Applied Energy Symposium 2020: Low carbon cities and urban energy systems
October 10-17, 2020
Paper ID: CUE 2020-D-044

Liquid Biofuel Participates in the Refined Product Market Competition: Integrated Supply Chain Optimization

Rui Qiu[1], Donghui Zhao[1], Qi Liao[1*], Xiao Yu[1], Xintong Wei[1], Haoran Zhang[2], Yongtu Liang[1**]

1 National Engineering Laboratory for Pipeline Safety/Beijing Key Laboratory of Urban oil and Gas Distribution Technology, China University of Petroleum-Beijing, Fuxue Road No.18, Changping District, Beijing 102249, PR China

2 Center for Spatial Information Science, The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba 277-8568, Japan

ABSTRACT

Replacing traditional fossil energy with renewable biofuel is considered to be an effective way to achieve the emission reduction target. The optimal design and operation of the supply chain is the key step in the large-scale development of biofuel. To fully utilize the extensive oil and gas supply chain infrastructure in China, this paper intends to incorporate liquid biofuel into the existing refined product supply network and explore the benefits of this integrated supply chain. Firstly, a mixed-integer linear programming model for a single-cycle integrated supply chain is developed to obtain the optimal supply scheme, transportation scheme and demand scheme of both liquid biofuel and refined product. The objective is set to minimize the total cost, including depreciated investment cost of bio-refinery, liquid fuel transportation cost, backlog cost on supply side and stock-out cost on demand side. The geographical distribution of biofuel yield, refinery production capacity, oil depot inventory levels and transportation volume requirements are rigorously taken into account. Finally, the existing refined product supply train in China is taken as a case study and two scenarios (with and without biofuel participation) are carried out for comparison from the perspective of economy and environment. The results demonstrate the economic and environmental benefit of the proposed integrated liquid biofuel-refined product supply chain, which can provide significant guidelines for the decision makers.

Keywords: liquid biofuel; refined product; integrated supply chain; economy and environment; mixed-integer linear programming

NOMENCLATURE

Abbreviations	
MILP	mixed-integer linear programming
Sets	
$i \in I$	Supply side
$j \in J$	Demand side
$k \in K$	Liquid fuel
$K_P, K_B, K_{G\&D} \subset K$	Refined product, Liquid biofuel, Gasoline and diesel
$r \in R$	Bio-refinery scale
$z \in Z$	Transportation mode
Symbols	
c	Cost-related parameters
v	Volume-related parameters
V	Volume-related variables
B	Binary variables

1. INTRODUCTION

In 2018, fossil fuel accounts for 84.7% of the total energy consumption in the world [1]. Large consumption of fossil fuels leads to increased carbon emission [2-3]. In compliance with the initiative of the Paris Agreement [4], China has made the commitment to peak carbon emission and increase the share of non-fossil fuels in primary energy by 20% around 2030 [5-6].

Replacing traditional fossil energy with renewable energy is considered to be an effective way to achieve this target, and biofuel is one of the representative [7-9]. Biofuel refers to solid, liquid or gaseous fuel extracted from biomass, which can replace traditional gasoline and diesel.

The optimal design and operation of the supply chain is a key step in the large-scale development of biofuel. So far, most researches have focused on the design and operation of an independent biofuel supply chain, ignoring the advantages of existing supply chain facilities [10-12]. Several of them have demonstrated that the juxtaposition of biofuel refining with existing industries such as pulp mills and oil refineries can create synergies effect [13-14]. In China, there is an extensive oil and gas supply chain infrastructure that can be used to transport refined oil and natural gas [15-16]. Currently, the benefit of the supply chain is hindered due to the imbalance of geographical location and economic development. This paper intends to incorporate liquid biofuel into the existing refined product supply network and explore the benefits of this integrated supply chain.

Overall, the contributions of this paper are as follows:

(1) To realize the participation of liquid biofuel into the existing refined product supply network, a mathematical model is developed to optimize the renewal and operation of the integrated supply chain.

(2) Two scenarios (without/with liquid biofuel participation) are compared from the perspective of economy and environment.

(3) A large-scale refined product supply chain is taken as the case study to verify the effectiveness of the proposed method, which can provide support for Chinese decision makers.

