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Oil, Earth mass and gravitational force

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HIGHLIGHTS

- Large amounts of fossil fuels are extracted annually worldwide.
- Would the extracted amounts represent any significant percentage of the Earth mass?
- What would be the consequence on Earth structure and its gravitational force?
- Modeling the potential loss of Earth mass might be required.
- The efforts for alternative renewable energy sources should be enhanced.

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ABSTRACT

Fossil fuels are intensively extracted from around the world faster than they are renewed. Regardless of direct and indirect effects of such extractions on climate change and biosphere, another issue relating to Earth's internal structure and Earth mass should receive at least some interest. According to the Energy Information Administration (EIA), about 34 billion barrels of oil (~4.7 trillion metric tons) and 9 billion tons of coal have been extracted in 2014 worldwide. Converting the amounts of oil and coal extracted over the last 3 decades and their respective reserves, intended to be extracted in the future, into mass values suggests that about 355 trillion tons, or $\sim 5.86 * 10^{-9}$ (~0.0000000058)% of the Earth mass, would be 'lost'. Although this is a tiny percentage, modeling the potential loss of Earth mass may help figuring out a critical threshold of mass loss that should not be exceeded. Here, I briefly discuss whether such loss would have any potential consequences on the Earth's internal structure and on its gravitational force based on the Newton's law of gravitation that links the attraction force between planets to their respective masses and the distance that separate them.

Million years ago, dense populations of plants, animals and microorganisms have lived, perished and sedimented as organic matter. High temperatures and pressures 'cooked' the accumulating organic matter over a long time and produced fossil fuels in the form of coal, oil, and gases embodied in sedimentary rocks as integral parts of rock structures and Earth mass. The first commercial oil wells have been drilled in 1850s (Taverne, 2008). Since then, fossil fuels have been extensively extracted in tremendous amounts from around the world to fulfill the energy needs of the Industrial Revolution. According to the US Energy Information Administration (EIA) (http://www.eia.gov), the production of oil in 2014 was estimated at about ~93 million barrels/day (Table 1). Considering that one barrel of oil weighs about ~140 kg in average (depending on oil grades and density), the weight of oil pumped out in 2014 would be: 93,000,000 * 140 * 365 = 4,752,300,000,000 kg (~4.75 trillion tons). During the last 34 years (from 1980 to 2014), the total amount of oil produced worldwide is estimated at about ~132 trillion tons (Table 1).

The production of coal, for its part, has significantly increased from 1980 to 2012. In 1980, it was about 4 billion tons, and in 2012 it has almost doubled (~9 billion tons) (Table 2). The total production of coal during the last 32 years (1980–2012) is estimated at about ~186 billion (0.186 trillion) tons (Table 2).

The total mass of oil and coal extracted during the last 34 years (1980–2014) would thus be: 132 trillion ton oil + 0.186 trillion ton coal = 132.186 trillion tons (~132,186,000,000,000 kg).

On the other hand, the reserve of oil is estimated at about 1,655,560,000,000 barrels[1] (~231,779,000,000,000 kg) and the reserve of coal at about 979,791,000,000 kg.[2] The total reserves of both oil and

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[1] https://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=57&aid=6&cid=ww,&syid=2014&eyid=2015&unit=BB. Accessed 20 January 2016.

[2] https://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=1&pid=7&aid=6&cid=ww,&syid=2011&eyid=2011&unit=MST. Accessed 20 January 2016.

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Table 1
Total Oil Production worldwide from 1980 to 2014.[a]

Year	Oil barrel per day	Oil barrel per year (365 days)	Oil weight (kg) per barrel (1 barrel = ~140 kg)
2014	93,201,088	34,018,397,029	4.76258E + 12
2013	91,014,472	32,859,632,846	4,27175E + 12
2012	90,466,487	32,737,529,404	4,25588E + 12
2011	88,532,260	32,059,502,305	4,16774E + 12
2010	88,099,485	31,946,591,792	4,15306E + 12
2009	85,703,404	31,006,494,741	4,03084E + 12
2008	86,514,617	31,287,562,535	4,06738E + 12
2007	85,130,475	30,862,881,629	4,01217E + 12
2006	85,134,828	30,890,356,212	4,01575E + 12
2005	85,099,148	30,896,112,587	4,01649E + 12
2004	83,402,075	30,353,438,358	3,94595E + 12
2003	79,606,389	29,056,332,127	3,77732E + 12
2002	77,100,672	28,141,745,138	3,65843E + 12
2001	77,672,247	28,350,370,199	3,68555E + 12
2000	77,725,453	28,369,790,498	3,68807E + 12
1999	74,838,478	27,316,044,346	3,55109E + 12
1998	75,680,734	27,623,467,855	3,59105E + 12
1997	74,219,760	27,090,212,579	3,52173E + 12
1996	71,986,085	26,274,920,890	3,41574E + 12
1995	70,304,631	25,661,190,425	3,33595E + 12
1994	68,636,649	25,052,376,739	3,25681E + 12
1993	67,101,335	24,491,987,260	3,18396E + 12
1992	66,552,553	24,291,682,002	3,15792E + 12
1991	66,339,100	24,213,771,606	3,14779E + 12
1990	66,435,706	24,249,032,577	3,15237E + 12
1989	65,518,811	23,914,365,960	3,10887E + 12
1988	64,394,518	23,503,998,975	3,05552E + 12
1987	62,099,487	22,666,312,587	2,94662E + 12
1986	61,533,681	22,459,793,718	2,91977E + 12
1985	59,156,363	21,592,072,594	2,80697E + 12
1984	59,563,225	21,740,577,209	2,82628E + 12
1983	57,927,660	21,143,595,915	2,74867E + 12
1982	58,097,931	21,205,744,676	2,75675E + 12
1981	60,602,099	22,119,766,036	2,87557E + 12
1980	63,987,116	23,355,297,504	3,03619E + 12
Total (kg)			1.32317E + 14
Total oil weight in trillion tons			132 trillion tons

