ISSN 2004-2965 Energy Proceedings, Vol. 18, 2021

International Conference on Applied Energy 2021
Nov. 29 - Dec. 2, 2021, in Bangkok, Thailand
Paper ID: #113

Integrated Assessment of Key Mitigation Technologies in Petroleum and Petrochemical Industry under CO2 Emissions Peaking and Neutrality Targets

Huang Hai[1]

1 Sinopec Economics & Development Research Institute (EDRI)

ABSTRACT

The introduction of CO_2 emissions peaking and neutrality targets bring huge challenges to China's petroleum and petrochemical industry. However, there is not enough research on the emission characteristics, mitigation technologies assessment and optimization of this industry. This paper constructs an integrated assessment and optimization model for mitigation technologies, which includes the following three parts. Firstly, the model analyzes the emission characteristics based on enterprises' emissions data. Secondly, the model selects key mitigation technologies and conducts the integrated evaluation based on the emission characteristics. Thirdly, the combination of mitigation technologies for typical enterprises have been optimized. The results show that it is difficult to widely apply emerging mitigation technologies in petroleum and petrochemical industry at present due to safety, cost and other factors; energy saving will still be an important measure for short-term emission reduction. In the long term, the adjustment of energy structure will play an increasingly important role. In addition, the emission composition of different enterprises varies greatly and they should apply different mitigation strategies.

Keywords: CO_2 emissions; mitigation technologies; integrated assessment and optimization model; petroleum and petrochemical industry;

1. INTRODUCTION

In the past few decades, the global temperature has increased rapidly, bringing many environment problems and affecting people's health[1]. After President Xi announced the carbon peaking and neutrality targets, many industries in China introduced measures to take part in the low-carbon transformation, including petrochemical industry and related companies. In addition, since the major petrochemical enterprises are located in well-developed provinces, which have taken more active actions to reduce emissions. In the future, they will face more pressure. So, it is a certain direction for the petrochemical industry to achieve low-carbon transformation and the application of mitigation technologies will be the only way.

However, the current research about comprehensive assessment of mitigation technologies in petroleum and petrochemical industry isn't systematic, lacking basis emissions analysis, industry combination and emissions reduction potential quantification. Our research tries to fill these gaps. Firstly, we identified the emission characteristics and main emission sources in different departments, which was the basis for mitigation technologies assessment. Secondly, combined with the emission characteristics, the relevant mitigation technologies were comprehensively assessed from the following three aspects, environment, economy and society. At last, we built different scenarios to calculate the reduction contribution of different technologies in short term and long term.

Our research has two innovations. In terms of methodology, the comprehensive assessment of mitigation technology in petrochemical industry is constructed; In terms of research content, the emission reduction contribution in different periods is calculated, and the key technologies in different departments are identified.

Selection and peer-review under responsibility of the scientific committee of the 13th Int. Conf. on Applied Energy (ICAE2021).
Copyright © 2021 ICAE

2. PAPER STRUCTURE

2.1 Methodology

The integrated assessment model for mitigation technologies in petroleum and petrochemical industry including three parts, emission inventory module, mitigation technology assessment module and optimization module, as shown in Fig. 1.