2. METHODOLOGY

The flowchart of the proposed methodology to evaluate the benefits of liquid biofuel participation in the refined product market competition is given in Fig.1. Firstly, a mixed-integer linear programming (MILP) model with the least cost as the objective is established to determine the supply scheme, the demand scheme, the transportation scheme for the entire supply chain, as well as the investment scheme of the bio-refinery. Next, two scenarios with or without liquid biofuel participation are simulated by the established model. Finally, the economic and environmental benefits of the above two scenarios are compared in detail.

In the existing supply chain, the refined product is divided into general gasoline and general diesel, denoted by Set K_P. The newly participated liquid biofuel is divided into bio-gasoline and bio-diesel, denoted by Set K_B. Both general gasoline and bio-gasoline can meet the sales standards, and both general diesel and bio-diesel can meet the same sales standards. Gasoline and diesel are denoted by Set $K_{G\&D}$.

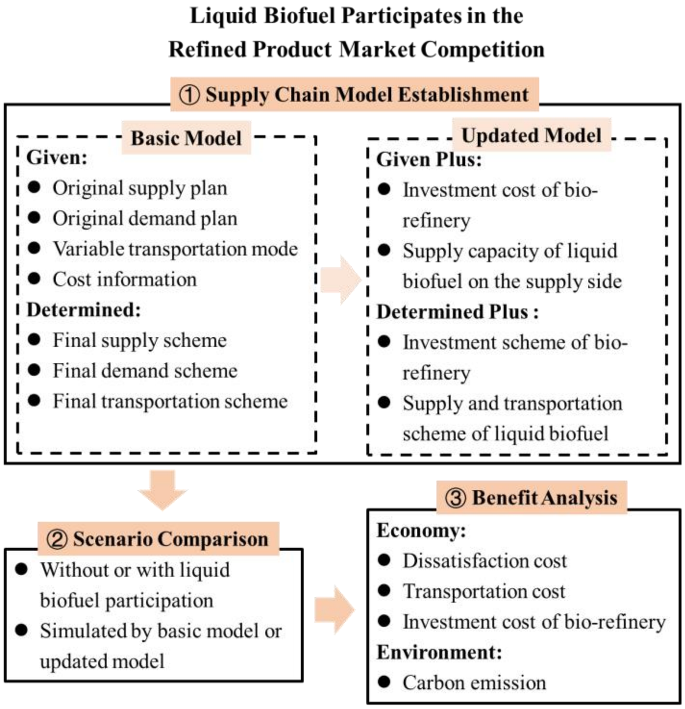

Fig 1 The flowchart of the proposed methodology

3. MATHEMATICAL MODEL

3.1 Objective function

For the integrated supply chain, only the following three parts of the cost are considered in the model: (1) Dissatisfaction cost f_1, (2) Transportation cost f_2, (3) Investment cost of bio-refinery f_3.

Generally, it is not accepted that the final supply of refined product is less than the planned supply of that or the final demand of gasoline and diesel is less than the planned demand of that. Thus, dissatisfaction cost is introduced, which includes backlog cost in the supply side and stock-out cost in the demand side. The calculation is given in Eq.(1).

$$\min f_1 = \sum_{i\in I}\sum_{k\in K_P} c^{refi}_{uni\ i,k} V^{refi}_{bac\ i,k} + \sum_{j\in J}\sum_{k\in K_{G\&D}} c^{depo}_{uni\ j,k} V^{depo}_{out\ j,k} \qquad (1)$$

Where $c^{\mathrm{refi}}_{\mathrm{uni}\ \mathrm{i,k}}$ is the unit backlog cost of liquid fuel k in supply side i, CNY; $c^{\mathrm{depo}}_{\mathrm{uni}\ \mathrm{j,k}}$ is the unit stock-out cost of liquid fuel k in demand side j, CNY; $V^{\mathrm{refi}}_{\mathrm{bac}\ \mathrm{i,k}}$ is the backlog volume of liquid fuel k in supply side i, t; $V^{\mathrm{depo}}_{\mathrm{out}\ \mathrm{j,k}}$ is the stock-out volume of liquid fuel k in demand side j, t.

