Environmental and economic assessment of the potential of upstream activities in Portugal

Grzegorz Zamojski

grzesiek.zamojski@gmail.com

Instituto Superior Técnico, Universidade de Lisboa, Portugal

June 2018

Abstract

Fossil fuels industry has been under heavy public pressure since the last decade, and is recently facing an inevitable revolution led by innovative solutions such as electric vehicles or alternative renewable energy sources. Countries are introducing strict legislation regarding the greenhouse gasses (GHG) emissions, that could once and for all end the era of internal combustion engines. However, few pay attention to a fact that oil can be a much needed stepping stone to a sustainable future.

Portugal has reportedly large off-shore deposits of commercially viable hydrocarbons, which until today remain undiscovered. There is an undeniable potential in exploration of those resources, that would not only help Portuguese economy to grow, but could also lead to a global emissions drop. This work aims to analyze the environmental impact of several scenarios, in which the crude imports have been successfully replaced by a domestic oil production. An life cycle impact assessment (LCIA) on the import activities related to a production of crude oil in Brazil has been performed, and compared to the scenarios of a successful introduction of a domestic fuel production in Portugal.

Import of fossil fuels is not only contributing to the GHG emissions, but with annual cost of 4.3 million dollars (Simoes, 2011),it is also a main constituent of a negative trade balance in Portuguese economy. Domestic oil production would not only significantly decrease the import of fuels to Portugal, but could also increase the export to other neighboring European countries with high demand in crude resources.

In all domestic production case studies investigated in this work, the environmental impact is highly dependent on the efficiency of extraction of crude oil from the potential discovery sites. With well productivity at levels equal to 25kboe/d and sea freight transportation of resources, as assumed in the reference case study of oil imports from Brazil, the average environmental impact between all categories for Portugal is equal to 107,5%. In other analyzed cases, with larger input differences, the results scale down to 50,4% of the reference value for impacts related to ionizing radiation, and up to 847,8% for impacts on human toxicity. Those deviations are closely related to case study assumptions, such as well productivity, number of exploration wells needed to establish production or oil transportation method to the refinery in Sines, Portugal.

Economics benefits of potential upstream activities in Portugal have been presented in this paper. In the analysis different state revenue streams have been investigated, leading to a specific income estimation for the different scenarios varying between \$20.6 billion, up to \$94.2 billion, assuming a fiscal regime transition.

Introduction

The global energy market is constantly evolving. To make proper policy changes in the present one has to look into the future to analyze different scenarios and their possible outcomes. World's energy production and consumption are increasing each year, and so are the related carbon dioxide (CO_2) emissions reaching a historic high of 32,5 gigatons of CO_2 emissions in 2017, what is a 1.4% rise from a previous year (IEA, 2018). Despite the fact that more countries are committed to their climate pledges and renewable technologies are advancing, oil is still the largest primary energy source constituting to 38,1% of total energy demand in 2017 (IEA, 2018).

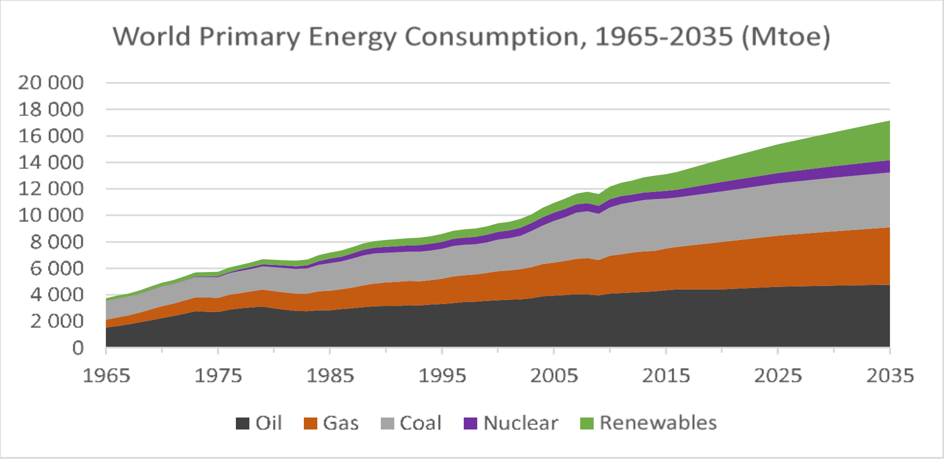
Portugal is one of the European countries in the process of rebuilding its economy since the great recession in recent years. Steady yearly growth can be seen both in the GDP and in the international trade with considerable yearly exports increase of 1% within last five years (mostly to the European Union stating 78,0% of total exports) (Simoes, 2011). However, with slowly decreasing, but still significant volume of imports, Portugal is recording a negative trade balance for many consecutive years. Taking into account that refined petroleum is the main exported commodity and the imports are led by crude oil, a looming discovery of domestic crude oil could be a pathway to strengthen Portuguese economy. However, it is not certain that the environment will benefit as much as the state in such situation. This paper investigates both, environmental and economic impacts of domestic crude oil exploration in Portugal.