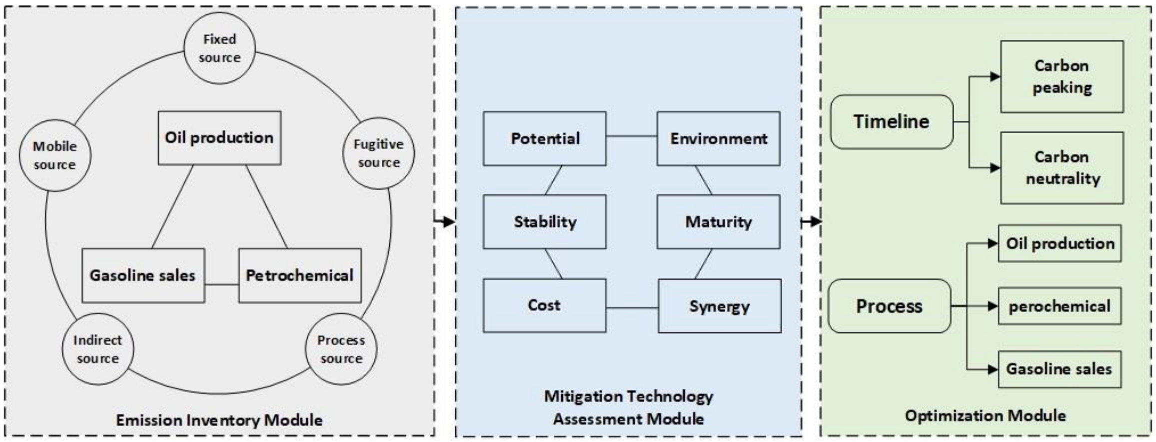

Fig. 1. Model framwork

2.1.1 Emission inventory module

In emission inventory module, according to the industry standards and the data from more than 80 enterprises (including 14 oil production enterprises, 35 petrochemical enterprises and 37 gasoline sales enterprises), our research counted the emissions from different sources including fixed, mobile, fugitive, process and indirect sources.

2.1.2 Mitigation technology assessment module

Score	Potential	Environment	Maturity	Cost	Stability	Synergy
1	Less than 5%	Huge environment damage	Concept stage	Unbearable	Extremely high risk	Huge negative effect
2	5%-10%	Environment damage	R&D stage	Affordable with policy support	High uncertainty	Negative effect
3	10%-20%	No obvious impact	Pilot stage	Affordable	Controllable risk	No effect
4	20%-30%	Environment benefit	Certain scope of application	Zero cost	Low risk	Positive effect
5	More than 30%	Huge environment benefit	Large scale application	Negative cost	Zero risk	Huge positive effect

Fig. 2. Score standard of index

In assessment module, our model selected the main mitigation technologies including renewable energy, green hydrogen, energy-saving, digital technology, methane recycling and Carbon capture, utilization and storage (CCUS). After that, we collected information from literature research like some representative reports and investigation from typical factories and experts' opinions. Finally, we scored these technologies form six indexes including potential, environment, maturity, cost, stability and synergy, Fig. 2.

2.1.2 Optimization module

In optimization module, our research built baseline (BAU) and emission reduction scenarios (ER). For BAU scenario, the intensity of each production unit is the same as that of the base year, and the change of product output refers to EDRI [2]. For ER scenario, the forecast data are mainly from IEA [3,4], ADB [5], BP [6], UNFCCC [7]. By comparing the two scenarios above, the emission reduction contributions of different technologies in different periods could be calculated.

2.2 Results

2.2.1 Emission characteristics

The emissions composition of different departments varies greatly. Oil production emissions mainly come from fixed source, indirect source and fugitive source; Petrochemical industry emissions mainly come from fixed source, process source and indirect source; Gasoline sales emissions mainly come from indirect source, mobile source and fugitive source, Fig.3.

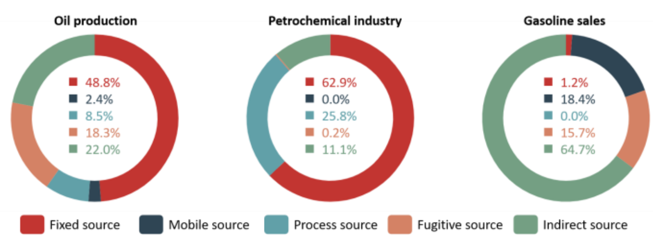

Fig. 3. Emissions sources

2.2.2 Technology assessment

(1) Renewable energy

 Copyright © 2021 ICAE

According to International Renewable Energy Agency, the electricity costs from photovoltaic and wind decreased rapidly and the capacity reached to 707GW and 699GW, respectively [8]. It can reduce pollution and improve people's health due to coal power replacement [9]. For oil production companies and oilgas sales department, it can help to use idle land effectively and save electricity cost. In contrast, since petrochemical department requires continuous, stable and huge energy supply and many factories lack land. So, it would be better to use green electricity from power grid, rather than construct renewable energy power station directly, Fig. 4.

