

Sustainability Best Practices for Oil and Gas Sector in Mexico

**María del Rocío Soto-Flores, Raúl Rodríguez-Ávila,
Christian Muñoz-Sánchez, Ingrid Yadibel Cuevas-Zuñiga**

Business School (ESCA-STO)

National Polytechnic Institute of Mexico (IPN)

Mexico City, Mexico

msotof@ipn.mx, raul.rodriqueza@pemex.com, cmunozs@ipn.mx, icuevasz@ipn.mx

Abstract

The objective of the research is to identify the best sustainability practices most used in companies in the oil and gas sector to reduce the environmental damages of their activities, in order to take them into account in Mexico. The research is documentary, in which the leading companies in the oil and gas sector were considered as subjects of study based on their environmental performance and the development of substantive activities. The results presented are the best sustainability practices and the environmental impacts derived from the central activities of the oil and gas sector, as well as the mechanisms for implementing best sustainable practices in the case of Mexico. There is evidence that companies in the sector invest in sustainability practices to improve their environmental performance, while continuing to obtain economic benefits, in the direction of low carbon economies, however, it is necessary to give greater impetus to renewable energy sources that have taken relevance in recent decades.

Keywords

Sustainability Best Practices, Environmental impacts, Oil and Gas Sector.

1. Introduction

The oil and gas sector is considered vital and strategic for the development and economic growth of many countries, including Mexico. This sector plays a central role as a supplier of hydrocarbons around the world, which are considered the largest sources of primary energy in global consumption with a participation of 57% (BP, 2017), they also represent economic potential and military strategic value (Puyana, 2015). The value chain of the sector consists of the Upstream, Downstream and Midstream phases, being its main activities: exploration, production, industrial transformation and hydrocarbon logistics.

Activities throughout the value chain of this sector have caused serious impacts on the physical and biological means of its areas of influence (Roa, 2011), leaving serious environmental liabilities and deteriorating the quality of the environmental services they provide, of which there is evidence throughout the world and in the history of this industry (Oilwatch, 2006). Globally, it is estimated that in the next 20 years, hydrocarbons will continue to contribute a significant share in global energy consumption (EIA, 2016), therefore, the sector would be carrying out activities around this projection, but facing fundamental challenges, on the one hand, the supply of these resources and, on the other, how to achieve it through ethical behavior in the economic, social and environmental dimensions (Saavedra & Jiménez, 2014). The incidence of companies in this sector in Mexico has taken on greater relevance today, mainly due to the implementation of the Energy Reform of 2013, which now allows private participation in the activities of the sector, which were previously exclusive to the Mexican state (SENER, 2013). In this research, the sustainability management carried out by leading companies in the sector is analyzed and compared, which have been considered based on their relevance and participation at the international level in terms of sustainability and, some of which develop activities in important natural areas protected from the planet, in addition to being dabbled in alternative energy sources, all in search of those sustainability practices with which they have managed to reduce the impacts on the means of areas of influence, as well as the mechanisms they use for their implementation. This paper is organized as follows; in the following section of the literature review is developed. Second, methodology is introduced. Third, sustainability management and best sustainability practices in the oil and gas sector are discussed. Fourth, mechanisms for implementation of sustainability best practices for the case of Mexico are presented. Finally, the theoretical and applied contribution of this research is provided.

2. Literature Review

2.1 Sustainable Development and Sustainability

Regarding the historical basis on the emergence and consolidation of the term of sustainable development as it is currently known, according to Pierri (2001), he states that the hegemonic proposal of the concept was brewing in the years between the United Nations Conference on the Environment Human, held in Stockholm, in 1972, known as the First Earth Summit, and the 1987 Brundtland Report, known as Our Common Future (WCED, 1987), which integrated the scenario to address the environmental issues associated with traditional sustainable development goals.

At the Stockholm Conference (1972), the global environmental issue was introduced, trying to reconcile development goals with nature protection. Subsequently, in the Brundtland Report (1987), it was pointed out that development and the environment cannot be separated and are inevitably linked, thereby establishing a position on sustainable development under this premise (Pierri, 2001). It is from this report that the term sustainable development emerges as: "That development that meets the needs of present generations without compromising the ability of future generations to meet their own needs" (WCED, 1987).