World Energy Demand Overview

Future energy demand is closely related to governmental policies, international climate policies, energy efficiency measures, and technological and social development. Taking into account estimations of International Energy Agency and BP annual statistical reports, a short energy demand forecast, and its main influential factors, can be described.

World's gross domestic product (GDP) is projected to almost double within the next 20 years (OECD, 2014), mostly driven by emerging economies. World's population growth, with estimated 8.8 billion people by 2035 (BP, Jan 2017), and increase in productivity, will be crucial in shaping of energy markets in the future. This rapid growth in economy and population is mostly propelled by countries like China or India. However, with energy efficiency increase, and therefore energy intensity decrease, the overall global energy demand in 2035 is projected to increase by 30.5% (BP, Jan 2017).

When comparing emerging economies, such as China or India, with well-developed European Union, a significant difference is visible in the forecasted demand changes. Between years 2015-2035, China and India are projected to grow their energy demand by 47% and 129%, while in the same period of time European Union is supposed to decrease primary energy consumption by 8% (BP, Jan 2017). To understand world's primary energy consumption trends, a more detailed split by sector is shown in graph below.



Graph 1 Forecast of world primary energy consumption by source

Renewables (including biofuels, wind power, solar electricity, hydroelectricity and geothermal energy) are prognosed to reach 17% of total consumption by 2035 with almost 3 billion toe. Consumption of renewables between 2015 and 2035 is estimated to be the fastest growing from all sources of energy, with 7.1% of annual growth, reaching globally over 291% in reference to 2015 (BP, Jan 2017).

Oil should still remain the most demanded commodity by 2035, with average annual growth of 0.7%. Total share of oil is prognosed to drop from 33% in 2016 to 29% in 2035, mostly because of advancement and decreasing costs in renewable technologies. However, combined share of all fossil fuels is estimated to be equal to 78%, in comparison to 85% in 2016. Out of these, natural gas will be increasing annually by 1.6% reaching up to 25% of total energy mix and overtaking coal (24%) for the second most consumed fuel in 2035.

The goal of this section was to highlight the fact, that even though renewable energy technology is advancing and becoming more affordable, fossil fuels will still remain the main source of globally consumed energy, with oil as the most dominant commodity for the near to medium long term.

Offshore upstream

The focus of this paper will be on the offshore upstream sector of oil exploration and production activities. Therefore a brief introduction into the topic is presented.

The upstream, also called the exploration and production (E&P) sector, consists of processes related to searching and extraction of oil, from first theoretical assumptions to the established plateau production. Exploration is a long and crucial part of the whole system, as it's creating fundaments for further supply chain steps. Areas with theoretical potential to contain hydrocarbons are subjected to geological and geophysical surveys, to detect relevant subsurface geological structures. Those with higher potential, often called leads, are investigated further to create the profile of the substructure, and if that later fits the criteria set by the oil company, the first exploration well is drilled to determine the presence of hydrocarbons at the prospect area. If the discovery has been confirmed the next step is the production, where the productivity of the well is slowly increasing up to a plateau level, which is its peak operating rate. Production can be limited by the market conditions or governmental regulation. Present market imbalance driven by the supply side of the industry and low oil prices can be an example of such situation, in which countries were forced to reduce the production in order to try to restore the global demand and supply balance. Therefore, upstream can be described as a well oriented sector investigating where to locate them, how deep and how far underground to dig them, and how to later construct and operate them, to ensure the highest return-on-investment (ROI) with the lightest, safest and smallest operational footprint. Oil exploration and production is a high-risk and expensive process which is usually undertaken only by big companies, consortiums and governments;

Based on the information of IEA the off-shore production was equal to nearly 30% of global crude oil output in 2015 (Manning, 2016). Most of the off-shore production is located on shallow waters, which are cheaper and less technically demanding, but more recently there has been a movement towards the deep-water projects. In general case of off-shore the basic equipment is similar to the on-shore drilling, however the environment is a lot more challenging than for the land-based installations.