Technologies	Department	Potential	Environment	Maturity	Cost	Stability	Synergy
Photovoltaic	Oil production	3	4	4	3	4	4
	Petrochemical	1	4	4	3	4	2
	Sales department	5	4	4	4	5	5
Wind power	Oil production	3	4	4	3	4	3
	Petrochemical	1	4	4	3	4	3
	Sales department	1	3	4	2	4	2
Electrification	Oil production	3	3	3	2	4	3
	Petrochemical	5	3	3	2	2	1
	Sales department	3	3	5	4	5	3
Energy-saving	Oil production	4	3	5	3	5	3
	Petrochemical	5	3	5	3	5	3
	Sales department	5	3	5	3	5	3
Digitization	Oil production	3	4	3	3	4	4
	Petrochemical	2	3	3	3	4	4
	Sales department	3	3	3	3	4	4
Green hydrogen	Oil production	1	4	2	1	2	2
	Petrochemical	3	4	2	1	2	5
	Sales department	1	4	2	1	2	3
Methane recycling	Oil production	5	4	3	4	3	5
	Petrochemical	1	4	3	4	3	3
	Sales department	3	4	3	4	3	4
CCUS	Oil production	2	2	3	2	2	5
	Petrochemical	3	2	3	2	2	3
	Sales department	1	2	2	2	2	2

Fig. 4. Technology assessment table

(2) Energy-saving technologies

Energy-saving technologies are the main measures for petrochemical industry to reduce carbon emission intensity, since they are mature and safe. There is an energy-efficiency improvement potential for China's petrochemical enterprises, compared with the world advanced level. In addition, the energy efficiency level of the oil production enterprises is directly related to the exploitation difficulty and oil quality, which increase the energy saving difficulty in the future for China's enterprises.

(3) Digitization

Through digitization, enterprises will not only optimize production operations, reduce cost and increase efficiency, but also produce synergy benefits of carbon emission reduction. Based on typical factory investigation, the emission potential would be 10%-20%.

(4) Green hydrogen

The hydrogen production from fossil fuels is one of the main carbon emission sources for petrochemical enterprises [10]. The development of green hydrogen technology has a greater contribution to the emission reduction in such enterprises.

(5) Methane recycling technologies

Since fugitive source is a main emission source of oil production enterprises. Methane recycling technology has great emission reduction potential in such enterprises. According to IEA's report [11], 54% methane can be recycled at zero cost.

(6) CCUS

At present, the technology still has disadvantages such as high energy consumption, lacking of safety and reliability [12]. However, there are already some pilot projects. This technology will play an important role in achieving carbon neutrality targets.

2.2.3 Emission reduction contribution

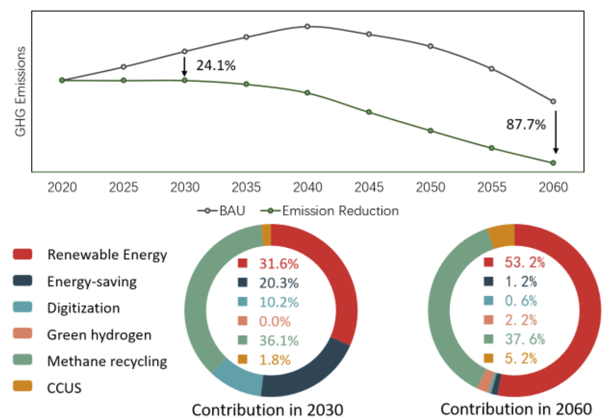

Fig. 5. Emissions reduction contribution in oil production

The optimization module output roadmaps of three departments. For oil production department, the greenhouse gas emissions will maintain a platform period from 2020 to 2035. Then it decreased rapidly. In the peak period, methane recycling, renewable energy and energy-saving are the most prominent low-carbon measures. In the neutrality period, the contribution of renewable energy will gradually increase; Methane recycling is still important. In the contrast, with the decoupling of carbon emissions and energy consumption, the contribution of energy-saving is

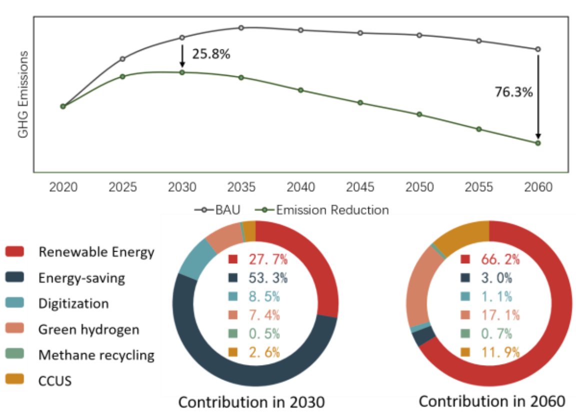

Fig. 6. Emissions reduction contribution in petrochemical department

declining in the long term, Fig.5.

