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# Oil-saving pathways until 2030 for road freight transportation in China based on a cost-optimization model

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ABSTRACT

This paper proposed a COSM (cost-optimization superstructure model) and derived the optimized oil-saving pathways for road freight transportation in China until 2030. The optimization target of the COSM was to minimize the accumulated energy and vehicle costs from 2010 to 2030 by choosing the most cost-effective fuel option for newly registered trucks each year. Based on the COSM, three scenarios were developed to evaluate the oil-saving pathway in terms of imported crude oil price, available alternative fuels and GHG emission reduction. The scenario analysis results indicate that: (1) for scenario A, the accumulated oil-saving potential was approximately about 13%, while the oil-saving potential of improving fuel consumption rate and load running rate was 17% and 16%; (2) for scenario B, the accumulated oil-saving potential increased to 82% in reference oil price and 23% in low oil price; (3) for scenario C, to reduce per ton of GHG emission, the increased cost will increase from 34 USD to 450 USD when the GHG emission target decreased from 15.4 billion tons to the turn point of 13.5 billion tons.


## 1. Introduction

As the transport sector was responsible for about one third and 62% of the global energy and oil consumption respectively, energy saving in transport sectors has great importance. With the largest population and the fastest growing economy, energy demand of China's transport sector increased from 25 Mtoe (million tonnes of oil equivalent) in 1980 to 205 Mtoe in 2010, at an average annual growth rate of 11%, which make China's transport the fastest growing energy-consuming sector. Meanwhile, the oil production capacity of China has been constrained to 200 Mtoe and the rest of demand are imported from the abroad, the problem of decreasing the dependence on petroleum-based of China's transport has attracted the attention of the whole world.

Among various end-use sectors of oil products, road transportation has the largest potential oil saving as the major consumer of oil products, especially diesel and gasoline. Referring to Fig. 1, which is a Sankey diagram of China's oil flows in 2010 generated using a previously described method [1], transportation accounted for approximately 59% of the total consumption of oil products, and road transportation accounted for 75% of the total consumption of oil products within the transportation sector. In the road transportation sector, diesel consumption by HDV (heavy duty vehicles, mainly trucks) was 10 Mt more than the gasoline consumption by LDV (light duty vehicles, mainly passenger vehicles). Therefore, modelling and forecasting of oil-saving potential in road transport especially road freight transport attracted a great deal of interest for the domestic and foreign scholars. Several important studies of road transportation in different countries are listed in Table 1.

Since China is in the process of rapid development process which is very different from the developed country, we further reviewed on the previous study of oil-saving from road transport at the Chinese level. In addition to improving the fuel consumption of conventional oil-based internal combustion truck and improving

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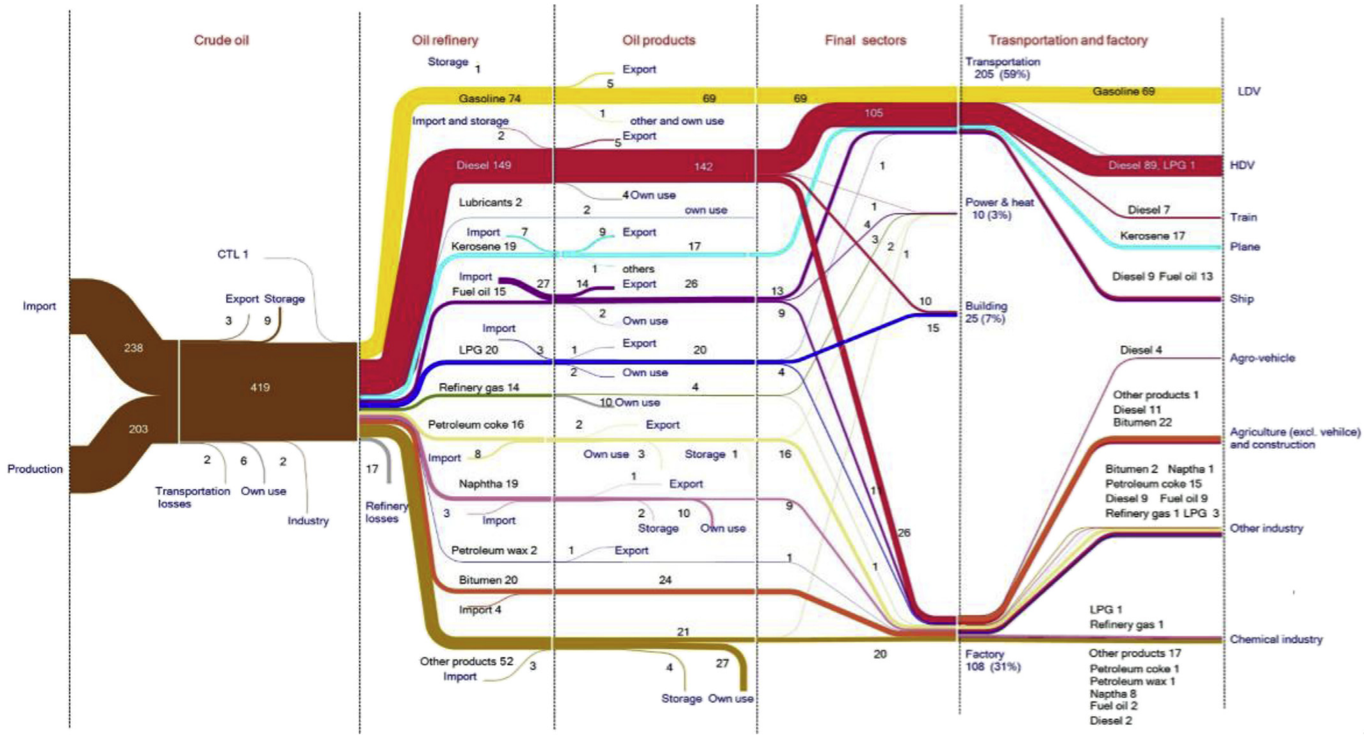


