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Estimation of Environmental Damage Costs from CO_2e Emissions in Libya and the Revenue from Carbon Tax Implementation

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Abstract

This paper addresses the GHG emissions from oil and gas extraction, production and combustion and other emissions sources in Libya. In general, this research deals with the primary energy tracing from well to wheel leading to inventor of pollutants emitted through this path. This study presents the first work conducted in the estimation of costs of the environmental damages caused by GHG emissions from Libyans activities, we involved not only the energy or industrial facilities but also the waste and livestock in this process. For Libyan market, we adopted a cost of CO_2e is 44 LD/ton CO_2e (which equivalents to 32 US$ or 29 €), the present study reveals that the prices of all fusel fuel must be increased by 79%, 138%, 19% and 80% for Gasoline, Diesel, Air-jet fuel and LPG respectively, and by 8%, 143%, 6%, 3% and 14% for air travailing tickets, MWh of electricity, ton of steel, ton of cement, kg of red meat and ton of garbage, respectively. The total revenue as a result of the implementation of carbon tax is 4.4 billion LD which equivalent to 10% of the Libyan GDP in 2015. The followed procedure enables to investigate the effect of each type of energy, production or service on the environment individually. This research paved the road for more intensive researches to account all pollutants in the social-economical-environmental system.

Keywords

Libya, Carbon Tax, CO_2e Emission Factors, Environmental Damage Costs, GHG Emissions, Fuel Consumption

1. Introduction

Global warming is seen by many as one of the greatest challenges the world faces today. In the 1800's Fourier discovered that the earth's atmosphere provided an insulation effect known from that time as the greenhouse effect. Later, Tyndall, proved that the greenhouse effect existed by concluding that water vapour was the strongest absorber of radiant heat in the atmosphere. In 1972 the United Nations convened a conference on the Human Environment in Stockholm that was the first major international conference to be held to discuss global environmental issues. Twenty years later the United Nations Framework Convention on Climate Change (UNFCCC) was established with the goal of stabilising atmospheric greenhouse gas concentrations. At the Kyoto Conference of Parties (COP) in 1997 it was agreed to reduce the overall emissions of six greenhouse gases to around 5% below 1990 levels by 2010 (targets varied for different countries) [1]. Despite the contribution of Libya in the emission of GHG gases does not exceed 0.22% of the global emission, Libya has ratified the United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), signed the Kyoto protocol (1997) and the Paris agreement on climate change (2015), and created a DNA in 2010. Libya vigorously works toward further international progress in the global warming as a security issue.

Environmental damage costs of carbon CO_2e emissions represent the uncompensated monetary values of environmental and health damages it causes. These costs—sometimes called external costs—are imposed on society and the environment, and are not accounted for by the producers or the consumers. External costs should reflect the value of the damage caused by industrial facilities or services, and associated processes. Most research had only been done in North America and Europe [2], and almost there is no work has considered the developing country. Despite the total emissions from these countries together is greater than what is emitted from the industrialized countries. The world total emissions for the year 2010 in million metric tonnes were 31780.36 the share of continents was a percentage as follows: North America 20.8%, Central and South America 39.6%, Europe 13.8%, Eurasia 7.7%, the Middle East 5.6%, Africa 3.6%, Asia & Oceania 44.6% [3]. According to the US Energy Information Administration, Libya emitted 60.60 million tonnes of CO_2 which is equal to 9.4 tonnes per person, making Libya ranks 56 in the global ranking out of 200 countries.

The major source of air pollution is the energy sector which is key to the Libyan economy. Nearly every aspect of our modern lifestyle is impacted by oil. Oil is used to power our vehicles, to create medicines that keep us healthy, and to make the plastics, cosmetics, and other personal products that enhance our daily lives. However, none of these products would exist without very complicated and very maculated process. Crude oil is extracted, refined, transmitted, stored and at the end burned.

