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# Coal-based synthetic natural gas (SNG): A solution to China's energy security and $CO_2$ reduction?

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## HIGHLIGHTS

- We evaluated life-cycle energy efficiency and $CO_2$ emissions of coal-derived SNG.
- We used GREET model and added a coal-based SNG and an end-use modules.
- The database was constructed with Chinese domestic data.
- Life-cycle energies and $CO_2$ emissions of coal-based SNG are 20–100% higher.
- Coal-based SNG is not a solution to both energy conservation and $CO_2$ reduction.

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## ABSTRACT

Considering natural gas (NG) to be the most promising low-carbon option for the energy industry, large state owned companies in China have established numerous coal-based synthetic natural gas (SNG) projects. The objective of this paper is to use a system approach to evaluate coal-derived SNG in terms of life-cycle energy efficiency and $CO_2$ emissions. This project examined main applications of the SNG and developed a model that can be used for evaluating energy efficiency and $CO_2$ emissions of various fuel pathway systems. The model development started with the GREET model, and added the SNG module and an end-use equipment module. The database was constructed with Chinese data. The analyses show when the SNG are used for cooking, power generation, steam production for heating and industry, life-cycle energies are 20–108% higher than all competitive pathways, with a similar rate of increase in life-cycle $CO_2$ emissions. When a compressed natural gas (CNG) car uses the SNG, life-cycle $CO_2$ emission will increase by 150–190% compared to the baseline gasoline car and by 140–210% compared to an electric car powered by electricity from coal-fired power plants. The life-cycle $CO_2$ emission of SNG-powered city bus will be 220–270% higher than that of traditional diesel city bus. The gap between SNG-powered buses and new hybrid diesel buses will be even larger—life-cycle $CO_2$ emission of the former being around 4 times of that of the latter. It is concluded that the SNG will not accomplish the tasks of both energy conservation and $CO_2$ reduction.



## 1. Introduction

China's economy has experienced fast growth for the past three decades. GDP in China grew from 364.5 billion Yuan in 1978 to 47.2 trillion Yuan in 2011. During the same period, China became the largest energy consumption nation in the world. The total energy consumption increased from 16.7 EJ in 1978 to 95.1 EJ in 2010 (National Bureau of Statistics of China (NBS), 2011). Imported energy accounted for 17% of China's total energy consumption in 2010 (National Energy Administration (NEA), 2011). Imported energy, especially petroleum products (65% of its consumption dependent on import), has posed a serious energy security challenge to China. Another big challenge faced by China is $CO_2$ reduction. China is the largest $CO_2$ emitter in the world and contributed 23.6% of world total $CO_2$ emissions from fuel combustion in 2009 (International Energy Agency (IEA), 2011). The Chinese government made a promise at the Climate Change Summit of United Nations in 2009 that China would reduce carbon intensity per GDP in 2020 by 40–45% of 2005 levels. There is an urgent need for China to find solutions to both energy security and $CO_2$ reduction.

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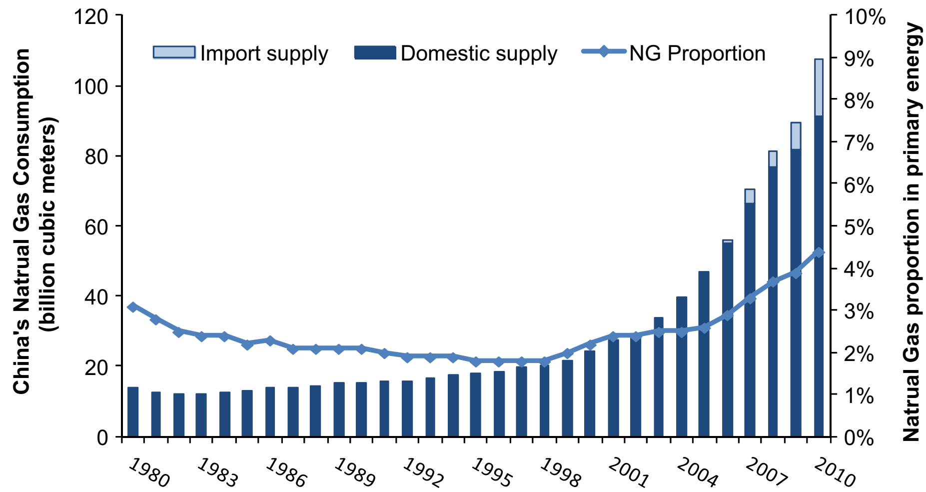


**Fig. 1.** China's NG consumption and its percentage of primary energy (1980–2010).

NG is currently regarded as the cost effective solution for global warming and energy security. Although NG has been a historically low portion of primary energy consumption in China, its consumption increased significantly in the past ten years, reaching more than 100 billion cubic meters in 2010. However, it was still less than 5% of total primary energy consumption, as shown in Fig. 1. China's 12th five-year-plan (2011–2015) projects NG consumption at 250 billion cubic meters in 2015, accounting for 7.5% of total primary energy consumption. On the supply side, the planned conventional NG output will be 140 billion cubic meters in 2015 (Hu, 2012), while shale gas production is projected to be 6.5 billion cubic meters (National Energy Administration (NEA), 2012). This discrepancy between the projected demand and supply of NG has become a driving force for the recent big wave of SNG projects in China.