On the other hand, the term of sustainability, Almagro (2015) describes that it is associated with the social state that helps the indefinite course of the survival of humans, through a healthy, safe, productive life and in balance with the environment and spiritual values. From the vision of Torres & Cruz (1999:6), "sustainability is a paradigm in the conjunction of its dimensions, in which its formulation is a framework for discussion between ideals and values on economy, society and the environment". Therefore, sustainable development and sustainability are terms that are better understood if they are explained together, so they are not independent, but complementary.

2.2 Sustainability Best Practices for Oil and Gas Sector

In most of the countries in which it operates Oil and Gas Sector, there are legal mechanisms for the environmental control of their areas of influence, such as environmental legislation and economic instruments, through which companies are sought to have fiscal controls to reduce their environmental impacts (Salassa, 2016). According to the organization Oilwatch (2006), The various instruments that exist to make or demand environmental control can be divided into: a) Strong, with the power of law, mandatory and with legal action, and, b) Weak, without force of Law, on a voluntary basis and that are aware of those who adopt them. From this perspective, legal mechanisms are not in themselves sustainability practices, however, they support companies in the sector to adopt sustainable practices.

Regarding the interpretation of the term "best practices", there are different ways in which it has been expressed, however, some of those that fit in the sector with respect to the impacts it causes, are those cited in the study "*Considerations in Developing Oil and Gas Industry Best Practices in the North*" Government of Canada (2009). Also, as indicated Finer et al. (2013), a best practice, from the vision of the oil and gas sector, is one that reduces the environmental impact associated with its common practice, which has been used successfully in the exploration or production of oil fields.

Not only are best practices developed and implemented for substantive activities¹, it is also done for items that apply transversally, including security and process monitoring. Globally, there are companies and organizations in the sector that contribute and share best practices towards sustainability. For example, IPIECA (International Petroleum Industry Environmental Conservation Association) is an international organization that promotes among its member's best practices and knowledge for the oil and gas sector, allowing it to improve its performance, increasing the understanding of new or emerging environmental concepts. (IPIECA, 2016).

2.3 Environmental Impacts derived from Activities of the Oil and Gas Sector

Internationally, the activities of companies in the oil and gas sector are considered potentially risky (Salassa, 2016), due to the implications of those accidents that generate oil spills on the natural environment (Mendoza et al.,2002).

¹ Those productive activities throughout the value chain of the oil and gas sector, which characterize and sustain the business, generating economic value, such as: exploration, extraction, industrial transformation (oil refining, natural gas processing, petrochemicals), storage and transportation.

The characterization of oil and natural gas, are a relevant factor that determines the processing and quality of final products, such as environmental impacts in case of accidental release (Olajire, 2014). An environmental impact is generated, when an action produces an alteration, favorable or unfavorable, on the environment or its components Conesa (2003).

According to Martins et al. (2015), Bravo (2007) and Guédez et al. (2003), the most common environmental impacts in the sector are: 1) Emissions: The greenhouse gas emissions and other pollutants with greenhouse effect are grouped here, to a greater extent: carbon dioxide (CO₂) and methane (CH₄), which come from the burning of fuels in productive processes and derived from the management of natural gas. 2) Spills: Here are the discharges of: oil, condensates, oil (gasoline, diesel, cope), chemical compounds, as well as sewage and acids, which can occur in water and soil. 3) Waste generation: This group includes solid waste (paper, cardboard, etc.) and hazardous waste (corrosive, explosive, toxic, flammable, etc.), which due to its danger require special handling and proper final disposal.

3. Methods

The methodology used in this work is documentary research, this method proves to be effective, since the type of organizations and companies related to the oil and gas sector have international participation and disseminate their performance and work through different sources, highlights their annual reports.

According to Arias (2012), This methodological process is based on the search, collection, analysis and interpretation of secondary information, that is, that which has been previously analyzed, such as that obtained in print, electronic and audiovisual sources, whose purpose is to contribute to new lines of knowledge.

The stages to develop documentary research, which are suggested by Arias (2012), are the following:

1. Search for printed and electronic sources of information.
2. Initial reading of available documents.
3. Preliminary research scheme.
4. Data collection through evaluative reading and abstract preparation.
5. Analysis and interpretation of information collected based on preliminary scheme.
6. Formulation of final scheme.
8. Review and presentation of final report.