Most of the development in recent years around the oil drilling is related to overcoming these challenges, where platform stability and deep-water drilling seem to be the key to the new large quantities of available oil resources. One of the differences from on-land production, is that the crew members have to live on the platform for a certain period of time. A platform has to provide all necessary services to the personnel such as sleeping quarters or cafeteria. However, recently with technological advancement more functions are being automated or supervised from the shore through the advanced control systems. Another major difference is the time needed for well completion. For off-shore wells it usually takes up to few months to drill down to the reservoir depending on the water and ground depth, and on geological characteristics, while for on-shore a well can be complete within days. In case of installations operating close to the shore the oil transportation can be conducted by set of pipelines, but for deep-water production special equipment for oil exploration, processing, storage and transportation is needed.

Due to unfavorable environmental conditions, the costs of upstream activities are much higher than for on-shore production. The costs of an on-shore well can range from 4.9 to 8.3 million dollars, with additional 1.0 to 3.5 million dollars in lease and operating expenses over the 20-year well life cycle (U.S. Energy Information Administration, 2016). In case of off-shore wells the costs can be estimated between 60 and 240 million dollars, for wells drilled at water depths ranging from 2,000m to 4,000m (U.S. Energy Information Administration, 2016). Regarding costs per barrel, it is highly dependent on well productivity and the size of discovered reservoir. Therefore, because of its technological complexity, high risk and associated high costs, off-shore drilling projects are usually undertaken by a group of partners rather than a single company. This spreads risks and allows to find financing for much more costly exploration than the one on-shore.

Objective

The goal of this paper is to present an environmental impact analysis results and a comparison of impacts related to the import of crude oil from Brazil to Portugal, with the potential domestic off-shore oil exploration and production in Portugal. Few case studies are investigated, with different input data based on different assumptions related to factors, such as e.g. oil production efficiency, number of wells drilled, number of platforms or oil transportation method. The analysis is focusing on the emissions rated to different impact categories influencing the environment, and therefore the nature, resources and human health. The main constituents for most relevant categories have been identified. All domestic production scenarios' impacts have been normalized and compared to the reference study of imports from Brazil.

With established case studies for environmental impact analysis, the aim of the research focuses on evaluation of current fiscal regime regarding crude oil exploration and production and comparison with more developed systems in well-established producing countries, such as e.g. Norway. A rough estimation of revenues is presented, taking into account current and potential future oil taxation scheme. Knowing that, some recommendations of possible ways of investment are given.

LCA Methodology

The goal of this environmental impact analysis is to perform a comparison of impacts related to the import of crude oil from Brazil to Portugal, with the potential domestic off-shore oil exploration and production in Portugal. The system boundaries in both cases have been selected from the early stages of well drilling, to the final crude arrival in the refinery in Sines, Portugal. The functional unit selected for this LCA is 1kg of crude oil produced offshore.

The dataset for Brazil has been based on the average numbers publicly available in the literature, or in some cases on the assumptions verified by the project stakeholder – Galp Energia. In case of dataset for Portuguese study, few scenarios related to annual oil production have been created based on the estimated time between reservoir discovery to first production, average well completion time and average well productivity. Also, main assumptions are well productivity, the amount of infrastructure put in place, and transportation method. The functional unit selected for this analysis is one kilogram of crude oil, what will ensure easy and accurate results comparison, as it is the common output from both process trees.

The software selected for the analysis is SimaPro 8.0, which is one of the most widely used LCA programs by the industry and academics. It is a professional tool that enables the thorough environmental analysis of products or services. It comes with a variety of inventory libraries and impact assessment methods. The inventory database chosen in this work is Ecoinvent version 3.3 from 2016, which incorporates a variety of LCI data from industries such as energy production, transport, production of chemicals, metal production and agriculture. It has a well-established process data related to oil production. The impact calculation method selected within the software is ILCD 2011 Midpoint+ version 1.09 from 2016, which was released by the European Commission Joint Research Center (EC-JRC) in 2012. It supports the correct use of characterization factors for impact assessment according to the guidance document "Recommendations for Life Cycle Impact Assessment in the European context" by the EC-JRC.

To prepare a customized process tree for the study cases, a reference process from the database had to be selected. The process related to the off-shore production oil and gas in Norway has been chosen based on the similarity of described related upstream activities. This process has been later modified according to the acquired data on oil production in Brazil for the import case, and based on the assumptions in scenarios prepared for Portuguese production case. Therefore, based on one reference process selected from the Ecoinvent database, four new processes have been created for later analysis.