SNG can be produced from different feedstocks. For example, due to the carbon-neutral nature of biomass, there are some biomass-based SNG demonstration projects that have been carried out by European institutes, such as Energy Research Center (ECN) in Netherlands, Center for Solar Energy and Hydrogen Research (ZSW) in Germany, and Paul-Scherrer Institute (PSI) in Switzerland and Austria. A commercial project of SNG from forest residues is proposed to construct and commission a 20 MW plant in 2012 and an 80 MW plant by 2016 in Sweden (Kopyscinski et al., 2010).

It seems that co-mingling biomass with coal for gasification is a relative promising option to reduce GHG emissions from coal-based SNG. Although there is no commercial scale operation in the world now, some interesting demonstrations in co-mingling biomass with coal for gasification have been done in US (Raju et al., 2009; Kreutz et al., 2008). High cost of feedstock collection and transportation are two major obstacles for commercial scale biofuel and bio-power production in China, because biomass resources are very scattered in the rural area. There is no plan for commercial plant of biomass-based SNG in China. Instead, some Chinese researchers believe that coal-derived SNG using China's abundant coal reserves will improve energy security, and SNG is a clean-coal technology that will help reduce $CO_2$ (Liu et al., 2009a; Liu and Xing, 2010).

There are more than 30 coal-based SNG plants (see Table 1) are under construction or planned in China. In Xinjiang Province (in Northwest China) alone, there are plans for twenty coal-based SNG plants, which will have a capacity of 77 billion cubic meters per year. SINOPEC plans to invest 140 billion Yuan (about USD 22 billion) to build 6000 km long pipeline with an annual capacity of transporting 30 billion cubic meters of SNG from Xinjiang to large NG consumers in Southeast China.

**Table 1**
Ongoing and planned coal-based SNG projects in China.

| Investor | Project location | Capacity (billion cubic meters/ year) |
|---|---|---|
| DT International Power | Fuxin, Liaoning Province | 4.0 |
| DT International Power | Hexigten Banner, Inner Mongolia | 4.0 |
| China Huaneng Group | Hulunbeier, Inner Mongolia | 4.0 |
| DT Huayin Power | Erdos, Inner Mongolia | 3.6 |
| Shenhua Group | Erdos, Inner Mongolia | 2.0 |
| Huineng Coal Power | Erdos, Inner Mongolia | 1.6 |
| Guodian Corporation | Nilka, Xinjiang Province | 10.0 |
| Guanghui New Energy Co. | Yiwu, Xinjiang Province | 8.0 |
| China Power Investment Co. | Qapqal, Ili, Xinjiang Province | 6.0 |
| China Power Investment Co. | Huocheng, Ili, Xinjiang Province | 6.0 |
| Huadian Group | Changji, Xinjiang Province | 6.0 |
| Qinghua Group | Yining, Ili, Xinjiang Province | 5.5 |
| Beikong New Energy | Qitai, Xinjiang Province | 4.0 |
| Henan Coal Chemical Group | Qitai, Xinjiang Province | 4.0 |
| LuAn Group | Ili, Xinjiang Province | 4.0 |
| China Huaneng Group | Changji, Xinjiang Province | 4.0 |
| Xinjiang Longyu Co. | Changji, Xinjiang Province | 4.0 |
| China National Coal Group | Changji, Xinjiang Province | 4.0 |
| Kailuan Group | Changji, Xinjiang Province | 4.0 |
| TBEA Group | Changji, Xinjiang Province | 4.0 |
| Yanzhou Mining Group | Changji, Xinjiang Province | 4.0 |
| Guanghui New Energy Co. | Altay, Xinjiang Province | 4.0 |
| Xuzhou Mining group | Tacheng, Xinjiang Province | 4.0 |
| Huahong Mining Co. | Changji, Xinjiang Province | 2.0 |
| Xinwen Mining Co. | Ili, Xinjiang Province | 2.0 |
| Shengxin Group | Changji, Xinjiang Province | 1.6 |
| Tianlong Group | Jimusaer, Xinjiang Province | 1.3 |
| UNIS Group | Hami, Xinjiang Province | 0.8 |
| Hongsheng New Energy | Zhangye, Gansu Province | 4.0 |
| National Ocean Oil Company | Datong, Shanxi Province | 4.0 |
| Total | | 120.4 |