Research on Carbon Emission Reduction of ICT Enabled Manufacturing Industry

——A Case Study of China Telecom

Juanjuan Feng[1,a], Yonglian Weng[2,b], Shuo Chen[1,c],Tianjian Yang[2,d*]

[1]China Telecom Research Institute, Guangzhou, China;
[2] School of Modern Post (School of Automation), Beijing University of Posts and Telecommunications, Beijing, China

[a]Fengjj8@chinatelecom.cn, [b]wylldph@bupt.edu.cn,
[c]Chens1@chinatelecom.cn, [d*]frankytj@bupt.edu.cn

Abstract. The development of Chinese traditional manufacturing industry is accompanied by high carbon emissions. In order to promote the sustainable development of manufacturing industry, information and communication technology (ICT) is applied to upgrade manufacturing with a hope of both promoting sustainability and improving its output. This paper investigates three main smart manufacturing scenarios: ICT-enabled production line upgrades in the iron and steel industry, smart warehousing and virtual reality (VR) remote troubleshooting. Their ICT-enabled emission reduction and future potentials are formulated. Results show that it is feasible to outline ICTs' enabling role on a low carbon economy and that ICTs will play a greater role on emission reduction in future.

Keywords: ICT; Enablement effect; Emission reduction; Smart manufacturing;

1 INTRODUCTION

Since the "Reform and Opening Up", Chinese manufacturing industry has shown a rapid development trend. The scale of Chinese manufacturing industry has accounted for more than 30% of the world, ranking first in the world for 14 consecutive years [1]. However, the rapid development of manufacturing industry has also brought many problems, such as greenhouse effect and pollution. In order to promote sustainable development, energy conservation and emission reduction in the manufacturing industry are receiving social attention. As the core technology of Chinese industrial digital transformation, information and communication technology provides a new solution for the low-carbon development of manufacturing industry. In the "14th Five Year Plan for Smart Manufacturing Development", China pointed out that it is necessary to develop the carbon emission management system and smart manufacturing system to reduce carbon emissions in the manufacturing industry [2], but how much carbon reduction effect these ICT solutions can bring to the society has not been quantified at present. It

A. Haldorai et al. (eds.), *Proceedings of the 2024 3rd International Conference on Artificial Intelligence, Internet and Digital Economy (ICAID 2024)*, Atlantis Highlights in Intelligent Systems 11,
https://doi.org/10.2991/978-94-6463-490-7_42

is necessary to calculate carbon emission reduction in combination with the actual situation of ICT enabled manufacturing industry, identify carbon reduction potential, provide reference for low-carbon transformation of ICT enabled manufacturing industry, and promote the realization of "carbon peek and neutrality" in manufacturing industry.

2 LITERATURE REVIEW

At present, some scholars have studied the ways that ICT can help other industries achieve carbon emission reduction. Phol et al. find that ICT can reduce the carbon emission by providing optimization and substitution solutions to other industries [3]. Freitag et al. also find that big data, data science and artificial intelligence can bring the positive influence to carbon emission reduction in many industries [4]. At same time, except for providing digital solutions to other industries, carbon emission of per unit business volume from ICT is decreasing [5]. Erdmann and Hilty point out under the influence of ICT's own energy consumption control and enabling other industries to reduce carbon emissions, ICT can help other industries achieve more carbon emission reduction than carbon emissions increase brought by digitization, even under the circumstances of rapid economic growth [6].

Some international institutions and organizations have studied the relationship between ICT and carbon emission reduction in manufacturing. A report of Mason and Huawei shows that 5G technology, artificial intelligence, IoT and cloud computing can significantly reduce carbon emissions of the manufacturing Industry by providing new ways of operating [7]. GSMA disclosed in its report that the use of information technology to digitize manufacturing can reduce carbon emissions for society by 11% of the total carbon emission reduction enabled by ICT [8]. GeSI pointed out in its "Smart2020" study that the five scenarios with the greatest potential for carbon emission reduction in ICT include the use of information technology to transform industrial machines and the automation in manufacturing [9]. In the updated "Smarter2030" report released by GeSI in recent years, it was estimated that ICT-enabled smart manufacturing worldwide can bring 2.7Gt of carbon dioxide emissions reduction to society [10]. At present, there is no research on ICT-enabled carbon emission reduction in manufacturing in China. Conducting quantitative measurement of ICT-enabled carbon emission reduction in Chinese manufacturing industry can better help China achieve the grand goal of "carbon peak and neutrality" in manufacturing.