2. Primary Energy Key Figures

Libya possesses substantial reserve of hydrocarbons. Libya is ranking 31 largest crude oil producer in the world. At the beginning of 2016 it possessed 48.36 billion bbl of proved reserves, amounting to 4% of global proved reserves. Libya has 27 oil and gas production fields, including 896 wells with average barrels per well daily 2300 [4]. The extracted oil is transferred from wells to refineries or export directly through pipelines along 7005 km. Also, the gas extracted to the condensate plants or transported directly through pipelines along 3743 km; and for condensate gas transported through lines of 882 km [5]. Oil production peaked at 2 billion barrels per day in 2010, but has since fallen and in 2011 as a result of unstable political situation in Libya. Figure 1 presents oil production and discovery forecast [6]. Libya is also well-endowed with natural gas. In 2016, there were 1.505 trillion cubic meters of proved reserves of natural gas. Production of natural gas in Libya in 2014 was 11.8 billion cubic meters giving it a reserves to production ratio of around 130 years, compared to 8.6 years in the US and 81 years in the Russian Federation. Libya also has a refined petroleum and petrochemical industries, during the year 2013, the refined facilities produced about 158,300 bbl/day. Table 1 shows the primary energy balance in the country. Table 2 the distribution of the primary energy along the sectors and also the annual production of each sector. Evidently, Libya will be producing and utilizing the fossil fuel for a long time. Mainly Libya has six types of primary energy, these are: Natural gas (NG), heavy fuel oil (HFO), light fuel oil (LFO) or diesel, Gasoline, air-jet fuel and liquefied petrol gas (LPG). Figure 2 presents 100% stacked column chart of data in Table 2, which compare the percentage that each sector contributes to the total fuel consumption. As it depicted in the Figure 2 regardless of the quantities-electric power generation industry is the biggest consumer of the NG, HFO and LFO. Of course, the transport sector-passenger cars-consume almost all the amount of gasoline as well as the case for air- jet fuel is fully consumed by aircrafts. While the LPG is almost consumed by the residential sector for coking purposes.

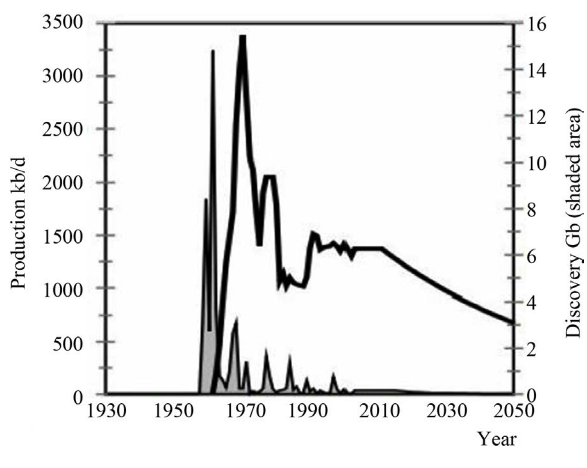

Figure 1. The Libyan oil Production and Discovery forecast.

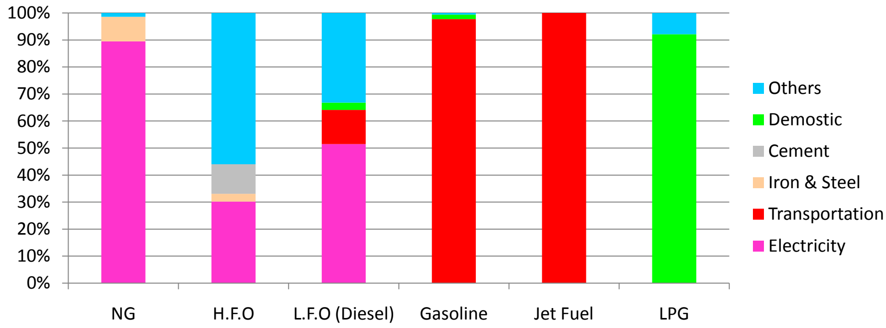

Figure 2. Comparison of percentage contribution of each sector in total fuel consumption.

Table 1. Primary energy balance in 10^3 m^3 per year.

Item	Dry Natural Gas	Liquefied Natural Gas	Crude Oil	Residual Fuel Oil	Distillate Fuel Oil	Gasoline	Jet Fuel	Kerosene	Liquefied Petroleum Gas
Production	1.2205E7	7.4633E3	7.9334E4	2.8437E3	2.6696E3	8.1249E2	9.2856E2	2.3794E2	1.8571E3
Consumption	6.720E6	0.0	1.3812E4	2.6696E3	4.6428E3	4.7428E3	2.6116E2	4.8169E2	5.845E3
Balance	+5.485E6	+7.463E3	+6.552E4	+1.741E2	-1.973E3	-3.830E3	+6.674E2	-2.437E2	-3.988E3

[Source: United States Energy Information Administration, is not available http://www.eia.doe.gov/].