Transportation cost is divided into the fixed cost and the transportation volume-related cost. It is determined by the distance, volume of different liquid fuel and transportation mode, as shown in Eq.(2).

$$\min \mathrm{f}_2 = \sum_{\mathrm{i}\in \mathrm{I}}\sum_{\mathrm{j}\in \mathrm{J}}\sum_{\mathrm{k}\in \mathrm{K}}\sum_{\mathrm{z}\in \mathrm{Z}}(\mathrm{c}^{\mathrm{tran}}_{\mathrm{fix}\ \mathrm{i,j,k,z}}\mathrm{B}^{\mathrm{tran}}_{\mathrm{i,j,k,z}} + \mathrm{c}^{\mathrm{tran}}_{\mathrm{uni}\ \mathrm{i,j,k,z}}\mathrm{l}^{\mathrm{tran}}_{\mathrm{i,j.z}}\mathrm{V}^{\mathrm{tran}}_{\mathrm{i,j,k,z}}) \quad (2)$$

Where $c^{\mathrm{tran}}_{\mathrm{fix}\ \mathrm{i,j,k,z}}$ or $c^{\mathrm{tran}}_{\mathrm{uni}\ \mathrm{i,j,k,z}}$ is the fixed or unit transportation cost of liquid fuel k from supply side i to demand side j by transportation mode z, CNY or CNY/t. $\mathrm{l}^{\mathrm{tran}}_{\mathrm{i,j.z}}$ is the distance from supply side i to demand side j by transportation mode z. $\mathrm{B}^{\mathrm{tran}}_{\mathrm{i,j,k,z}}$ is a binary variable which indicates whether liquid fuel k is transported from supply side i to demand side j by transportation mode z. $\mathrm{V}^{\mathrm{tran}}_{\mathrm{i,j,k,z}}$ is the corresponding transportation volume, t.

Due to the participation of liquid biofuel, the additional investment cost of bio-refinery needs to be considered. In this paper, it is assumed that the depreciated investment cost of bio-refinery is only related to its production scale, construction location and its lifetime, as shown in Eq.(3) and (4).

$$\min \mathrm{f}_3 = \sum_{\mathrm{i}\in \mathrm{I}}\sum_{\mathrm{r}\in \mathrm{R}}\alpha \mathrm{c}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}}\mathrm{B}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}} \quad (3)$$

$$\alpha = \frac{n(n+1)^T}{(n+1)^T-1} \quad (4)$$

Where $\mathrm{c}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}}$ is the investment cost of bio-refinery with scale r near supply side i. $\mathrm{B}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}}$ is a binary variable which indicates whether bio-refinery with scale r is invested near supply side i. α is the investment recovery rate. n is the discount rate and T is the lifetime of bio-refinery.

3.2 Constraints

If the bio-refinery with a typical scale is invested near the supply side, the total supply of the liquid biofuel must be above its minimum supply volume and below its maximum supply volume, as shown in Eq.(5). Only one scale can be selected, as shown in Eq.(6).

$$\sum_{r\in R}\mathrm{B}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}}\mathrm{v}^{\mathrm{bio}}_{\mathrm{min}\ \mathrm{r}} \le \sum_{k\in K_B}\mathrm{V}^{\mathrm{refi}}_{\mathrm{sup}\ \mathrm{i,k}} \le \sum_{r\in R}\mathrm{B}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}}\mathrm{v}^{\mathrm{bio}}_{\mathrm{max}\ \mathrm{r}}, \forall \mathrm{i}\in \mathrm{I} \quad (5)$$

$$\sum_{\mathrm{r}\in \mathrm{R}}\mathrm{B}^{\mathrm{ref}}_{\mathrm{bio}\ \mathrm{i,r}} \le 1, \forall \mathrm{i}\in \mathrm{I} \quad (6)$$

Where $\mathrm{v}^{\mathrm{bio}}_{\mathrm{min}\ \mathrm{r}}$ or $\mathrm{v}^{\mathrm{bio}}_{\mathrm{max}\ \mathrm{r}}$ is the minimum or maximum supply volume of biofuel in bio-refinery with scale r, t.

For each supply side, the planned supply of the refined product is equal to the final supply volume plus the backlog volume, as shown in Eq.(7).

$$\sum_{\mathrm{j}\in \mathrm{J}}\sum_{\mathrm{z}\in \mathrm{Z}}\mathrm{V}^{\mathrm{tran}}_{\mathrm{i,j,k,z}} + \mathrm{V}^{\mathrm{refi}}_{\mathrm{bac}\ \mathrm{i,k}} = \mathrm{V}^{\mathrm{refi}}_{\mathrm{sup}\ \mathrm{i,k}}, \forall \mathrm{i}\in \mathrm{I}, \mathrm{k}\in \mathrm{K}_\mathrm{P} \quad (7)$$

Where $\mathrm{V}^{\mathrm{refi}}_{\mathrm{sup}\ \mathrm{i,k}}$ is the planned supply volume of liquid fuel k in supply side i, t.