4. Data Collection

Given the nature of the work, it was decided to develop the method of documentary research, since there is a wide range of secondary sources of information (Baena, 2017), such as the reports on sustainability of organizations and companies in the oil and gas sector, as well as of the reports of global groups and agencies in the areas of environmental protection and sustainable energy. In particular, a detailed review of the references on sustainability management and environmental impacts related to the substantive activities of the oil and gas sector was established. In this case, the evidence was mainly taken from sustainability reports of selected companies, including, BP (2018), ExxonMobil (2018), Royal Dutch Shell (2018), Lukoil (2018), PetroChina (2018), Petrobras (2018) and Pemex (2018).

5. Results and Discussion

5.1 Sustainability Management and Best Sustainability Practices in the Oil and Gas Sector

Companies in the oil and gas sector are increasingly concerned about the impacts they cause on the environment of their areas of influence derived from their substantive activities, and under a sustainable approach they are carrying out various actions to reduce these impacts, as well as to contribute to the solution of local, regional and global environmental problems. One of the ways in which these companies are achieving this purpose is through their commitment and participation with various initiatives, projects or programs, both local and international that are focused on reducing or avoiding, as much as possible, their impacts. (See Table 1)

Table 1. Commitment and participation in the field of sustainability of companies in oil and gas sector

Initiatives / Projects / Programs	Companies in the oil and gas sector						
	BP	Exxon-Mobil	Royal Dutch Shell	Lukoil	Petro-China	Petro-bras	Pemex
Sustainable Development Goals	X	X	X	X	X	X	X
Principles of the Global Agreement	X	-	X	X	X	X	X
Paris Agreement	X	X	X	X	X	X	X
Zero Routine Flaring by 2030	X	-	X	X	-	X	-
Methane Association of the Oil and Gas Sector	X	-	X	-	-	-	X
Oil and Gas Climate Initiative	X	X	X	-	X	X	X
Methane Guiding Principles	X	X	X	-	-	-	-
Voluntary Principles on Security and Human Rights	X	X	X	-	-	-	-

Another way in which companies are contributing to reduce such impacts is through their participation and collaboration with various groups, organizations, institutes or associations, of international scope (See Table 2), which are focused on solving the problem of environmental impacts that derive from various activities, including those of the oil and gas sector. These groups are not only companies, but also governments, NGOs, educational institutions, research centers and other productive sectors, which also have an interest or are related to environmental impacts, and who wish to collaborate on sustainable solutions. Oil companies tend to participate to a greater extent with international associations that are focused on addressing the problems of the elements of the physical environment, in particular, air and water (see Table 2).

Table 2. Participation in associations that regulate sustainability of companies in oil and gas sector

Associations / Organizations	Companies in the oil and gas sector						
	BP	Exxon-Mobil	Royal Dutch Shell	Lukoil	Petro-China	Petro-bras	Pemex
International Petroleum Industry Environmental Conservation Association	X	X	X	-	-	X	X
Global Gas Flaring Reduction Partnership	X	X	X	-	-	-	X
Climate & Clean Air Coalition	X	-	X	-	-	-	X
Climate Leadership Council	X	X	X	-	-	-	-
World Business Council for Sustainable Development	X	X	X	-	X	-	X
Oil Spill Response Limited	X	X	X	-	-	X	-
Global Carbon Capture and Storage Institute	-	X	X	-	-	-	-
International Emissions Trading Association	X	-	X	-	X	-	-
American Petroleum Institute	X	X	X	-	-	-	-
Natural Capital Coalition	-	-	X	-	-	-	-

Tables 3, 4, 5 and 6, present a summary of the best sustainability practices for companies in the oil and gas sector, focused on reducing their impacts on the physical and biological means of their areas of influence, which were identified through the review and analysis of secondary sources of information, mainly sustainability reports of companies in the sector. International best practices in terms of sustainability were identified, particularly in the environmental dimension, which these companies currently use, and which, due to their level of operations and international presence. It should be noted that, in Mexico, the vast majority of these companies have a stake in the national sector, after opening to private investment.

Table 3. Sustainability practices to reduce air pollution

Sustainability Practices
Reduction of the venting and continuous burning of hydrocarbons.
Management and control of GHG emissions (CO ₂ and Methane) and pollutants.
Environmental monitoring of waste gases and air quality.
Research to reduce CO ₂ and methane emissions.
Use of more efficient technologies to detect and reduce methane emissions.
Development of projects to reduce GHG emissions and criteria pollutants.
Development of programs for the use and use of associated natural gas.
Participation in local and international programs, plans and initiatives on emission reduction.
Adoption of registration systems for GHG emission information and criteria pollutants.
Report and dissemination of GHG inventory and criteria pollutants.
Share the practice of GHG emission control with companies in the branch and segments of society.
Promote natural gas as a low carbon fuel in energy sectors.