Table 2. Annual fuel combustion and the goods production (10^3 m^3 fuel or unit of production/year).

Utility	Dry Natural Gas	Residual Fuel Oil	Distillate Fuel Oil (Diesel)	Gasoline	Jet Fuel	Liquefied Petroleum Gas	Production
Electricity	6.013E6	8.055E2	2.389E3	-	-	-	7.0525E7 MWh/year
Transportation	-	-	5.880 E2	4.636E3	2.620 E2	-	-
Residential	-	-	1.2357E2	7.9194E1	-	5.3843E3	-
Iron & Steel	6.0904E5	7.8116E1	-	-	-	-	1.324E6 ton iron/year
Cement	3.2757E3	2.916E2	-	-	-	-	7.20E6 ton cement/year
Livestock	-	-	-	-	-	-	6.827E4 ton meat/year
Solid waste	-	-	-	-	-	-	1.8942E6 ton waste/year
Other	9.4684E4	1.4944E3	1.5401E3	2.7606E1	0	4.607E2	-

[Source: Authors collection].

Figure 3 presents a historical chart of CO_2 emissions in million tons per year. The reduction in values after 2010 is a result of the country's civil war and not a real drop in the percentage of CO_2 emissions [7]. Therefore, we must put in

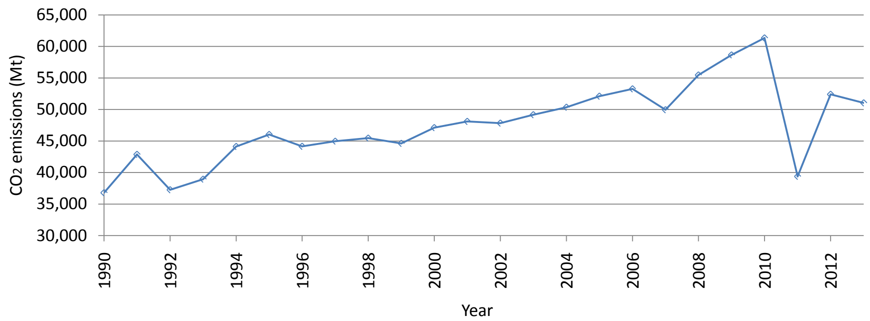

Figure 3. Historical chart of CO_2 emissions in million ton per year for Libya.

place controls to use this energy without harming the already fragile environment. Scientific evidence suggests that the increasing concentration of carbon dioxide, observed since the late 1950s has probably contributed to increasing the average world temperature. As the combustion of fossil fuels is largely responsible for carbon emissions, a widespread demand for policy interventions in the energy sector has arisen. However, a carbon tax seems to be the easiest way to face the problem. Environmental taxes have some advantages over other instruments: First, taxes indicate the cost of a good environment; second, they provide an incentive to introduce new technological processes promoting efficiency and energy conservation; third, they allow producers to choose where pollution abatement has to be implemented, thus contributing to reducing environmental damage at minimum economic cost; finally, taxes provide new revenue that could be used to subsidize environmental technological innovation [8].

3. Economic Effects

Knowledge of the magnitude of emissions released from a specific industrial facility, as is available in environment related researches (as it depicted in **Figure 4** [9]), does not in itself provide information on the subsequent impacts of these pollutants on human health and the environment, nor the associated monetary costs of such damage. An application of modelling frameworks that link knowledge of pollutant emissions with their impacts and consequent damage costs is therefore necessary. There has been significant research undertaken to develop improved scientific modelling frameworks and economic methods for estimating the impacts and damage costs of air pollution. It is clear that calculating values of damage costs on the basis of a single value for each tonne of emission is a gross simplification. In reality, the link between the quantity of emissions and the eventual damage costs is complex. Many factors will affect the damage costs caused by a unit of emissions, including and not only [10]:

- Weather conditions (wind speed and direction, air pressure, whether it is raining, etc.).
- The height and velocity of emissions to air.
- The population eventually affected (number, distribution by age and income, etc.).