[a] Source: Energy Information Administration (USA): http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=5&pid=53&aid=1&cid=ww,&syid=1980&eyid=2015&unit=TBPD Accessed on 20 January 2016.

Table 2
Total coal production worldwide from 1980 to 2012*.

Year	Coal production (tons)
2012	8,687,297,074
2011	8,443,802,731
2010	7,999,454,814
2009	7,601,609,006
2008	7,470,959,169
2007	7,235,882,783
2006	6,965,038,273
2005	6,636,340,567
2004	6,216,305,801
2003	5,813,253,141
2002	5,429,459,293
2001	5,375,192,780
2000	5,137,687,939
1999	4,978,418,246
1998	5,039,867,508
1997	5,069,638,967
1996	5,047,504,716
1995	4,955,331,148
1994	4,872,044,207
1993	4,794,646,914
1992	4,929,168,603
1991	5,018,521,216
1990	5,345,000,328
1989	5,311,262,411
1988	5,234,804,720
1987	5,119,885,558
1986	5,009,016,691
1985	4,891,863,416
1984	4,665,243,152
1983	4,415,548,925
1982	4,379,196,923
1981	4,221,808,991
1980	4,179,632,567
Total (tons)	1.86491E + 11
(Total in trillion tons)	(~0.186 trillion tons)

* Source: Energy Information Administration (USA): http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=1&pid=7&aid=1&cid=ww,&syid=1980&eyid=2012&unit=TST Accessed on 20 January 2016.

coal would thus be: 231,779,000,000,000 kg Oil + 979,791,000,000 kg Coal = 232,758,790,000,000 kg (~233 trillion tons). Subsequently, the total sum of oil and coal extracted during the last 34 years and their respective reserves would be 132 + 233 = 355 trillion tons (or 350,000,000,000,000 kg) (~$3.5 * 10^{14}$ kg).

By reporting this value to the value of the Earth's mass estimated at about $5.97 * 10^{24}$ kg[3] (5,972,190,000,000,000,000,000,000 kg), which includes the mass of the atmosphere estimated at about 5.1480×10^{18} kg (Trenberth and Smith, 2005), we find that the mass of the oil and coal already extracted during the last 34 years and their respective reserves, intended to be extracted in the future, would represent about $5.86 * 10^{-9}$ (~0.0000000058) % of the global Earth mass. In other words, about 0.0000000058% of the Earth mass would be 'lost' in the form of burned oil and coal. Although this percentage may appear tiny, a small percentage of a gigantic number such as the Earth's mass would represent an important overall value. Moreover, the real amounts of the extracted oil and coal should be greater than the estimated here, if we should take into account the amounts of oil and coal that have been extracted before 1980, for which no relevant statistics are available.

As such, the questions that could be raised here are: what would be the potential consequences of fossil fuel extraction and burning on Earth's mass at the long-term? What would be the effects on the Earth's internal structure and on its gravitational force in regard with neighboring planets and stars based on Newton's universal law of gravitation that links the gravitational force proportionally to the mass? According to Newton's law, two planets in the universe attract each other with a gravitational force (F) that is proportional to their corresponding masses but inversely proportional to the square of the distance between them (Fig. 1). The force (F) can be calculated through the equation: $F = gm1 * m2 / r^2$, where '*F*' is the attraction force between two masses (*m1* and *m2*), '*g*' is a gravitational constant and '*r*' is the distance between the two planets or masses (from center-to-center). Subsequently, if the Earth would lose some of its mass in the form of oil and coal burned overtime, the question is: would Earth gravitational force and its rotation be impacted in whatever way with respect to other planets or stars? If so, how, and to which extent such impacts could be avoided or reverberated on Earth?

One, however, may argue that the potential loss of Earth mass in the form of burned fossil fuels would fit in Lavoisier's Law, "*Nothing is lost, … everything is transformed*", but extracting enormous amounts of fossil fuels from Earth would move a large part of Earth mass from one part (Earth interior) to another (Earth surface and atmosphere in the form of gases; mainly CO_2), potentially resulting in the fragilization of the Earth's internal structure relative to its state upon formation about 4.5 billion years ago (Dalrymple, 2001). Additionally, the major part of the extracted fossil fuels is burned, and therefore, one metric ton of extracted fossil fuels will never produce one metric ton of counterpart products to eventually maintain comparable or proportional masses between the extracted and transformed fossil fuels. In other words, the loss of Earth's mass by burning oil and coal would not be compensated by new deposits of oil and coal as quickly as they are depleted nor by similar mass of transformed byproducts obtained by industrial

[3] http://solarsystem.nasa.gov/planets/earth/facts. Accessed 20 January 2016.