In the calculations of SimaPro input values for the case of imported crude from Brazil to Portugal some data was acquired from the literature or from project stakeholders (Galp Energia), but in other cases assumptions and simplifications had to be made. In some cases, where no data could be found in literature, the input values have been calculated by multiplying the initial data from the base Norwegian process by a scaling factor, being a total number of production wells in a case study over the number of wells on which the Norway's process was established. This was selected upon an observation, that the well infrastructure is one of the dominating process in most environmental impact categories.

Revenue Estimation Methodology

Oil extraction plays a dominant role in many economies as a source of export earnings, but the most important benefit for a country from development of the oil and gas sector is likely to be its fiscal role in generating tax and other revenue for the government. To ensure that the state as resource-owner receives an appropriate share of the profits generated from extraction of oil and gas, the fiscal strategy must be properly designed.

The fiscal regime as it is right now is based on few instruments. There is a royalty levied on production in excess of 10,000 barrels of crude oil per year, at 9% in the case of onshore areas and 10 % in the case of shallow (less than 200 meters water depth) offshore areas. However, no royalty is levied on production obtained from deep offshore areas, and this is where most companies are planning to start their exploration and later on establish production. On top of that, the oil companies are subject to corporate income tax, to which an additional municipal charge may be added.

All activities related to oil exploration and production may only be performed under concessions “granting exclusive rights without prejudice of any third parties to other activities or resources or to national interests concerning national defense, the environment, navigation and scientific investigation, and management and preservation of maritime resources” (Ministry of Finance, 2013). The specific contracts between the state and the contractor are confidential, therefore it is hard to estimate a total value payed in services, cash or technology throughout the years of operation.

When it comes to payments for surface rentals, the concessionaire should pay a fee stated in the concession agreement, which may vary from €12.50 to €250.00 per year per square kilometer according to the potential of the area and the contractual period (ENMC, 2017).

The concessionaire is also obliged to pay the corporate income tax at applicable rates, which is levied on its profits. Rates may vary annually in accordance with the provisions of the state budget approved by the parliament. Corporate income tax rate is currently equal to 21% (Stron, 2013). An additional municipal surcharge of 1.5% is levied, while the state surcharge is applied as shown in the table below.

Table 1 Rates of state surcharge on taxable profits (Stron, 2013)

Taxable Profits	State Surcharge
excess of €1.5 million	3%
excess of €7.5 million	5%
excess of €35 million	7%

While searching for a good example of a well-designed and highly profitable fiscal regime, an example of Norway is highlighted in many sources of literature. The revenue streams from the oil exploration and production are mostly profit-based with an addition of concessions for exploration and production. A company involved in the off-shore upstream activities is subject to a marginal tax rate of 78%, where 27% corresponds to an ordinary corporate income tax and 51% resource rent tax) (Ministry of Petroleum and Energy , 2013). All production licenses are subject to an area fee that is paid after the initial exploration period has expired. The exploration period is normally four to six years, after which the annual area fee increases from NOK34,000 ($4,200) to NOK137,000 ($16,900) per square kilometer.

The revenue estimation is investigated for both current and possible future design of a fiscal regime. The state economic benefits have been calculated based on the scenarios designed for an LCA analysis. For comparison, the total revenues in year 2030 are calculated with data for Portuguese and Norwegian taxation systems.

Environmental Analysis

To investigate the differences between current situation of oil imports from Brazil and potential oil exploration and production activities in Portugal, the case study of Brazil has been treated as a reference situation, while the scenarios for Portugal are assessed by comparison. The data describing each of the scenarios has been presented in a table below.

Table 2 Summary of variable data for all scenarios

Input	Unit	Brazil	PT0	PT1	PT2	PT3
Investigated year	-	2016	2030	2030	2030	2030
Average well productivity	kboe/d	25	25	25	15	35
Total annual oil production	kg	1,37E+11	4,22E+10	4,22E+10	1,92E+10	7,33E+10
Total annual gas production	m3	2,35E+09	5,02E+07	5,02E+07	2,28E+07	8,73E+07
Number of production wells	-	107	33	33	25	51
Wells completed per year	-	-	4	4	3	5
Total number of wells (exploration+production+injection)	-	241	75	75	57	93
Average well vertical depth	km	5500	3500	3500	3500	3500
Total lenght of wells	km	1323,76	259,87	259,87	196,87	322,87
Number of wells per platform	-	20	20	20	20	20
Total number of platofrms	-	13	4	4	3	5
Transportation Method	-	Tanker	Tanker	Pipeline	Pipeline	Pipeline
Distance for transportation	km	20372	88	88	88	88