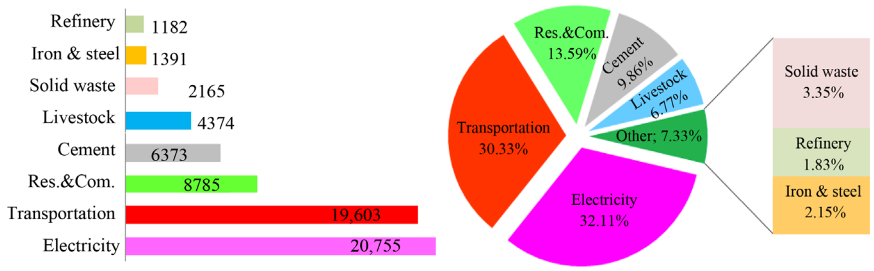

Figure 4. The annual CO_2e (10^3 ton/year) emitted by sectors, and the share of each sector in total CO_2e emissions.

- The existence of other chemicals in the atmosphere.
- The retention of the pollutants in the atmosphere.

The effects of air pollution on human health and the environment have economic impacts. According to the Healthy People report, each year in the United States: The health costs of human exposure to air pollutants range from $40 to $50 billion and the environment costs $6 billion by acid rains damages. These human and ecological impacts are translated into economic values, and the externalities are identified in the ExternE [11]. Zwaan and Rabl in [12], provided a high level economical assessment for impacts during the electricity production in typical power plant in Europe conditions. They estimated the global damage of 29 €/t of CO_2e (exchange rate 1 € = 1.513 LD). In fact, the ExternE can be considered as a fundamental for any socio-eco-environment assessment, especially in the absence of information about the cost of environmental damage as is the case for Libya.

For Libya, there are fewer economic studies concerned the environment damage cost. Even there are no studies inventoried air emissions from petroleum, production and service sectors in the country. However, there is one study evaluated the environmental impact of massive use of mobile electricity generators in Libya in order to compensate the deficit in electricity during the over load periods [13]. Despite the cited study, there remain major gaps in knowledge on overall global damage costs for air pollution, and the evolution of economic damages over time. Some non-health damages have still not been evaluated at the global level, such as the impacts of air pollution on biodiversity and visibility. In this study, the value of damage from CO_2e was adopted (29 €/ton CO_2e which equivalent to 43.88 LD or 32 US$). This value is close to what Patrick Luckow and etc has been suggested in [14], the levelized cost for 2020-2050 in US$ per ton CO_2e are: 26.24$ for low case, 41.4$ for mid case and 59.53$ for high case. One of the most important policy schemes proposed for combating against greenhouse gas emissions is tax policy, which is known as carbon tax. A carbon tax sets a per-unit charge on emissions so that it is an environmental tax that is levied on the carbon content of fuels [15]. Table 3 provides an overview of existing national and sub national jurisdictions that have introduced a direct carbon tax [16].

Table 3. Countries and jurisdictions that have applied carbon tax.

No	Country/Jurisdiction	Year adopted	Tax rate
1	British Columbia	2008	CAD30 per tCO_2e
2	Chile	2014	USD 5 per tCO_2e
3	Costa Rica	1997	3.5% tax on hydrocarbon fossil fuels
4	Denmark	1992	USD31 per tCO_2e
5	Finland	1990	EUR35 per tCO_2e
6	France	2014	EUR7 per tCO_2e
7	Iceland	2010	USD10 per tCO_2e
8	Ireland	2010	EUR 20 per tCO_2e
9	Japan	2012	USD2 per tCO_2e
10	Mexico	2012	Mex$ 10 - 50 per tCO_2e*
11	Norway	1991	USD 4 - 69 per tCO_2e*
12	South Africa	2016	R120 per tCO_2
13	Sweden	1991	USD168 per tCO_2e
14	Switzerland	2008	USD 68 per tCO_2e
15	United Kingdom	2013	USD15.75 per tCO_2e

*Depending on fossil fuel type and usage.

4. CO_2e Emission Factors

4.1. CO_2e Emission Factor in the Extraction, Transmission and Storage Stages

Fugitive emissions from oil and gas operations are a source of direct and indirect greenhouse gas emissions in many countries. Unfortunately, these emissions are difficult to quantify with a high degree of accuracy and there remains substantial uncertainty in the values available for some of the major oil and gas producing countries. This is partly due to the types of sources being considered. For a given segment and subcategory of the oil and gas industry there may be many similarities in emissions between one region or geographic area and another. However, there also may be many differences. In the absence of better data, it may be necessary to assume corresponding values reported for other regions, but ultimately, tests should be performed to verify the validity of these selections. In some countries government agencies, industry associations, and even individual companies are currently undertaking such initiatives, and developing their own factors. In Libya the lack of available and reliable data pushed us to adopt the emission factors warranted in Table 4 [17].