The points that stand out in terms of best practices to combat air pollution are focused on the control of greenhouse gas emissions, in particular, carbon dioxide and methane, which are the most generated in the oil and gas industry, and contribute to global warming and climate change.

Table 4. Sustainability practices to reduce water pollution

Sustainability Practices
Conservation management and efficient use of water.
Deployment of water conservation technologies.
Development of projects for conservation and efficient use of water.
Use of tools to identify operational sites located in areas with potential water scarcity.
Evaluation and monitoring of water risks.
Adaptation of water consumption to local or regional conditions.
Reduction of the level of pollutants discharged in effluents.
Management of water resources (produced / fresh water) and effluents (wastewater).
Environmental monitoring of wastewater and water quality.
Use and use of alternative water sources (treated salt water, rainwater).
Research, technology and training on prevention and response to oil spills.

In reference to best practices aimed at combating water pollution, its main focus is the maximum use of the resource, especially if companies participate in areas with scarcity problems, knowing that their demand in the world is increasing. The best practices are also focused on preventing the contamination of various water effluents (rivers, lakes and seas) through their wastewater discharges, through proper treatment and the use of new methods.

Table 5. Sustainability practices to reduce soil pollution

Sustainability Practices
Reduction of the level of waste generated.
Research and development of technologies for treatment of generated waste.
Evaluation and monitoring of risks due to waste generated.
Land conservation management.
Research and development of land conservation technologies.
Environmental monitoring of soils and quality of services it provides.
Aerial monitoring of environmental surveillance through drones.
Adoption of hazardous waste information registration systems.
Hazardous waste management for handling and final disposal.

The best practices that stand out to combat soil pollution, focus on the level of hazardous waste generated, and avoid the deterioration of this element by its management and disposal, managing the proper management and risk

prevention, knowing that derived from Its activities generate a great diversity of waste with dangerous characteristics (corrosive, reactive, explosive, toxic, flammable). Considering that waste from industrial activities, due to its danger, is associated with environmental problems such as erosion and desertification.

Table 6. Sustainability practices to reduce pollution of the biological environment

Sustainability Practices
Conservation management and efficient use of natural resources.
Management for the protection and conservation of wildlife.
Identification and evaluation of risks on ecosystems and areas of influence.
Management and control of risks and impacts on ecosystems and biodiversity.
Development of programs for the adequate attention of wildlife.
Development and participation in projects and programs for the conservation of ecosystems and biodiversity.
Development of restoration plans and compensation of biological resources.
Development of plans and projects for restoration of damaged ecosystems.
Development of biodiversity plans when operating in critical habitats.
Modification of the engineering design of assets for protection of wildlife habitats.
Participation with scientific organizations of biodiversity protection and nature conservation.

Regarding the best practices aimed at the elements of the biological environment, they are oriented towards the care and preservation of habitats and species those sites with high biological wealth and with vulnerable fauna and in danger of extinction.

According to the information shown in the tables, companies in the sector actively employ sustainability practices aimed at the different elements of nature. All these practices are a sample of the most popular and in which companies in the oil and gas sector agree, hence they qualify as best practices, however, there will undoubtedly be others, not less important and more specific, but, it will depend on the importance that companies give in its application.

5.2 Mechanisms for Implementation of Sustainability Best Practices for Oil and Gas Sector in Mexico

According to the analysis of secondary sources of companies in the oil and gas sector at a global level, the most outstanding sustainability mechanisms for the implementation of best sustainability practices in the case of Mexico are identified, being the following:

a) Linking with universities and research centers

In Mexico there are several public universities, highlighting the National Polytechnic Institute (IPN) and the National Autonomous University of Mexico (UNAM) that perform a relevant task of linking with the productive sectors and, in particular, with the national oil and gas sector. In turn, this same work is being carried out by leading private educational institutions, which are options for this purpose. Regarding the Research Centers, there is the Mexican Petroleum Institute (IMP), which was created with the objective of supporting the development of the national oil sector. Today the Institute works on developing projects and providing services for the oil industry, expanding its horizon to the private sector.