For each demand side, the planned demand of the gasoline and diesel is equal to the final demand volume plus the stock-out volume, as shown in Eq.(8).

$$\sum_{\mathrm{i}\in \mathrm{I}}\sum_{\mathrm{z}\in \mathrm{Z}}\mathrm{V}^{\mathrm{tran}}_{\mathrm{i,j,k,z}} + \mathrm{V}^{\mathrm{depo}}_{\mathrm{out}\ \mathrm{j,k}} = \mathrm{V}^{\mathrm{depo}}_{\mathrm{dem}\ \mathrm{j,k}}, \forall \mathrm{j}\in \mathrm{J}, \mathrm{k}\in \mathrm{K}_{\mathrm{G\&D}} \quad (8)$$

Where $\mathrm{V}^{\mathrm{depo}}_{\mathrm{dem}\ \mathrm{j,k}}$ is the planned demand volume of liquid fuel k in demand side j, t.

For each supply side, the planned supply of the refined product must be above its minimum volume and below its maximum volume, as shown in Eq.(9). It is noted that if the planned supply volume is fixed, the minimum volume is equal to the maximum volume.

$$\mathrm{v}^{\mathrm{refi}}_{\mathrm{min}\ \mathrm{i,k}} \le \mathrm{V}^{\mathrm{refi}}_{\mathrm{sup}\ \mathrm{i,k}} \le \mathrm{v}^{\mathrm{refi}}_{\mathrm{max}\ \mathrm{i,k}}, \forall \mathrm{i}\in \mathrm{I}, \mathrm{k}\in \mathrm{K}_\mathrm{P} \quad (9)$$

Where $\mathrm{v}^{\mathrm{refi}}_{\mathrm{min}\ \mathrm{i,k}}$ or $\mathrm{v}^{\mathrm{refi}}_{\mathrm{max}\ \mathrm{i,k}}$ is the minimum or maximum supply volume of liquid fuel k in supply side i, t.

For each demand side, the planned demand of the gasoline and diesel must be above its minimum volume and below its maximum volume, as shown in Eq.(10). It is noted that if the planned demand volume is fixed, the minimum volume is equal to the maximum volume.

$$\mathrm{v}^{\mathrm{depo}}_{\mathrm{min}\ \mathrm{j,k}} \le \mathrm{V}^{\mathrm{depo}}_{\mathrm{dem}\ \mathrm{j,k}} \le \mathrm{v}^{\mathrm{depo}}_{\mathrm{max}\ \mathrm{j,k}}, \forall \mathrm{j}\in \mathrm{J}, \mathrm{k}\in \mathrm{K}_{\mathrm{G\&D}} \quad (10)$$

Where $\mathrm{v}^{\mathrm{depo}}_{\mathrm{min}\ \mathrm{j,k}}$ or $\mathrm{v}^{\mathrm{depo}}_{\mathrm{max}\ \mathrm{j,k}}$ is the minimum or maximum demand volume of liquid fuel k in demand side j, t.

For each demand side, the minimum or maximum demand volume of gasoline and diesel is determined by the minimum or maximum storage volume, the forecast sales volume, as well as the current storage volume, as shown in Eq.(11) and (12).

$$\mathrm{v}^{\mathrm{depo}}_{\mathrm{min}\ \mathrm{j,k}} = \mathrm{v}^{\mathrm{stor}}_{\mathrm{min}\ \mathrm{j,k}} + \mathrm{v}^{\mathrm{depo}}_{\mathrm{sale}\ \mathrm{j,k}} - \mathrm{v}^{\mathrm{depo}}_{\mathrm{stor}\ \mathrm{j,k}}, \forall \mathrm{j}\in \mathrm{J}, \mathrm{k}\in \mathrm{K}_{\mathrm{G\&D}} \quad (11)$$

$$v^{depo}_{max\ j,k} = v^{stor}_{max\ j,k} + v^{depo}_{sale\ j,k} - v^{depo}_{stor\ j,k}, \forall j \in J, k \in K_{G\&D} \quad (12)$$

Where $v^{stor}_{min\ j,k}$ or $v^{stor}_{max\ j,k}$ is minimum or maximum storage volume of liquid fuel k in demand side j, t. $v^{depo}_{sale\ j,k}$ or $v^{depo}_{stor\ j,k}$ is the forecast sales or current storage volume of liquid fuel k in demand side j, t.