As introduced before, there is a reference case study of Brazil with data for year 2016. The other cases have been prepared based on data from literature, project's stakeholders inputs, assumptions or calculations, and correspond to a potential scenario of established domestic crude oil production in Portugal in year 2030. The results on environmental analysis for those cases have been are presented below, followed by an estimation of state revenues in the three main cases varying more significantly in inputs (PT1,PT2 and PT3).

The result for the scenarios, presented in table below, are a percentage of the environmental impact to the reference case (Brazil).

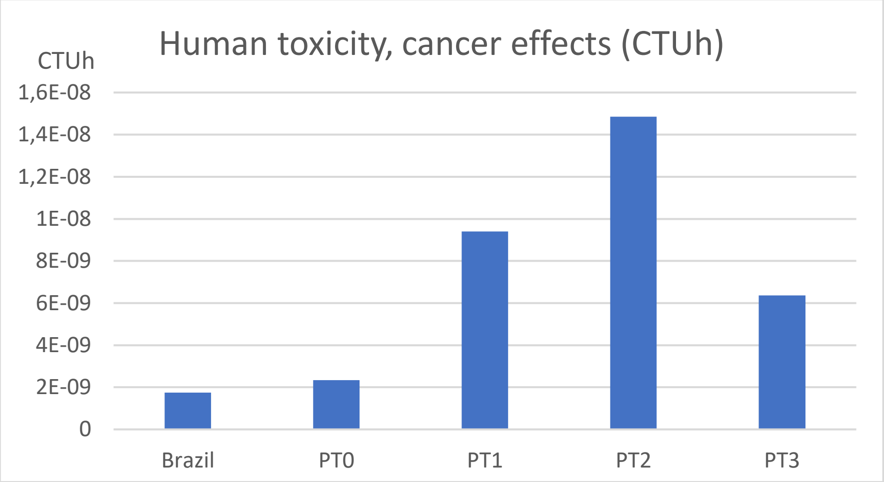
Table 3 Environmental impact analysis results in reference to Brazil case (%)

Impact Category	Unit	Brazil	PT0	PT1	PT2	PT3
Climate change	kg CO2 eq	0,066619695	105,7%	126,1%	207,6%	89,0%
Ozone depletion	kg CFC-11 eq	7,87393E-09	103,7%	125,3%	206,3%	88,4%
Human toxicity, non-cancer effects	CTUh	1,53987E-08	133,9%	183,3%	299,6%	128,4%
Human toxicity, cancer effects	CTUh	1,75145E-09	133,4%	537,0%	847,8%	363,3%
Particulate matter	kg PM2.5 eq	2,26515E-05	111,0%	173,8%	281,9%	120,8%
Ionizing radiation HH	kBq U235 eq	0,304605461	70,4%	70,7%	117,8%	50,5%
Ionizing radiation E (interim)	CTUe	2,13379E-06	70,4%	70,6%	117,6%	50,4%
Photochemical ozone formation	kg NMVOC eq	0,001320469	104,0%	110,2%	182,8%	78,4%
Acidification	molc H+ eq	0,000396823	103,2%	123,7%	203,3%	87,1%
Terrestrial eutrophication	molc N eq	0,001494714	112,6%	129,5%	213,8%	91,6%
Freshwater eutrophication	kg P eq	4,11461E-06	111,5%	267,0%	426,6%	182,8%
Marine eutrophication	kg N eq	0,000136731	112,7%	131,1%	216,3%	92,7%
Freshwater ecotoxicity	CTUe	0,106492306	114,4%	352,9%	560,3%	240,1%
Land use	kg C deficit	0,053062376	114,5%	170,3%	277,1%	118,8%
Water resource depletion	m3 water eq	1,54629E-05	91,5%	143,7%	233,5%	100,1%
Mineral, fossil & ren resource depletion	kg Sb eq	1,09606E-06	127,7%	279,2%	427,6%	200,5%

As expected, the results of case PT0 in most impact categories are closest to the current scenario of imports from Brazil, while PT1, PT2 and PT3 are showing extremely different values. The impact on climate change and ozone depletion are one of the most relevant categories, as they are directly not only affecting the environment, but consequently also the political aspects related to international agreements regarding the emissions. The ratio of impacts for those two categories, are quite similar. Case study PT1 has a higher impact than the reference of Brazil, and is equal in both categories around 125%, while PT2 exceeds the import scenario by a magnitude of 2, doubling the emissions to over 206% in both categories.