b) Participation in associations and organizations in the oil and gas sector

Participation in organizations and associations that integrate important companies in the oil and gas sector and other productive sectors, as well as governments and NGOs that aim to find solutions to the problem of environmental impacts. For example, the case of IPIECA (International Petroleum Industry Environmental Conservation Association), which has extensive experience supporting the sector in environmental and social issues, and is integrated by the national oil company (PEMEX) along with other important oil companies (BP, ExxonMobil, Shell, Total, Petrobras). Another important organization is IOGP (Internal Association of Oil & Gas Producers), which serves as a regulator of the oil and gas industry, as well as a global partner to improve safety and social and environmental performance.

c) Participation in initiatives for Sustainability in the oil and gas sector

Important organizations develop and promote initiatives around environmental protection, which are inviting governments and various sectors around the world, including oil and gas, to contribute to them. There are relevant initiatives to combat environmental pollution that companies in the sector can participate, for example:

- ❖ The 2030 Agenda for Sustainable Development and the SDGs
- ❖ The Ten Principles of the UN Global Compact
- ❖ The Paris Agreement (COP21)
- ❖ Zero Routine Flaring by 2030
- ❖ The Oil and Gas Climate Initiative
- ❖ Methane Guiding Principles
- ❖ The Global Methane Initiative

e) Indicators and performance goals in sustainability

The approach of indicators and goals to reduce the environmental impacts derived from the substantive activities of companies in the oil and gas sector, is a way for them to adopt sustainability practices. Some goals could be set or aligned based on international agreements and initiatives, such as those previously indicated, being the most followed by companies in the oil and gas sector, the SDGs of the 2030 Agenda and the Paris Agreement, the latter more specific to set goals for reducing GHG emissions and other pollutants, aimed at combating air pollution.

a) Participation in the development of sustainability policies and guidelines

A fundamental part to accelerate the implementation of sustainability practices in companies in the productive sectors is to have environmental policies and guidelines. Policies and guidelines are identified to promote sustainability in companies in the oil and gas sector, such as:

- ❖ Emission management; which promotes the reduction of GHG emissions and pollutants
- ❖ Energy management; focused on energy efficient use
- ❖ Water and effluent management; focused on water use and effluent treatment
- ❖ Integral waste management; focused on the generation, management and disposal of waste
- ❖ Ecosystem and biodiversity management; focused on protecting and preserving habitats

c) Training in best sustainability practices

An essential part in the implementation of sustainability practices in companies is that their staff is properly trained around these issues, which in many cases turns out to be a fundamental factor for their success. In this regard, there are some oil companies, such as Petronas, Royal Dutch Shell, Lukoil and PetroChina, whose objective in terms of sustainability is to carry out actions that contemplate their contribution to the development of the global oil and gas sector. On the other hand, one of the benefits of establishing alliances or collaboration agreements with other companies or organizations in the sector is that through them you can share knowledge and stay updated on sustainability issues

5. Conclusions

At international level, various groups, organizations and companies in the oil and gas sector have undertaken actions and new trends focused on reducing environmental impacts. One of the main actions is to reorient the conventional consumption and production of primary energy sources, moving from an economy of high CO₂ emissions and other greenhouse pollutants, to a low carbon economy, making companies in the sector more responsible and sustainable. In recent years, international initiatives and agreements, such as the “Zero Routine Flaring by 2030”, the “Paris Agreement” and the “SDGs of the 2030 Agenda”, have encouraged companies in the oil and gas sector towards implementation of best sustainability practices throughout its value chain, in order to contribute to its goals, so they turn out to be ideal channels for adoption. These channels are promoted by leading international organizations that group important companies, associations and governments in favor of the environment. Leading companies in the oil and gas sector, concerned and committed to environmental protection, including BP, ExxonMobil, Shell, Lukoil, PetroChina, Petrobras and Petronas, have designed and implemented best sustainability practices in the development of their substantive activities.

In the case of Mexico, best sustainability practices are carried out in the oil and gas sector, although not all of the most representative of the sector, mostly through PEMEX, a state company that was in charge of the activities of the sector, exclusively, for more than 80 years, however, due to the opening of the sector to private companies, special attention will have to be given to new participants, since they represent an imminent risk of causing environmental impacts, so they will have to implement best sustainable practices and comply with environmental legislation at the national and international levels.

Acknowledgements

This work was financially supported by the Instituto Politécnico Nacional, México. The authors would like to thank this institution for their support and commitments to this research project. May thanks also to the referees for their valuable comments and suggestions to improve this research.