While methane (CH_4) is the predominant type of greenhouse gas emitted as a fugitive emission in the oil and gas sector, noteworthy fugitive emissions of carbon dioxide (CO_2) and, to a much lesser extent, nitrous oxide (N_2O), may also occur. CO_2 is present as a natural constituent of most untreated hydrocarbon streams and occurs in high concentrations in some enhanced oil recovery

Table 4. Refined production based tier-1 emission factors.

Category	emission factor	Unit
Wells	7.600E−02	ton/y per number of producing wells
Gas Production	5.063E−02	ton per (10^3) m^3 gas production
Gas Processing	9.822E−02	ton per (10^3) m^3 gas receipts
Gas Transmission	3.400E+00	ton per km of transmission pipeline
Gas Storage	8.400E−04	ton per (10^3) m^3 gas stored
Natural Gas Liquids Transport	2.900E−01	ton per (10^3) m^3 condensate
Liquefied Petroleum Gas LPG	1.075E+01	ton per (10^3) m^3 NGL
Oil Production	1.702E+03	ton per (10^3) m^3 conventional oil production
Oil Transport	1.765E−02	ton per (10^3) m^3 oil transported by pipeline

schemes (*i.e.*, where CO_2 and fireflood schemes are used). Consequently, it is a constituent of all fugitive emissions, plus noteworthy amounts of raw CO_2 are stripped from the produced gas at sour-gas processing and ethane extraction plants, and are subsequently discharged to the atmosphere through vents or flare systems.

4.2. CO_2e Emission Factor in the Exploitation Stage

Carbon dioxide emissions have been computed using specific emission factors indicating the amount of carbon emitted by each ton of fuel burned in the combustion process. By knowing the CO_2e emission factor associated with any activity or manufacturing process, Table 5 can be created. Table 5 provides the emission factors for every type of fuel based to combustion stadium and other activities for several sectors in Libya. Table 5 shows that the CO_2e emission factors are different for the same types of fuel, depending on the consumer sector. This is due to different fuel utilization techniques and efficiencies. For example, mobile gasoline-electrical generators have a greater emission factor than the gasoline fuelled passenger cars and vice versa for the diesel fuelled cars and the diesel-electrical generators. From this point of view, this table is important.

5. Results and Discussions

5.1. Estimation of CO_2e Emissions

From the primary energy balance for 2010 presented in Table 1 and by using the emission factors from Table 2, we calculate the CO_2e emissions for the fuel production stage, which includes the extraction, transmission, refined and storage processes. The obtained results are tabulated in Table 6. In where emission factors, emissions quantity, domestic demand and exported part are tabulated. The annual emissions based on fuel fired combustion process are tabulated in Table 7.

Introducing a new term that is the Specific Emission Factor (SEF) which

Table 5. Emission factors based on fuel combustion and utility in ton $CO_2e/(10^3\ m^3$ fuel or unit of production).

Utility	Dry Natural Gas	Residual Fuel Oil	Distillate Fuel Oil (Diesel)	Gasoline	Jet Fuel	Liquefied Petroleum Gases	Non oil sources ton CO_2e/ ton product
Electricity	1.93	3175	2766	-	-	-	-
Transportation	-	-	9663	2634	6555	-	-
Residential	-	-	2812	6471	-	1,533	-
Iron & Steel	1.93	3106	-	-	-	-	-
Cement	1.93	3097					-
Solid waste	-	-	-	-	-	-	1.143 (ton/ton waste)
Livestock	-	-	-	-	-	-	64.07 (ton/ton meet)

[Source: Authors collection].

Table 6. Emission factors EF (ton $CO_2e/10^3m^3$ fuel) and amount of emissions based on production of various fuels (ton/year).

Item	Dry Natural Gas	Residual Fuel Oil	Distillate Fuel Oil (Diesel)	Gasoline	Jet Fuel	Liquefied Petroleum Gases
EF (ton $CO_2e/10^3\ m^3$ fuel)	1.5074E−1	5.7868E−2	4.7656E−1	7.7611E−1	1.6E−1	6.808E−2
Emission (ton CO_2e/year)	1.8398E6	1.6456E2	1.2722E3	6.3058E2	1.4857E2	1.2643E2
Share of domestic use (ton/year)	1.013E6	1.5449E2	1.2722E3	6.3058E2	4.1.023E1	1.2643E2
Share of exported part (ton/year)	8.2682E5	1.0075E1	0	0	1.0755E2	0

Table 7. Annual CO_2e emissions in the consumption level.