3 MEASUREMENT METHOD

International organizations have provided different measurement methods in ICT enabled society emission reduction, including the coefficient theory measurement method proposed by GSMA, the LCA method based on the product life cycle proposed by GeSI, and the GHG measurement method proposed by WRI and WBSCD.

- Coefficient theory method: This measurement method is based on on-site investigation, and it calculates the energy and other operational savings after the application

of mobile communication technology. The ICT-enabled emission reduction is then formulated as the amount of possible emissions reduction per mobile subscriber.

- LCA: LCA is a basic principle to calculate and report the GHG emission reductions. GeSI put forward this method to take the enabling effect (carbon emission reduction) and rebound effect (carbon emission increase caused by deployment of ICT systems) into account, making the carbon emission reduction calculation more reasonable.
- GHG protocol methods: GHG protocol methods firstly list the main activities within the organizational boundary and their direct and indirect energy consumption before the application of ICT solutions, and then analyze the changes in the energy usage of each activity after the application of ICT. Thereby the ICT-enabled emission reduction effect can be analyzed and calculated. Similar methods also include ISO14064-2.

This paper integrates these methodologies to quantify the carbon emission reduction of ICT-enabled manufacturing industry as Figure 1 shows.

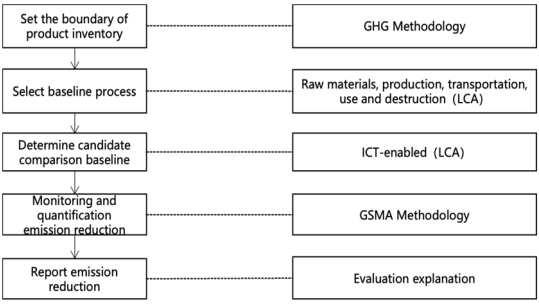

Fig. 1. Measurement method of manufacturing carbon emission reduction

4 MEASUREMENT OF ICT-BASED CARBON EMISSION REDUCTION

4.1 Scope of Investigation

This paper conducted a series of interviews with the planning department, data department of China Telecom, who provides quite some smart solutions to manufacturing industries. Main application scenarios, principles of emission reduction, data availability and significance of emission reduction were discussed with experts from ICT experts and product managers. Then three major carbon reduction scenarios of ICT enabled manufacturing industry were identified: smart warehousing, digital production line and remote troubleshooting with VR/AR as Table 1 shows.

Table 1. Smart manufacturing scenarios and emission reduction principles

Typical Scenarios	Emission reduction principles
1.Smart warehousing	Increase turnover rate, reduce spatial demands

2.AR remote troubleshooting	Avoid expensive trips of experts
3.Digital production lines	Increase output and reduce unit input

4.2 Emission Reduction Enabled by Digitization of Production Line

This section selects the steel digitization production line in smart manufacturing for carbon reduction calculation and analysis. Taking the customized transformation of an iron and steel group B as an example, China Telecom has used 5G technology and its derivatives to build a model-driven controller for solid waste recycling in a rotary hearth furnace workshop. It integrates big data into production, intelligently monitors and adjusts the process in production, improves the energy utilization rate and recycles useful metals in the waste. As show in figure 2.

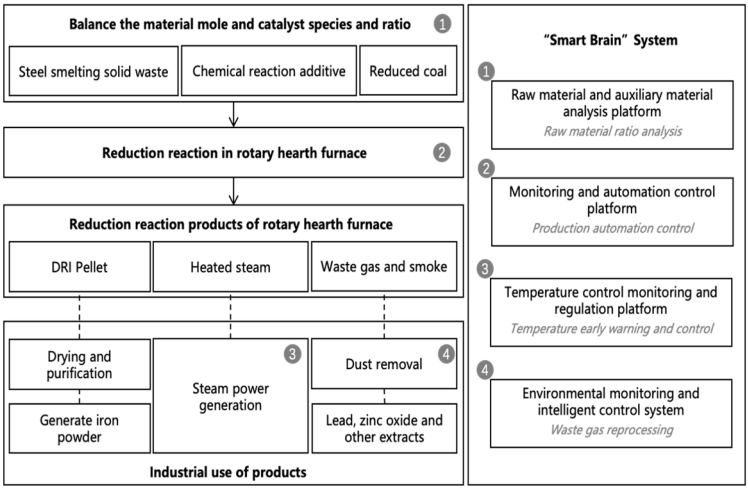

Fig. 2. Digitization of steel production line enabled by China Telecom

The pilot project of steel production line upgrade mainly includes three aspects:

1. The intelligent energy consumption monitoring platform is used for intelligent power consumption control of steel boiler.
2. The model-based ICT system is used to drive the production line, and the metallurgical zinc containing dust sludge is directly reduced in the rotary hearth furnace to generate DRI pellets (direct reduction ironmaking) and zinc oxide powder.
3. The rotary hearth furnace generates power generation steam to reduce the carbon emission of standard coal combustion.

Tab**le 2.** Carbon emission reduction data of digitization of steel production line

Index	Data
Market share of the steel group B in China (%)	9.7
DRI Pellets processed by Iron and steel group B yearly (million tons)	0.25

Metallization rate of traditional rotary hearth furnace factory	65%
Metallization rate of intelligent rotary hearth furnace factory	70%
Mass of DRI pellets produced by direct reduction process of rotary hearth furnace (million tons)	0.1589
Mass of zinc oxide powder generated by direct reduction process of rotary hearth furnace (tons)	5700
Carbon emissions saved in steelmaking process per ton of DRI pellets (ton)	0.14
Carbon emissions from the process of treating each ton of metallurgical dust and sludge in the traditional rotary hearth furnace plant (ton)	0.22
Carbon emission of the process of treating each ton of metallurgical dust and sludge with intelligent rotary hearth furnace (ton)	0.19
Steam generated by rotary hearth furnace process for power generation (million tons)	0.1589
Carbon emission saved in production process for each ton of zinc generated (ton)	0.338[11]
Standard coal quantity to be burned for one ton of steam (ton)	0.13[12,13]
Carbon dioxide emissions from combustion of standard coal (ton/ton)	2.54[14]
Total carbon emission reduction (thousand tons)	61.8

See in table 2. In brief, total emission reduction comes from 3 parts: producing more DRI pellets and zinc oxide powder with approximately the same energy inputs, and treating metallurgical dust and sludge more efficiently. It can be calculated that in 2022, China Telecoms enables steel group B to reduce emission by 61.8 thousand tons by providing ICT solutions. Based on the market share of the steel group B, it can be speculated that China's ICT solutions applied to the steel industry should contribute by at least 638 thousand tons of emission reduction in China.

4.3 Emission Reduction of Smart Warehousing and AR/VR trouble shooting

For simplicity, calculating tables are directly given below for ICT-enabled smart warehousing and VR troubleshooting apps. As show in table 3 and 4.

Table 3. Carbon emission reduction of smart warehousing

Index	Data
Proportion of warehouses applying smart ICT solutions (%)	30
Space demands reduced by smart warehousing (%)	15
Commercial warehousing area in China (thousand m^2)	1080000
Average annual power consumption of warehouse (kwh/m^2)	152.4
China Telecom's market share (%)	33
Total carbon emission reduction (thousand tons)	1434.4

Table 4. Carbon emission reduction of AR/VR

Index	Data
China Telecom's business customers using VR remote diagnosis and troubleshooting in 2022	164
The average number of trouble-shootings per enterprise per day	12
Average annual working days of VR troubleshooting system	104
Support ratio within the local region (%)	50
Cross-region support ratio (%)	50
Transportation mode when a cross-region support is needed	High speed rail
Transportation mode when a local support is needed	taxi
Average travel distance during a cross-region support (km)	1000
Average travel distance during a local support (km)	20
Total carbon emission reduction (ton)	155.1

5 EMISSION REDUCTIONS IN FUTURE

Based on above-stated calculation methods, it shows that the emission reduction scale is proportional to penetration rate of ICT solutions. Based on some forecasts of ICT solution penetration for 2025-2030 from China Telecom, it shows the scale of ICT application and ICT-enabled emission reduction are both to increase quickly. Table 5 shows the growth forecast for the three smart manufacturing ICT solutions. With the rapid development of 5G and 6G, industry 4.0 becomes a trend. Accordingly, ICT-enablement effect will play a greater role in achieving a low carbon economy.