References

- Almagro, V. F. (2015). *Medición y análisis del desarrollo sustentable en México*. CDMX: Instituto Politécnico Nacional.
- Arias, F. G. (2012). La investigación científica. En F. G. Arias, *El proyecto de investigación. Introducción a la metodología científica*. Editorial Episteme, Sexta ed. Caracas, Venezuela.
- Baena, P. G. (2017). Protocolo y diseño de la Metodología de la Investigación. En G. Baena Paz, *Metodología de la investigación*. Tercera ed. Ed. Patria, México.
- BP. (2017). BP Statistical Review of World Energy 2017. British Petroleum. London, United Kingdom: BP, Available: <https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf>, May 4, 2018.
- BP. (2018). BP Sustainability Report 2017. London, Reino Unido: BP, Available: <https://www.bp.com/content/dam/bp/businesssites/en/global/corporate/pdfs/sustainability/group-reports/bp-sustainability-report-2017.pdf>, January 15, 2019.
- Bravo, E. (2007). Los impactos de la explotación petrolera en ecosistemas tropicales y la biodiversidad. *Acción Ecológica*, 1-61.
- Conesa, F. V. (2003). *Guía Metodológica para la evaluación del Impacto Ambiental*. Ediciones Mundi-Prensa. Madrid, España:
- EIA. (2016). International Energy Outlook 2016. U.S. Energy Information Administration. Washington, D.C., United States: U.S. EIA. Available: [https://www.eia.gov/outlooks/ieo/pdf/0484\(2016\).pdf](https://www.eia.gov/outlooks/ieo/pdf/0484(2016).pdf), May 8, 2017.
- ExxonMobil. (2018). ExxonMobil Sustainability Report Highlights 2017. Irving, Texas, Estados Unidos: ExxonMobil. Available: <https://corporate.exxonmobil.com/en/~media/Global/Files/sustainability-report/publication/2017-Sustainability-Report.pdf>, January 18, 2019.
- Finer, M., Jenkins, C. N., & Powers, B. (2013). *Potential of Best Practice to Reduce Impacts from Oil and Gas Projects in the Amazon*. (M. Convertino, Ed.).
- Government of Canada. (2009). Considerations in Developing Oil and Gas Industry Best Practices in the North. YT, Canada: Government of Canada. Available: <https://www.esrfunds.org/sites/www.esrfunds.org/files/publications/ESRF175-AECOM.pdf>, May 15, 2019.
- Guédez, M. C., De Armas, H. D., Reyes, G. R., & Galván, R. L. (2003). Los Sistemas de Gestión Ambiental en la Industria Petrolera Internacional. *Interciencia*, 28(9), 528-533.
- IPIECA. (2016). About IPIECA. Available: <http://www.ipieca.org/es/acerca-de-ipieca/>, March 18, 2019
- Lukoil. (2018). Lukoil Group Sustainability Report 2017. Moscú, Federación Rusa: Lukoil Group. Available: <http://www.lukoil.com/InvestorAndShareholderCenter/ReportsAndPresentations/SustainabilityReport>, January 25, 2019.
- Martins, S., Silva, M., Azevedo, M., & Silva, V. (2015). Producción de petróleo e impactos ambientales: Algunas consideraciones. *Holos*, 6, 54-76.
- Mendoza, Q.-M. A., Herrera, R. M., & Olguín, P. G. (2002). Monitoreo Ambiental de la Actividad Petrolera en el Sur del Golfo de México. *Revista Actividades Productivas*, No. 43, México.
- Oilwatch. (2006). Manual de Monitoreo Ambiental para la Industria Petrolera. Available: <http://www.oilwatch.org/doc/documentos/manual-esp.pdf>, August 5, 2018
- Olajire, A. A. (2014). The Petroleum Industry and Environmental Challenges. *J Pet Environ Biotechnol*, 5(4), 1-19.
- Pemex. (2018). Informe de Sustentabilidad de Pemex 2017. CDMX, México: Petróleos Mexicanos. Available: http://www.pemex.com/eticintegridad/sustentable/informes/Documents/inf_sustentabilidad_2017_esp.pdf, August 21, 2018.
- Petrobras. (2018). Petrobras Relato Integrado 2017. Rio de Janeiro, Brasil: Petrobras. Available: <https://www.investidorpetrobras.com.br/ptb/1004/sustentabilidade2017.pdf>, February 7, 2019.
- PetroChina. (2018). PetroChina Sustainability Report 2017. Beijing, China: PetroChina Company Limited. Available: <http://www.petrochina.com.cn/petrochina/xhtml/images/shyhj/2017kcxzfzbg.pdf>, February 3, 2019.
- Petronas. (2018). Petronas Sustainability Report 2017. Kuala Lumpur, Malasia: Petroliaam Nasional Berhad (PETRONAS). Available: <https://www.petronas.com/ws/sites/default/files/2018-07/sustainability-report-2017.pdf>, February 7, 2019