Utility	Dry Natural Gas	Residual Fuel Oil	Distillate Fuel Oil (Diesel)	Gasoline	Jet Fuel	Liquefied Petroleum Gases	Non oil sources (ton CO_2e/year)
Electricity	1.1605E7	2.5575E6	6.608E6	0	0	0	-
Transportation	0	0	5.6818E6	1.2211E7	1.7174E6	0	-
Residential	0	0	3.4748E5	5.1246E5	0	8.2541E6	-
Solid waste	0	0	0	0	0	0	1.8942E6
Iron & Steel	1.1756E6	2.4263E5	0	0	0	0	-
Cement	6.3221E3	9.0309E5	0	0	0	0	-
Livestock	0	0	0	0	0	0	6.827E4
Other	1.8274E5	4.6326E6	4.6203E6	1.2566E5	0	7.0625E5	-

presents the amount of CO_2e emitted in ton per unit of fuel or per unit of production or per unit of service. The FE is calculating from:

$$SEF_i = \frac{\sum_{j=1}^{n} E_j}{\sum_{j=1}^{n} m_j} \quad (1)$$

where: SEF_i is the specific emission factor of fuel type, production type or service type i (ton of CO_2e/unit of consumption fuel, electricity or production), E_j presents the total emission of one type of fuel j (ton of CO_2e), n is the types of fuel, and m is the fuel consumption, production or service (unit of consumption fuel, electricity or production).

5.2. Estimation of CO_2e Tax

The cost of CO_2e is calculated from the following expression:

$$C_i = SEF_i \times CED \quad (2)$$

where: C_i the cost of the CO_2e emission or Price or Tax (LD/ton of CO_2e), i is the fuel, production or service type, CED is the cost of environmental damage in (LD/ton of CO_2e).

The emission factor for a component i may be different from the emission factor of the same component, this is because the efficiencies of the facilities that utilize the component i are not the same, as it evident from Table 5 in where for the same fuel there are different emission factors.

For example if we want to calculate the specific emission factor for gasoline (SEF_{gasoline}), then i is gasoline, n is equal to 3, which are transportation, residential and other sectors as it indicated in Table 8, accordingly:

$$SEF_{\text{gasoline}} = \frac{1.2211E7 + 5.1246E5 + 1.2566E6}{4.7428E6} = 2.9476\ \text{tonCO}_2\text{e}/\text{m}^3$$

And therefore, the cost will be:

$$C_{\text{gasoline}} = 2.9476\ \text{tonCO}_2\text{e}/\text{m}^3 \times 43.88\ \text{LD}/\text{tonCO}_2\text{e} = 129.34\ \text{LD}/\text{m}^3\text{gasoline}$$

5.3. Economical Evaluation

There are many subsidized goods provided by the Libyan government to people as well as fossil fuel such as gasoline, diesel and also electricity. Therefore, the percentage of increasing in the goods prices is not reflected the real image. According to other countries, for example the USA and UK as (01/25/2016) prices, these percentages of increasing in fuel prices will be as tabulated in Table 9. On January 1, 2009, China initiated a modest reform of its fuel tax, which led to an increase in the gasoline consumption tax from 0.2 Yuan per liter to 1.0 Yuan per liter, and an increase in the kerosene consumption tax from 0.1 Yuan per liter to 0.8 Yuan per liter [18].

Figure 5 is a clustered column chart that presents the percentage of increasing in the goods prices. In fact, this number cannot be considered as an indicator on the intensity of emissions of CO_2, because the reference is not a unique. Indeed, the specific emission factor SEF can be that index if the reference is unified for the same set of products, for example, the fossil fuel, NG, LPG, Biofuel, Biomass, wood, etc.., the purposes of burning all types of fuels indeed is to produce heat,

Table 8. Economical statistical data including SEF and SC.

