

The Life Cycle Assessment Of The Coal, Oil, And LNG

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Abstract. Coal is used as the basic energy source in China, however, the exploitation and utilization of coal has a serious environmental impact. Compared to coal and petroleum, the LNG has less storage space, easy transportation and storage, large calorific value, and higher safety performance. Therefore, we build the life cycle inventory from the exploitation stage to usage stages. We choose four environmental impact categories include GWP, AP, EP, and POCP as the environmental impact assessment indicators. Through the life cycle assessment (LCA) we can analyze the environmental impact of the coal, oil and LNG.

Introduction

Energy is indispensable basis for the social progress, human survival and development. The coal consumption accounted for 68.8% of the total primary energy consumption in China. However, the coal consumption accounted for the proportion of energy consumption is less than 30% [1]. The combustion of fossil fuels, especially the coal, is one of the largest sources of pollutions. Compared to coal and petroleum, the usage of natural gas is more efficient. LNG is natural gas that is cooled to -162°C to coagulate it [2]. LNG has less storage space, easy transportation and storage, large calorific value, and higher safety performance [3].

Although LNG is clean energy, CO₂, NO_x, and CH₄ discharged into the atmosphere will cause harm to the environment and human. Therefore, this article evaluates the environmental impact of the coal, oil and LNG through life cycle assessment from exploitation, treatment, transportation to combustion stage. This article adopts the method of life cycle assessment (LCA) to evaluate three kinds of energy using Gabi software. LCA is an analytical method for the direct and indirect environmental impact in the entire life cycle.

Methodology

In 1990, the environmental toxicology and chemical society defined life cycle assessment (LCA): Life cycle assessment is an objective process to evaluate the environmental pressure of a product, process, and activity. In 1997, the ISO14040 standard divided the life cycle assessment into four parts: the determination of the purpose and scope, inventory analysis, impact assessment and result interpretation.

The functional unit is 1000 t coal, oil and LNG, and transport distance is 1km. The LCA system boundary of coal includes exploitation, transportation and combustion stages, and the exploitation stage includes exploitation, washing and conveyor. The LCA system boundary of oil includes exploitation, transportation and combustion stages, and the exploitation stage includes oil extraction and gas gathering. The LCA system boundary of LNG includes exploitation, gasification, transportation and combustion stages [4], and the exploitation stage includes exploitation, pretreatment and liquidation.

The inventory quantifies and analyzes the energy consumption and pollution emissions of the

product, process and activity in their entire life cycle. The inventory of this article includes imported and exported data, and carries it on to the discussion, verification and analysis. Data mainly comes from the statistical yearbook both at home and abroad, environmental impact statements and enterprise actual operation data and so on. The inventory of the coal, oil and LNG is shown in Table 1[5].

Table 1 The inventory of the coal, oil and LNG

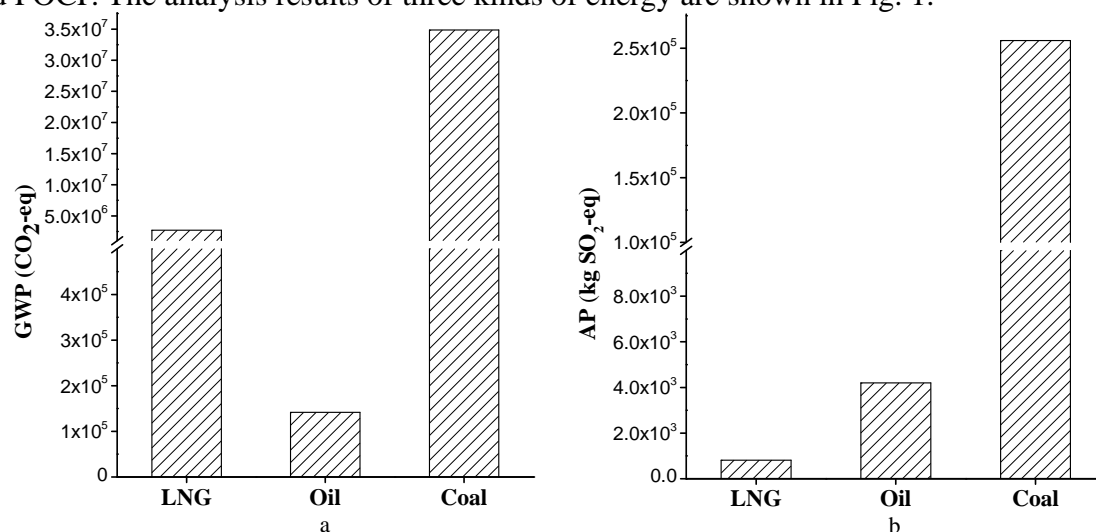
	name	unit	Coal	Oil	LNG
input	electricity	kWh	27740	83440	240634.01
	water	t	1670	2099.8	75395.51
	coal	t	277.4	/	/
	oil	kg	/	3066	/
	natural gas	t	/	/	8.68
	gasoline	kg	/	85050	/
	diesel	kg	2.5	56810	/
output	CO ₂	t	1784.3	60.6	2421.29
	CO	t	2.42	1.25	0.18
	NO _x	t	11.17	1.25	0.6
	CH ₄	t	4.47	/	11.14
	NM VOC	kg	719	/	/
	SO ₂	t	17.51	2.48	0.07

According to the actual situation, this article selects the environmental impact categories as GWP, AP, EP and POCP.