- Pierri, N. (2001). Historia del concepto de desarrollo sustentable. En N. Pierri, & G. Foladori (Edits.), *¿Sustentabilidad? Desacuerdos sobre el desarrollo sustentable* (págs. 27-81). Uruguay: Trabajo y Capital.
- Puyana, M. A. (2015). *La economía petrolera en un mercado politizado y global, México y Colombia* (Primera ed.). Ciudad de México: FLACSO, México.
- Roa, A. T. (2011). *La triste historia ambiental del extractivismo petrolero*. (C. B. Colombia, Ed.) PETROPRESS, 4-10.
- Royal Dutch Shell. (2018). Royal Dutch Shell Sustainability Report 2017. Royal Dutch Shell. Available: <https://reports.shell.com/sustainability-report/2017>, January 20, 2019.
- Saavedra, T. N., & Jiménez, I. F. (2014). Necesidades de Innovación y Tecnología para la industria de petróleo y gas en Colombia. *Revista de Ingeniería* (40), 50-56.
- Salassa, B. R. (2016). Fiscalidad y petróleo: un análisis tributario-ambiental a partir de gravámenes concretos. *Revista de derecho*, 45, 262-293.
- SENER. (2013). Reforma Energética. Secretaría de Energía, CDMX. Available: http://reformas.gob.mx/wp-content/uploads/2014/04/Explicacion_ampliada_de_la_Reforma_Energetica1.pdf, March 25, 2018.
- Torres, P., & Cruz, J. (1999). Indicadores del desarrollo sustentable: construcción y usos. *Argumentos* (34), 5-30.
- WCED. (1987). Our Common Future (Brundtland Report). United Nations. World Commission on Environment and Development.

Biographies

Maria del Rocio Soto-Flores is a specialist in the economics of technological change and competitiveness and industrial innovation and focuses his research on innovation theory, sustainability transition in energy sector, green technologies, and sustainability development. Dr. Soto is Professor of the Instituto Politécnico Nacional (IPN), Escuela Superior de Comercio y Administración (ESCA-STO) in Mexico City and is member of the Mexican National Researchers System (SNI-CONACYT). She was also member of the network of centers in support of innovation, funded by the CyTED of Spain. He served as Director for Mexico of the Latino-Iberoamericana Association of Technology Management.

Raúl Rodríguez-Ávila has 20 years of experience in the oil and gas sector in Mexico, He is currently working for Mexico's national oil company (PEMEX) with the role of specialist coordinator in operations programming. He is a Petroleum Chemical Engineer graduated from the School of Chemical Engineering and Extractive Industries (ESIQIE) by the Instituto Politécnico Nacional (IPN). He earned MSc in Business Management for Sustainability from Escuela Superior de Comercio y Administración (ESCA-STO), Instituto Politécnico Nacional (IPN).

Christian Muñoz-Sanchez is a specialist in innovation theory, sustainability transitions, sustainability development, technological capabilities, and innovation systems. He is professor of the Instituto Politécnico Nacional (IPN), Escuela Superior de Comercio y Administración (ESCA-STO) in Mexico City. He has published journal and conference papers on innovation systems, technological development, and energy transitions. He is member of the IEOM Society International.

Ingrid Yadibel Cuevas Zuniga works in the line of research innovation and its relationship to sustainability development, its focus on green technologies, agro-industry and strategies to incorporate actions of sustainability for organizations. Dr. Cuevas is head of the Graduate Department at Escuela Superior de Comercio y Administración (ESCA-STO), Instituto Politécnico Nacional (IPN), and participates actively in a master's degree and doctorate programs. She has received several national and international awards, including the medal Lázaro Cárdenas, the highest distinction given by the Instituto Politécnico Nacional (IPN) to the leading members of its community.