Production	Specific emission SEF_i	Specific cost SC_i	Present price per unit consumption	Percentage of increasing in prices (%)
Gasoline	2.9476 ton/m^3	129.34 LD/m^3	150 LD/m^3	86.2
Diesel	4.7296 ton/m^3	207.54 LD/m^3	150 LD/m^3	138.4
Air Jet	6.576 ton/m^3	288.56 LD/m^3	1,500 LD/m^3	19.3 (7.7 ticket price)*
LPG	1.533 ton/m^3	67.268 LD/m^3	84 LD/m^3	80.1
Electricity	0.651 ton/MWh	28.566 LD/MWh	20 LD/MWh	142.8
Iron & Steel	1.07 ton/ton	46.952 LD/ton	820 LD/ton	5.7
Cement	0.1213 ton/ton	5.321 LD/ton	180 LD/ton	3.0
Red meat	64.07 ton/ton	2811.4 LD/ton	20,000 LD/ton	14.1
Solid waste	1.143 ton/ton	50.155 LD/ton	-	-

*Aircraft fuel accounts for 40% of ticket prices, and therefore ticket prices will increase by 7.7%.

Table 9. The increasing percentage in gasoline and diesel according to the USA and the UK fuel prices.

Production	CO_2e tax	Present price per unit consumption	Percentage of increasing in prices (%)
Gasoline (USA)	86.7 USD/m^3	0.56 USD/liter	15.5%
Diesel (USA)	151.4 USD/m^3	0.55 USD/liter	27.5%
Gasoline (UK)	86.7 USD/m^3	1.47 USD/liter	5.9%
Diesel (UK)	151.4USD/m^3	1.47 USD/liter	10.3%

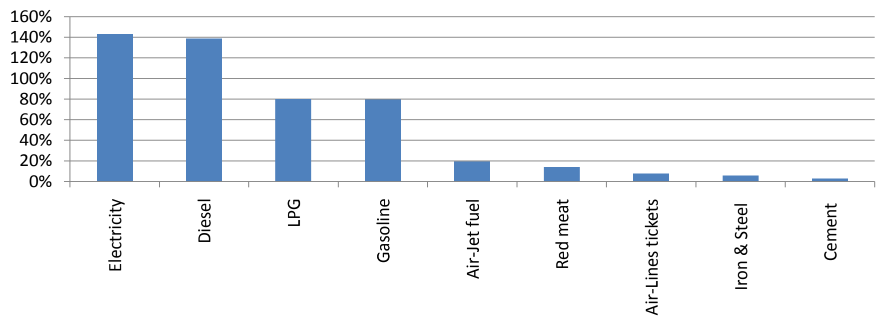

Figure 5. Percentage increasing in fuel and good prices due to implementation of the carbon tax.

hence the reference must be the heating value of burning one unit volume or mass of fuel. This presents one face of the coin, while the other face is representing the efficiencies of the facilities those converted the thermal energy of the fuel to a useful energy such as power plants in case of electrical energy, or vehicles, airplanes, etc... in case of kinetic energy.

From authors opinion, if we able to unify the denominator of the SEF for all production and service sectors, then we can put the basis for the fair environmental and economical comparisons between any sources of energy. And this is not a simple work and need to a large and reliable database, which is not available in the most of developing countries. In this context,, the world bank group adopted and granted many studies conducted the cost of environmental degradation program, which is now under way in eight countries in the Middle East and North Africa, and consists of a country study and a training course.

Economical statistical data is tabulated in **Table 10**, in where the incomes from applying the carbon tax of goods are figured out. The annual revenue is about 4.4 billion LD which represents about 10% of the country GPD for 2010, as it depicted in **Figure 6**. The most weighted companies are: The Libyan oil & gas company, the general electric company of Libya, the general company to produce and import meat, general company for hygiene and environment, the iron & steel complex and the Libyan company for cement manufacturing. Note that all these companies are owned by the Libyan government, as it presented in **Figure 7**.

The revenue column in **Table 10** is indicating also to the cost of the environmental damage due to CO_2e emissions.

It is obviously from **Figure 7** that the consumption of gasoline, diesel, fuel-jet and LPG in transportation and domestic utility is the more damage to the environment than the electricity sector and that was unexpected! We believe that, this situation is special for Libya only, because of the massive use of gasoline and diesel by the citizens for electricity generation to meet the shortage of the power.