The transportation volume must be above its minimum volume and below its maximum volume, as shown in Eq.(13).

$$B^{tran}_{i,j,k,z} v^{tran}_{min\ i,j,k,z} \le V^{tran}_{i,j,k,z} \le B^{tran}_{i,j,k,z} v^{tran}_{max\ i,j,k,z}, \forall i \in I, j \in J, k \in K, z \in Z \quad (13)$$

Where $v^{tran}_{min\ i,j,k,z}$ or $v^{tran}_{max\ i,j,k,z}$ is the minimum or maximum transportation volume of liquid fuel k from supply side i to demand side j by transportation mode z, t.

4. RESULTS AND DISCUSSION

A large-scale refined product supply chain in China is taken as the case study to demonstrate the superiority of the proposed model. There are 49 refined product suppliers (S1-S49) and 26 refined product demanders (D1-D26). Among them, 23 suppliers (S1-S23) have relatively fixed production plans and if the planned supply is not completed, backlog cost is incurred. The other 26 suppliers (S24-S49) need to purchase refined product from outside, thus their supply plans are more flexible and have no backlog cost, but the unit transportation cost is higher. Pipeline, trains and ships are used for transportation. The location, planned supply and planned demand information are shown in Fig.2 and Fig.3.

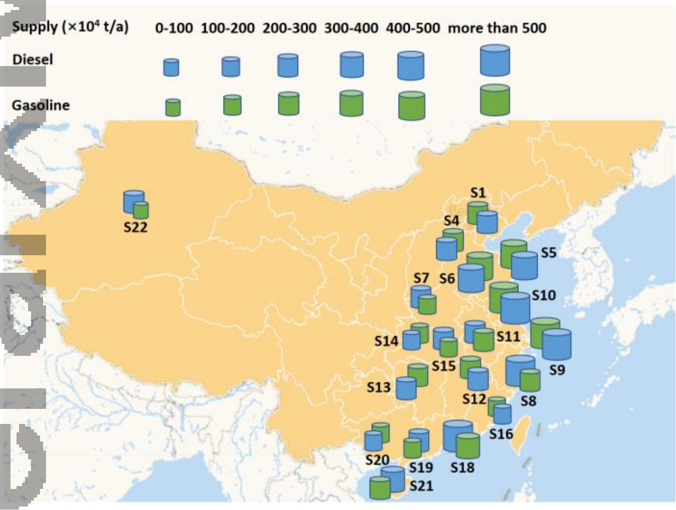

Fig 2 Location and planned supply of the supplier

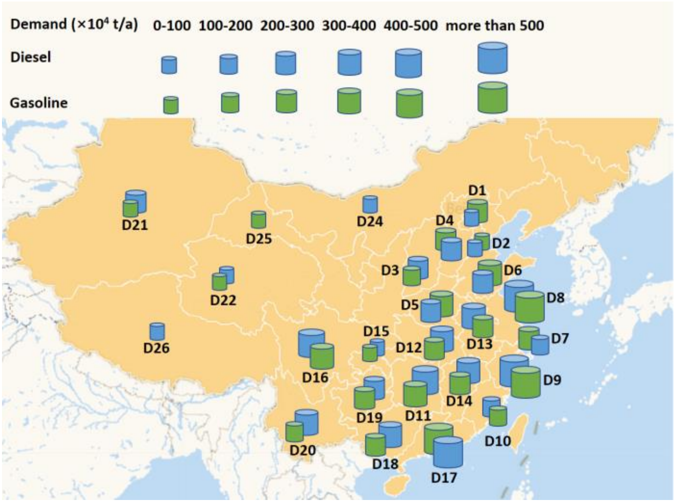

Fig 3 Location and planned demand of the demander

Liquid biofuel comes from straw, animal manure and garbage. To fully utilize existing refined product supply network, the potential of biomass near the suppliers is investigated, shown in Table 1.