The result explanation is based on the results of the inventory analysis and impact assessment to identify the major issues of the product life cycle and to evaluate the results, including integrity, sensitivity and consistency[6].

Results and discussion

Because the environmental impact potential is different with three kinds of energy, we calculate environmental impact through Gabi 5 software. The environmental impact categories are GWP, AP, EP and POCP. The analysis results of three kinds of energy are shown in Fig. 1.



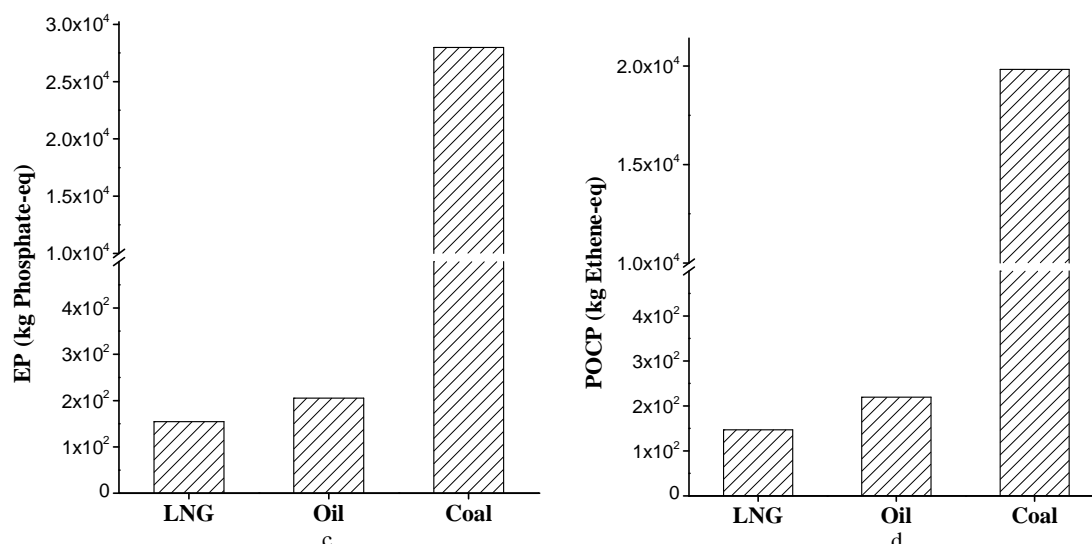


Fig. 1 The environmental impact potential of the coal, oil and LNG

GWP is mainly due to CO₂ emissions; secondly, CH₄ and CO also play a small role. As shown in figure 3.1 (a), the largest contribution of GWP is the coal and LNG, and the smallest contribution is the oil.

AP is mainly due to the emissions of NO_x and SO₂. As LNG is pre-processed, it is a clean energy, the contribution of SO₂ is less than NO_x for AP. As shown in figure 3.1 (b), the AP of LNG is much higher than the coal and oil.

EP is usually caused by excess N and P element content in water, and the impact of N is highest in the LNG life cycle. This article uses NO₃⁻ as a reference to determine equivalent coefficient. As shown in figure 3.1 (c), the largest contribution of GWP is the coal, and the smaller contribution is the oil and LNG.

The contribution of POCP is mainly highest, and ethylene is the reference. As shown in figure 3.1 (d), the largest contribution of GWP is the coal, and the smaller contribution is the oil and LNG.

This article selects the range of error as plus or minus 1%, namely when a certain factor changes 1%, this factor after calculating changes value. The higher the value is, the larger the impact on final results, so that we can determine the factor which is causing the highest environmental impact. Specific results are shown in Table 2.

Table 2 The sensitive value of the coal, oil and LNG

	LNG	Oil	Coal
GWP	Carbon dioxide	Carbon dioxide	Electricity
AP	Electricity	Sulphur dioxide	Electricity
EP	Nitrogen dioxide	Nitrogen dioxide	Electricity
POCP	Electricity	Sulphur dioxide	Electricity

For the LNG, the highest impact factors for GWP and EP is CO₂ and NO_x emissions respectively. However, the highest impact factors for AP and POCP is electricity. For the oil, the highest impact factors for GWP and EP is CO₂ and NO_x emissions respectively. However, the highest impact factors for AP and POCP is electricity. For the coal, the highest impact factors for GWP, AP, EP and POCP is electricity.

Conclusions

This article constructs the coal, oil and LNG life cycle inventory including imported materials, energy and exported pollutants. This article selects GWP, AP, EP and POCP as indicators of environmental impact assessment. This article concludes with the specific results as follows:

(1) The largest environmental impact of the coal, oil and LNG for the GWP, AP, EP and POCP is the coal. With the exception of GWP, the smallest environmental impact for other categories is LNG. Therefore, we can make LNG substitute the coal so that it can reduce the environmental impact.

(2) Through the sensitivity analysis, we can know the largest contribution on the coal is the electricity. For the oil and LNG, except for the impact of the electricity, we can know that CO₂, NO_x, and SO₂ make a certain impact.

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