For PT3 the impact is lower than the reference and amounts to around 89%. The results for climate change are presented in graph below. To analyze further, the specific process stage contributions can be investigated. As it was mentioned in above section, the share of sea freight in total climate change contribution for Brazil is equal to 0.00264 kg CO2 eq, giving around 4% of total impact in this category. While the share corresponding to the process of pipeline transportation in PT1 amounts to 0.014 kg CO2 eq, giving 16.81% of total climate change impact contribution.

The biggest deviation from the reference values per category has been recorded for human toxicity, with emphasis on impacts related to cancer effects. In all three cases the values exceed the reference of Brazil by a minimum of 363,3% for PT3, reaching up to 537,0% and 847,8% for PT1 and PT2 respectively. The graph below shows the results for this impact category expressed in Comparative Toxic Unit for human (CTUh), being an estimated increase in morbidity in the total human population per unit mass of a chemical emitted.



Graph 2 Human toxicity, cancer effects category results (CTUh)

The biggest impact on this category is indicated by the transportation step, where in extreme case of PT2 the pipeline process step contributes to over 73,94% of the result, out of which 28% corresponds to slag from electric steel production to landfill, and therefore to ground water. When investigating the impacts corresponding to water, the eutrophication and eco-toxicity are relevant. In all impact categories, the results are much higher than in case of Brazil, and sub-processes contributing to that are mostly related to infrastructure, so to processes of well and pipeline, are shearing in cases PT1, PT2 and PT3 between 70% to 88% of the impact. In case of PT0, it can be observed that the result is much more similar to the reference case. It is due to a fact that the transport method of finished product is in this case done by sea freight and not by the pipeline. Therefore, for PT0 the impacts of transportation process in any category does not exceed 3,5%, which it reaches for the acidification, and only 0,7% for the impacts on human toxicity. However, the offshore platform in case of PT0 scenario contributes at average in all categories at 43,9%, as it reaches even up to 82,6% for the human toxicity category.

In most of the impact categories, the environmental impact of Portuguese cases PT1 and PT2 is higher, than for a reference case of Brazilian oil production. Only PT3 in some categories is showing results below the reference. It has to be noted, that the simulations have been based on the same process for Norway, the oil composition is the same, there is same technology applied for production (only number of wells and depth of the reservoir varies), there are almost all the same sub-processes as constituents(transportation step is different), the investigated cases and the values are calculated using the scaling factor (ratio of production wells between case study and Norway). Therefore, the main differences between processes are related to different transportation method (what can be seen in case of similarity between import case and case PT0) and distance, different wells depth and their number, and most importantly to different well productivity. It can be seen, that if an optimistic strategy of 35 kboe/d in PT3, the impacts of 8 out of 15 categories are lower than in the reference. However, when the impact category is not production-based but infrastructure based (e.g. toxicity or eco-toxicity), then in such category the use of a pipeline for transportation is a lot less environmentally friendly than a transoceanic tanker, as the difference between the values corresponding to PT0 and PT3 are easily visible and mount to 114,4% and 240,1%, respectively.

The share of global emissions represented by the production activities in each of the scenarios has been presented in a table below. While investigating the results of normalization, it can be assumed that each of the case studies within the scope of the analysis is playing a minor role in the total global emissions and resource extraction. The highest share of analyzed impacts can be seen within the category “Human toxicity, non-cancer effects”, and in case of three scenarios for Portugal in category “Mineral, fossil & renewable resource depletion”, where the share exceeds 1% of global emissions. However, in other categories the results do not go over a limit of 0,4%, what is a marginal fraction.