Table 1 Liquid biofuel near the supplier

Liquid biofuel ($\times 10^4$ t/a)	Source		
	Straw	Animal manure	Garbage
S1	48.0	48.0	0.0
S2	48.0	48.0	48.0
S4	0.0	48.0	0.0
S6	48.0	48.0	48.0
S7	48.0	48.0	0.0
S9	48.0	48.0	0.0
S10	0.0	0.0	48.0
S13	0.0	48.0	0.0
S15	0.0	0.0	48.0
S18	0.0	0.0	48.0
S21	0.0	48.0	48.0

The unit backlog cost and the unit stock-out cost and are set as 360 CNY/t. The fixed transportation cost is set as 5×10^4 CNY. The discount rate is set as 8% and the lifetime of bio-refinery is set as 25 years. Four design scale of the bio-refinery can be selected with 24×10^4 t/a, 48×10^4 t/a, 72×10^4 t/a, 96×10^4 t/a.

The cost results of two scenarios (without/with liquid biofuel participation, S1/S2) are shown in Table 2. The time horizon is set to one month. It can be seen that transportation cost accounts for a large share of total cost. With liquid biofuel participation, although the bio-refinery investment cost increases, the transportation cost decreases sharply. Meanwhile, the stock-out cost on the demand side is also decreased.

Table 2 Cost results of the two scenarios

Cost (×10^{4}CNY) Scenario	f	f_1		f_2	f_3
		Backlog cost	Stock-out cost		
S1	53973	1026	1033	51914	0
S2	47066	1026	36	45692	312

The design and the supply scheme of the invested bio-refinery are shown in Fig.4 and Table 3. The participation of liquid biofuel avoids the supply of some refined product with excessively high transportation cost, and satisfies the demand on the demand side that is out of stock originally. Biofuel is considered to be an energy with zero carbon emissions. The carbon emission factor of the regular gasoline and diesel are set as 2.9 kg CO^2/kg and 3.1 kg CO^2/kg. In this studied month, it replaces 24×10^4 t of regular gasoline and 23.8×10^4 tons of regular diesel, reducing about 144×10^4 tons of carbon emissions.

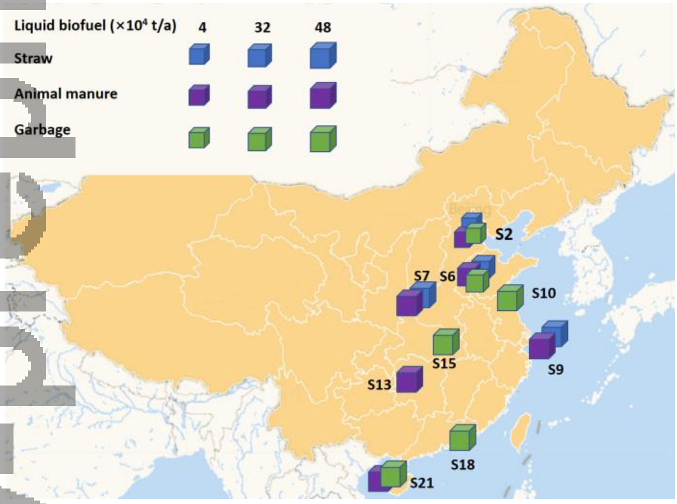

Fig 4 The design scheme of the invested bio-refinery

Table 3 The supply scheme of the invested bio-refinery

Start	End	Transportation	Liquid biofuel (×10^4 t/m)	
			Gasoline	Diesel
S2	D2	Pipeline	0.6	0.0
S9	D4	Ship	2.1	0.0
S7	D5	Pipeline	4.0	3.2
S9	D7	Pipeline	0.0	4.0
S13	D11	Pipeline	2.0	2.0
S15	D12	Pipeline	2.0	2.0
S10	D12	Ship	2.0	0.0
S6	D13	Pipeline	3.4	4.6
S9	D17	Ship	1.9	0.0
S21	D18	Ship	4.0	0.0
S21	D19	Ship	0.0	4.0
S18	D20	Pipeline	2.0	2.0

5. CONCLUSION

This paper evaluates the economy and environmental benefits of the participation of liquid biofuel in the refined product market competition. A MILP model for a single-cycle supply chain is established to obtain the optimal supply scheme, transportation scheme and demand scheme of both liquid biofuel and refined product with the minimal cost as the objective. Our main conclusions are as follows:

(1) Incorporating liquid biofuel into the existing refined product supply network brings economy benefit, and reduces the transportation cost and the stock-out cost on the demand side (12.0% and 96.5%).