6. Conclusion

A method of estimating environmental damage costs of CO_2e emissions from

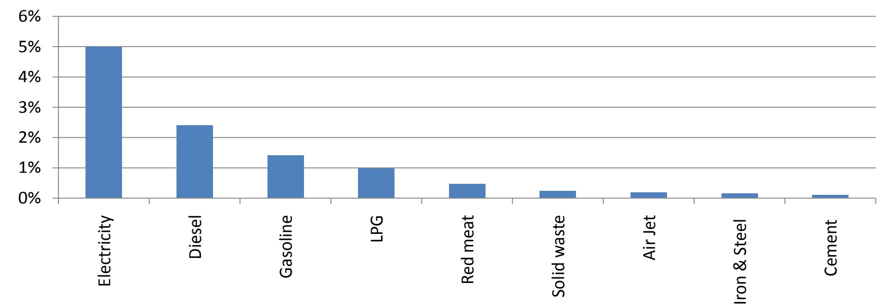

Figure 6. Revenue as a result of carbon tax implementation as a percentage of the GDP.

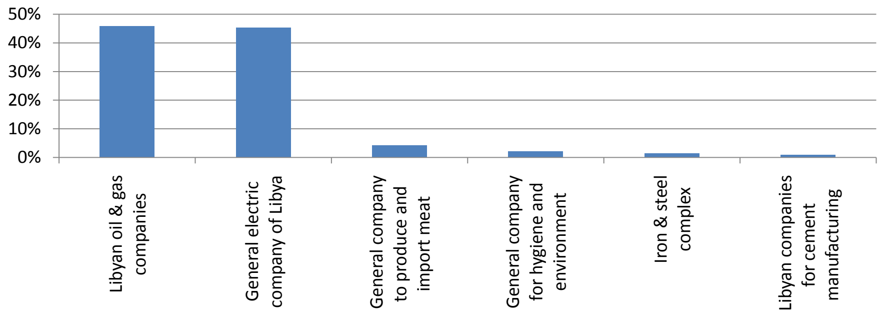

Figure 7. The percentage shares in terms of the governmental companies in the budget support.

Table 10. Revenue from Carbon tax implementation.

Fuel or Good	Cost C_i	Annual consumption or production	Revenue (LD/year)	Percent of the GDP†
Gasoline	129.34 LD/m^3	4.7428E6 m^3/year	613,430,000	1.53%
Diesel	207.54 LD/m^3	4.6428E6 m^3/year	963,566,712	2.41%
Air Jet	288.56 LD/m^3	2.6116E5 m^3/year	75,360,330	0.19%
LPG	67.268 LD/m^3	5.845E6 m^3/year	393,181,460	0.98%
Electricity	28.566 LD/MWh	7.0527E7 MWh/year	2,014,674,282	5.04%
Iron & Steel	46.952 LD/ton	1.324E6 ton/year	62,164,448	0.16%
Cement	5.321 LD/ton	7.5E6 ton/year	39,907,500	0.10%
Red meat	2811.4 LD/ton	6.827E4 ton/year	191,934,278	0.48%
Solid waste	50.155 LD/ton	1.8942E6 ton/year	95,003,601	0.24%
	Total revenue		4,399,616,675	10.13%

†GDP = 39.973 billion LD (2010).

well to wheel by sector and by fuel consumption type was developed. With this approach, an estimation of environmental damage costs of fossil fired was carried in Libya. All types of energies supplied to peoples and some goods and services (electricity, gasoline, diesel and LPG) are evaluated. Furthermore, the environmental damage costs for the none fossil fuel service or production sectors (such as: Iron & steel, cement, red meat and municipality services) are also estimated. The gross environmental damage costs in Libya are 4.4 billion LD which equivalent to 10% of the country GDP. This value should be turn into projects for the environment's good to compensate the damage winning a result of human activities. The followed procedure enables to investigate the effect of each fossil fuel on the environment individually for comparison of mitigation variants. Obviously from the results of the study that the electricity generation (which including both the general grid and that generated locally by house holders) has the heaviest weight on the environment. In this context, the mitigation policy is explicit, a shift to produce of clean energy. Fortunately, Libya has a high potential of solar and wind energies. Thus the solution will be employed the revenue from carbon tax implementation in the production of electrical power from solar and wind energies.

7. Future Plans and Investigations

This work is the first step made in order to achieve the following aims:

1. Estimating the effect of different carbon tax on CO_2e emissions on the economic growth of the country, leading to obtain the optimum tax values for various public and private business;
2. Estimating the air emissions inventory of Oil and Gas extraction, refinery, transmission, storage and exploitation, in order to evaluate the gross environmental damage costs by considering all pollutants emit from the chim-

neys of the power plants; and

3. Putting the renewable energy sources those that have high potential in the country in a fair competition with the fired fossil fuel energy.

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