Table 4 Scenarios' share in global emissions after normalization

Impact Category	Unit	Brazil	PT0	PT1	PT2	PT3
Climate change	kg CO2 eq	0,015724%	0,005126%	0,019823%	0,032649%	0,013992%
Ozone depletion	kg CFC-11 eq	0,000668%	0,000214%	0,000838%	0,001378%	0,000591%
Human toxicity, non-cancer effects	CTUh	0,791093%	0,326801%	1,449790%	2,370505%	1,015932%
Human toxicity, cancer effects	CTUh	0,007319%	0,003013%	0,039305%	0,062054%	0,026595%
Particulate matter	kg PM2.5 eq	0,128441%	0,043969%	0,223177%	0,362056%	0,155167%
Ionizing radiation HH	kBq U235 eq	0,143044%	0,031064%	0,101094%	0,168440%	0,072189%
Ionizing radiation E (interim)	CTUe	0,000000%	0,000000%	0,000000%	0,000000%	0,000000%
Photochemical ozone formation	kg NMVOC eq	0,064446%	0,020668%	0,070987%	0,117822%	0,050495%
Acidification	molc H+ eq	0,014159%	0,004509%	0,017512%	0,028790%	0,012339%
Terrestrial eutrophication	molc N eq	0,016743%	0,005817%	0,021687%	0,035796%	0,015341%
Freshwater eutrophication	kg P eq	0,011112%	0,003823%	0,029665%	0,047402%	0,020315%
Marine eutrophication	kg N eq	0,009582%	0,003331%	0,012564%	0,020723%	0,008881%
Freshwater ecotoxicity	CTUe	0,017856%	0,006301%	0,063023%	0,100046%	0,042877%
Land use	kg C deficit	0,002302%	0,000813%	0,003921%	0,006379%	0,002734%
Water resource depletion	m3 water eq	0,000003%	0,000001%	0,000004%	0,000006%	0,000003%
Mineral, fossil & ren resource depletion	kg Sb eq	0,000003%	0,117292%	0,831476%	1,273309%	0,596940%

State Revenues Estimation

Table below is showing estimates of total state revenues for all three study cases (PT1, PT2 and PT3) taxed using current regime and the one based on Norwegian system. The lowest state revenue has been calculated for the present taxation strategy in case study PT2, which is characteristic for low well productivity. The largest state revenues have been achieved with Norwegian taxation and highest well productivity. It highlights the fact, that not only the environmental impact is directly connected to the well productivity, but also the economic impact is related to well productivity as well.

Table 5 Revenue estimation for case studies PT1, PT2 and PT3 per Norwegian fiscal regime ($)

Year	PT1 ($)		PT2 ($)		PT3 ($)	
	Current Regime	Norwegian Regime	Current Regime	Norwegian Regime	Current Regime	Norwegian Regime
2018	2,08E+05	6,62E+05	2,08E+05	6,62E+05	2,08E+05	6,62E+05
2019	2,08E+05	6,62E+05	2,08E+05	6,62E+05	2,08E+05	6,62E+05
2020	2,08E+05	6,62E+05	2,08E+05	6,62E+05	2,08E+05	6,62E+05
2021	2,08E+05	6,62E+05	2,08E+05	6,62E+05	2,08E+05	6,62E+05
2022	1,35E+08	3,57E+08	8,10E+07	2,14E+08	1,89E+08	4,99E+08
2023	6,73E+08	1,78E+09	3,23E+08	8,55E+08	1,13E+09	2,99E+09
2024	1,21E+09	3,20E+09	5,66E+08	1,50E+09	2,07E+09	5,48E+09
2025	1,75E+09	4,63E+09	8,08E+08	2,14E+09	3,02E+09	7,97E+09
2026	2,29E+09	6,05E+09	1,05E+09	2,78E+09	3,96E+09	1,05E+10
2027	2,83E+09	7,47E+09	1,29E+09	3,42E+09	4,90E+09	1,30E+10
2028	3,37E+09	8,90E+09	1,53E+09	4,06E+09	5,84E+09	1,54E+10
2029	3,90E+09	1,03E+10	1,78E+09	4,70E+09	6,78E+09	1,79E+10
2030	4,44E+09	1,17E+10	2,02E+09	5,34E+09	7,73E+09	2,04E+10
Total	2,06E+10	5,45E+10	9,45E+09	2,50E+10	3,56E+10	9,42E+10

As a conclusion, the Portuguese fiscal regime needs to be reevaluated to maximize the gains within the resource rental. Norwegian tax fees cannot be directly a good example for a developing case of Portugal, as Norway has few decades of established oil production, and does not need to lure new investors towards large endeavors in deep offshore exploration. Nevertheless, the huge differences in state revenues show, that policymakers have to design a fiscal regime for the oil sector that will attract investment as well as secure a reasonable share of economic rent for the government.

Conclusions and future work

As it was presented above, fossil fuels are still dominant source of energy, and will be in the upcoming decades. Therefore, the sector will be still growing and the companies, both local and foreign, should be interested in investment in the area in case of successful discovery of crude oil in the Portuguese offshore basins. However, it is very much dependent on fiscal regime that will be established by the local authorities in the coming years and on the fluctuating crude oil prices, which are dictating the decisions related to such high investment initiatives.