**Fig. 1.** China's oil flows in 2010 [2,3] (Unit: Mt; GTL: coal to liquid).

the load running rate of trucks [4,11–13], deploying alternative fuels and engine technologies was also an effective strategy, such as liquid natural gas [12,14], compressed natural gas [15–19], bio-diesel [11,20], bio-ethanol [21], and gasoline with a hybrid engine. With so many options for alternative fuels and engine technologies, a deep analysis was needed to determine an optimized oil-saving pathway for the future. In previous studies, researchers projected the oil-saving potential of road freight transportation based on empirical assumptions that a certain scale of alternative fuel and engine technologies penetrated in a certain time. For instance, in the study of Hao et al., it was assumed that the shares of LNG-fueled trucks would linearly increase to 20% in 2030 [12]. In the study of Zhang et al., it was assumed that bio-diesel will account for 5%, 10%, and 20% of vehicle diesel in 2010, 2020, and 2030, respectively [22]. In the study of Yan et al., it was assumed that the demand of bio-ethanol and bio-diesel will increase to 12.9 and 3.63 Mtoe in 2030 respectively [20]. In the study of Ou et al., it designed the oil-saving potential of bio-ethanol and bio-diesel will be 37 Mt and 20 Mt in 2050 respectively in the baseline scenario whereas the oil-saving potential of bio-ethanol and bio-diesel will be 82 Mt for

**Table 1**
Literature review of road transportation study in domestic and abroad.

| Reference | Methodology | Planning horizon | Scenario considered | Country | Model |
|---|---|---|---|---|---|
| Baptista P [4] | Set the maximum market share of alternative vehicle technologies in new vehicle sales | 2050 | Liquid fuels scenario, diversified scenario, electricity scenario, and hydrogen scenario. | Portuguese | Excel-based model |
| MIT [5] | Set the market penetration rates of alternative vehicle | 2035 | The market mix scenario, the turbocharged ICE Future scenario, the hybrid strong scenario. | U.S. | Excel-based model |
| Huo H et al. [6] | Set the parameters in 2015, 2020 and 2030 for different scenarios | 2030 | Fuel-consumption improvement scenario, dieselization scenario, fuel diversification scenario, electrification scenario, aggressive policy scenario. | China | Excel-based model |
| Liu J et al. [7] | Set energy consumption share | 2020 | 2009 mix scenario, 2020 predicted mix scenario, 2020 slightly cleaner mix scenario, and all nuclear scenario. | China | GREET model |
| Dodds P and McDowall W [8] | Set the degree of car market segmentation, the imposition of market share constraints and the use of lumpy investments to represent infrastructure | 2060 | Different scenarios for vehicle technologies and fuel supply infrastructure. | UK | MARKAL model |
| Bahn O et al. [9] | Set constraints on the proportion of transportation demand that needs to be satisfied via EVs | 2050 | Baseline scenario, energy policy scenario and climate policy scenario. | Canada | TIMES-Canada |
| Liimatainen et al. [10] | Used the Delphi method to explore the future scenario | 2030 | Technology industry scenario, Mining and bio-industry scenario, Efficient road transport scenario, Eco society scenario | Finnish | Delphi |