For petrochemical department, greenhouse gas emissions will peak around 2030. In the peak period, renewable energy and energy-saving are the most prominent low-carbon measures. In the neutrality period, green hydrogen and CCUS will play more and more important roles with the development of such technologies, Fig.6.

For gasoline sales department, In the short term, the emission reduction needs the joint contribution of renewable energy, energy-saving, digitization and methane recycling technologies. In the long term, renewable energy will be the most important emission reduction technology, Fig 7.

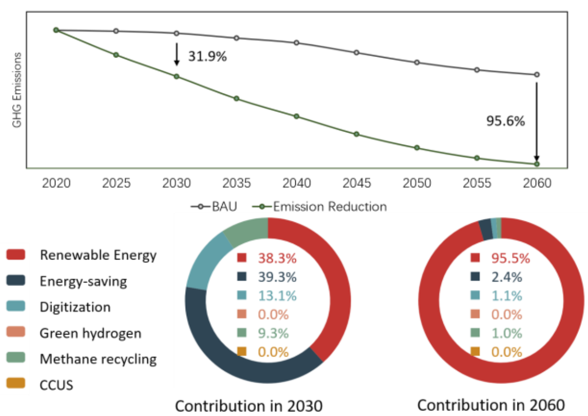

Fig. 7. Emissions reduction contribution in gasoline sales department

2.3 Conclusions and discussion

The following conclusions can be drawn from this study. Firstly, the emission composition of different departments varies greatly. Secondly, different emission reduction strategies should be adopted in different periods. At this stage, emerging mitigation technologies are still difficult to be widely used due to maturity, stability and cost. Energy-saving is still an important short-term emission reduction measure for all sectors. In the long term, the adjustment of energy structure will play a more and more important role in emission reduction process. Thirdly, different types of enterprises should focus on different mitigation technologies.

In addition, further research around cost-benefit analysis can be conducted, aiming to propose the lowest cost emission reduction strategies for different enterprises under carbon market scenario.

ACKNOWLEDGEMENT

We gratefully acknowledge the comments and suggestions of anonymous reviewers.

REFERENCE

[1] IPCC. Fifth assessment report [EB/OL]. [2019–12–17]. https://www.ipcc.ch/assessment-report/ar5/.

[2] DERI. Development report of China's energy and petrochemical industry 2021 [M].

[3] International Energy Agency. The future of hydrogen [R/OL]. https://www.iea.org/reports/the-future-of hydrogen.

[4] International Energy Agency. Energy technology perspectives 2015-Chapter 8 energy technology innovation in China[R/OL]. [2019–12–17]. https://www.iea.org/reports /energy-technologyperspectives-2015.

[5] Asian Development Bank. Roadmap for carbon capture and storage demonstration and deployment in the People's Republic of China[M/OL]. (2015).

[6] BP. BP technology outlook [EB/OL]. (2018) [2019–12–18]. https://www.bp.com/en/global/corporate/what-we-do /technology-at-bp/technology-outlook.html.

[7] UNFCCC Secretariat. Third synthesis report on technology needs identified by parties not included in annex I to the convention [R]. Bonn: UNFCCC, 2013.

[8] International Renewable Energy Agency. Renewable energy market analysis: GCC 2019 [R/OL]. https://irena.org/publications/2019/Jan/Renewable-Energy-Market-Analysis-GCC-2019.

[9] Cao C, Cui X Q, Cai W, et al. Incorporating health co-benefits into regional carbon emission reduction policy making: A case study of China's power sector[J]. Applied Energy, 2019, 253.

[10] Cheng Y, Wang X M, Li Y N, et al. China's Hydrogen Energy Industry in 2020 and Future Prospects[J]. Petroleum & Petrochemical Today, 2021, 29(4).

[11] International Energy Agency. Methane tracker 2021 [R/OL]. https:// www.iea.org/ reports/ methane-tracker-2021.

[12] Global CCS Institute. Database of CCS facilities [EB/OL]. https://co2re.co/FacilityData.

 Copyright © 2021 ICAE