

According to the human activity system, this process belongs to Osinergmin, Minem, Minam, national and foreign investors, operating companies that exploit natural gas, mainly. The beneficiaries of this process are companies that exploit natural gas, national and foreign investors, local and regional governments, companies that provide local governments, populations in the direct and indirect area of influence of natural gas exploitation and the communities, among others. As victims, flora, fauna, soil, air, rivers and populations of the area of direct and indirect influence are considered, as well as native communities. The main actors in this process are the companies that exploit natural gas, Osinergmin, Minem, Minam, local and regional governments.

The process would occur under the implementation of a free market policy avoiding the detriment of the rigor of environmental studies in state contracts for natural gas; inadequate regulation of the development of the natural gas industry in all its phases as a result of an outdated legal framework; the existence of social conflicts and inequity.

This primary task model must be validated against the worldview, the relevant system, the basic definition and the conceptual model, oriented to the problem, by all the stakeholders involved, in order to evaluate the consistency; Consistency proven, becomes the primary task model confirmed and validated. An evaluation based on this model allows the development of context diagrams, causal diagrams and models of problem-oriented systems dynamics; From these, the Forrester diagrams are made, establishing indicators to arrive at simulation models of different scenarios that allow to establish the variables that will require particular attention using an appropriate sensitivity analysis; The complexity of this task merits developing a deeper investigation of the problematic situation of LPG supply.

Conclusions

1. The application, even partial, of the methodology of soft system dynamics, showing the necessary steps for the confirmation of the variables involved in the LPG supply problem, based on the cosmovision of the different interest groups, has made it possible to demonstrate and sustain its existence.
2. As a result of the application of this methodology, all the risks that, if materialized, will cause an interruption in the production of LGN and, therefore, a reduction in the production of LPG affecting its distribution and, as a consequence, have been identified Demand satisfaction.

3. With the identification of the risks, the one of the endogenous and exogenous variables involved is also achieved, fulfilling the purpose of verifying the existence of correspondence with the variables identified from the worldview of the interest groups.
4. The methodology of soft system dynamics has proven to be an appropriate analysis tool to detect variables whose level of affectation to the problem can be analyzed using multivariate analysis techniques such as factor analysis or through structural equation models.
5. The application of the factor analysis or the modeling of structural equations allows to find the interrelation between the variables and their respective load factors, which will indicate the relative contribution that each variable makes to the problematic situation.
6. The knowledge of the degree of correlation or causal relationship between the variables, within the different contexts generated from the worldview of the interest groups, allows quantifying and analyzing their relationship, as well as their behavior regarding the behavior of other related variables; this allows to predict with a certain degree of precision, the value of the impact of the variables on the LPG supply problem.
7. Once the entire system is known, and the units of analysis defined, it is possible to develop a modeling of system dynamics and a sensitivity analysis to measure the impacts of the variables, as a function of time.

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Date received: 14/06/2019
Date reviewed: 26/08/2019
Date accepted: 30/08/2019