(2) The newly supplied clean biofuel also brings environmental benefit, and reduces the carbon emissions about 1727×10^4 tons per year.

Future work should extend the benefit assessment of this integrated supply chain to a broader perspective, including distinguishing the standard between different types of fuel, considering more detailed infrastructure investment, as well as the coordination of multiple transportation modes.

ACKNOWLEDGEMENT

This work was funded by the National Natural Science Foundation of China (51874325). Additional funding came from the National key R & D program on intergovernmental science and technology innovation cooperation research project (No.2018YFE0196500) and the Grant-in-Aid for Early-Career Scientists (19K15260) from the Japan Ministry of Education, Culture, Sports, Science and Technology.

REFERENCES

[1] C. Suo, Y.P. Li, H. Mei, et al. Towards sustainability for China's energy system through developing an energy-climate-water nexus model. Renew. Sust. Energ. Rev., 2021, 135: 110394.

[2] Chih-Chun Kung, Jianhong E. Mu. Prospect of China's renewable energy development from pyrolysis and biochar applications under climate change. Renew. Sust. Energ. Rev., 2019, 114: 109343.

[3] Muhammad Abdul Qyyum, Yus Donald Chaniago, Wahid Ali, et al. Coal to clean energy: Energy-efficient single-loop mixed-refrigerant-based schemes for the liquefaction of synthetic natural gas. J. Clean. Prod., 2019, 211: 574-589.

[4] Kai Fang, Qifeng Zhang, Yin Long, et al. How can China achieve its Intended Nationally Determined

Contributions by 2030? A multi-criteria allocation of China's carbon emission allowance. Appl. Energy, 2019, 241: 380-389.

[5] Nan Zhou, Lynn Price, Dai Yande, et al. A roadmap for China to peak carbon dioxide emissions and achieve a 20% share of non-fossil fuels in primary energy by 2030. Appl. Energy, 2019, 239: 793-819.

[6] Meng Yuan, Haoran Zhang, Bohong Wang, et al. Future scenario of China's downstream oil reform: Improving the energy-environmental efficiency of the pipeline networks through interconnectivity. Energy Policy, 2020, 140: 111403.

[7] Tuomas Mattil, Riina Antikainen. Backcasting sustainable freight transport systems for Europe in 2050. Energy Policy, 2011, 39(3): 1241-1248.

[8] Reza Alizadeh, Peter D.Lund, Leili Soltanisehat. Outlook on biofuels in future studies: A systematic literature review. Renew. Sust. Energ. Rev., 2020, 134: 110326.

[9] Ja Kyong Ko, Jae Hoon Lee, Je Hyeong Jung, et al. Recent advances and future directions in plant and yeast engineering to improve lignocellulosic biofuel production. Renew. Sust. Energ. Rev., 2020, 134: 110390.

[10] Yu Li, Rajkamal Kesharwani, Zeyi Sun, et al. Economic viability and environmental impact investigation for the biofuel supply chain using co-fermentation technology. Appl. Energy, 2020, 259: 114235.

[11] Seongwhan Kang, Seongmin Heo, Matthew J. Realff, et al. Three-stage design of high-resolution microalgae-based biofuel supply chain using geographic information system. Appl. Energy, 2020, 265: 114773.

[12] Yohanes Kristianto Nugroho, Liandong Zhu. Platforms planning and process optimization for biofuels supply chain. Renew. Energ., 2019, 140: 563-579.

[13] Yawer Jafri, Elisabeth Wetterlund, Marie Anheden, et al. Multi-aspect evaluation of integrated forest-based biofuel production pathways: Part 2. economics, GHG emissions, technology maturity and production potentials. Energy J., 2019, 172: 1312-1328.

[14] Kristina M. Holmgren, Thore S. Berntsson, Eva Andersson, et al. Comparison of integration options for gasification-based biofuel production systems – Economic and greenhouse gas emission implications. Energy J., 2016, 111: 272-294.

[15] Xingyuan Zhou, Haoran Zhang, Shengchao Xin, et al. Future scenario of China's downstream oil supply chain: Low carbon-oriented optimization for the design of planned multi-product pipelines. J. Clean. Prod., 2020, 244: 118866.

[16] Bohong Wang, Yongtu Liang, Taicheng Zheng, et al. Optimisation of a downstream oil supply chain with new pipeline route planning. Chem. Eng. Res. Des., 2019, 145: 300-313.