In the environmental impact analysis results it has been presented, that the impacts associated with local crude oil exploration and production will be very much dependent on the quality, quantity and productivity of established production. The results show, that in cases such as PT0, with inputs very similar to the reference case of Brazil (mainly the average well productivity equal to 25 kboe/d) the environmental impact is almost the same as in reference averaging 107,5% within 16 environmental impact categories. However, even in a situation of higher well productivity and faster development of the reservoir leading to larger amount of production wells, if a pipeline will be introduced instead of sea freight as in case of PT3, the average impact throughout all categories will be higher reaching over 130,2% with highest impacts on human toxicity reaching up to a 363,3% of reference value for case of imports from Brazil. Those deviations are highly connected to the infrastructure (wells, platforms or pipelines), so it can be highlighted that a more precise analysis would have to be performed with more specific inputs from companies planning to develop the reservoir. There are many variables, which may lead to different outcomes regarding the environmental impact of the exploration and production projects. It can be concluded, that with high well productivity and with low infrastructure employment the production of oil in Portugal would have similar impacts on environment in comparison to imports from Brazil.

There is a huge chance for Portuguese government to collect a significant share of the oil profits, and to invest in low carbon solutions development. With good management of revenues, and taking a lesson from countries with well-established oil revenue streams (e.g. Norway), Portuguese economy can be on the rise in the upcoming decades. Within the investigated scenarios and corresponding assumptions, and with regard to current fiscal regime, the state revenues have been estimated to reach from 20,6 to 35,6 billion dollars in year 2030. However, if the taxation system would shift to a similar one to the Norwegian, the total revenues for the same period of 13 years would range between 54,5 and 94,2 billion dollars. Such amount could be distributed between different goals and areas of state business, however to facilitate a smooth transition from potential oil-related economy in the future towards a low-carbon sustainable system, investment in funds such as Portuguese Carbon Fund should be made, as it would not only increase the competitiveness of Portuguese economy, but also allow to put a timeline for oil exploration and production activities in Portugal.

At this stage, there is so little data available to public information, and there are so many variables influencing the results, that it is impossible to say, if it is better to import oil or produce oil locally in long term by using only such a simple analysis. However, as it was presented in this work, with favorable natural and economic environment for crude resources development, Portugal may feel a recognizable change in the following years. Taking into account the economic benefits associated with domestic crude oil production, it is surely worth to be prepared for a successful discovery, and have all the instrument in place to fully benefit from this opportunity.

The future work in this topic should be performed on impacts on a local scale, and not global or state centered. Domestic crude oil production can affect mostly local communities and businesses, therefore a social impact analysis should be performed. It would also be good to repeat a similar study to the one contained in this work, but at a point in which more data is available for precise investigation of both environmental and economic impacts. Also, there should be a larger transparency within the crude oil exploration and production projects, what would not only accelerate external bodies to investigate the possible outcomes of such actions, but could also ease current negative public reception of any domestic crude initiatives.

References

ANP. (2017). Agência Nacional do Petróleo. www.anp.gov.br/.
BP. (2017). BP Statistical Review of World Energy.
BP. (Jan 2017). BP Energy Outlook 2035: January 2017.
ENMC. (2017). Entidade Nacional para o Mercado de Combustíveis. http://www.enmc.pt/
IEA. (2018). Global Energy & CO2 Status Report.
Manning, M. (2016). Offshore production nearly 30% of global crude oil output in 2015.
Michael, F. T. (1989). Comments on Crude Oil Gravity Adjustment.
Ministry of Finance. (2013). The history of green taxes in Norway. https://www.regjeringen.no/en/topics/the-economy/taxes-and-duties/The-history-of-green-taxes-in-Norway/id418097/
Ministry of Petroleum and Energy . (2013). Act of 13 June 1975 No. 35 relating to the Taxation of Subsea Petroleum Deposits, etc. (the Petroleum Taxation Act). Last amended by Act of 21 June 2013 No. 66. .
OECD. (2014). OECD Database. GDP long-term forecast: https://data.oecd.org/gdp/gdp-long-term-forecast.htm
Simoes, A. (2011). The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development.
Stron, C. B. (2013). The Oil and Gas Law Review. London: Law Business Research Ltd.
U.S. Energy Information Administration. (2016). Trends in U.S. Oil and Natural Gas Upstream Costs.