Table 5. Growth Forecast of Smart Manufacturing Solutions

ICT Solutions in Smart Manufacturing	2022	2025	2030
Smart Warehousing Penetrating Rate	30%	37.5%	54.3%
Production Line Upgrading	1	1.1^3 to 2022	1.1^8 to 2022
VR remote troubleshooting 2B customers	223	390	959

6 CONCLUSIONS

This paper quantifies the carbon emission reduction in the ICT enabled society in the field of smart manufacturing. Based on interviewing ICT product managers and experts from China Telecom, three typical ICT-enabled scenarios are identified, i.e., smart production line upgrade, smart warehousing and VR remote troubleshooting. Their emission reduction and future potentials of these low carbon ICT solutions are then worked out. ICT solutions play an important role in energy conservation and emission reduction and show huge growth potential. However, it should also be seen that China Telecom's production line upgrading project only informatized a small part of the complex iron

and steel manufacturing processes, and that was even not one of main production processes. And smart warehousing projects are also a relatively common process in manufacturing enterprises. So the ICT penetration needs to gradually move from peripheral scenarios in the industrial field to its core scenarios, and it will bring more eco-friendly contributions.

REFERENCE

1. Xinhua News Agency. (2024) The overall scale of China's manufacturing industry has ranked first in the world for 14 consecutive years. https://www.gov.cn/lianbo/bumen/202401/content_6927104.htm
2. Ministry of Industry and Information Technology of the People's Republic of China. (2021) 14th Five Year Plan for Smart Manufacturing Development. https://www.gov.cn/zhengce/zhengceku/2021-12/28/5664996/files/a22270cdb0504e518a7630fa318dbcd8.pdf
3. Pohl J, Hilty LM, Finkbeiner M. (2019) How LCA contributes to the environmental assessment of higher order effects of ICT application: a review of different approaches. J Clean Prod 219:698–712. https://doi.org/10.1016/j.jclepro.2019.02.018
4. Freitag C, Berners-Lee M, Widdicks K, Knowles B, Blair GS, Friday A. (2021) The real climate and transformative impact of ICT: a critique of estimates, trends, and regulations. Patterns 2:100340. https://doi.org/10.1016/j.patter.2022.100576
5. GreenTouch. (2015) Final results from green meter research study. https://www.semanticscholar.org/paper/GreenTouch-Final-Results-from-Green-Meter-Research-White/36c886d1ed27370b48567de2dc6c033fb12c1464
6. Erdmann L, Hilty LM. (2010) Scenario analysis: exploring the macroeconomic impacts of information and communication technologies on greenhouse gas emissions. J Ind Ecol 14:826–43. https://doi.org/10.1111/j.1530-9290.2010.00277.x
7. Gabriel C, Andy H, Chern A. (2020) Green 5G: Building a Sustainable World. Huawei Technologies Co. Ltd., Tech. Rep. https://www.huawei.com/en/public-policy/green-5g-building-a-sustainable-world
8. GSMA. (2019)The Enablement Effect- The impact of mobile communications technologies on carbon emission reductions. https://www.gsma.com/convening-for-good/enablement-effect
9. GeSI. (2008) SMART 2020"Enabling the low-carbon economy in the information age". https://gesi.org/research/smart-2020-enabling-the-low-carbon-economy-in-the-information-age
10. GeSI.(2019) SMARTer 2030"ICT Solutions for 21 Century Challenges". https://smarter2030.gesi.org/
11. SUME (2021). Carbon emission level of zinc smelting in the context of carbon neutrality. http://www.chinasume.com/news!show.action?id=59f7e8b2b12a40db90a3312884fd1f23&&code=43
12. General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China, China National Standardization Administration. (2007). GB/T 754-2007 Parameter Series of Steam Turbines for Power Generation. https://openstd.samr.gov.cn/bzgk/gb/newGbInfo?hcno=FC788218F15F159E88085006E3658E1D
13. Inspection and Quarantine of the People's Republic of China, China National Standardization Administration. (2016). GB/T 50441-2016. Standard for calculation of

energy consumption in petrochemical engineering design. http://www.sdjlha.com/uploads/file/2304/1682320061898933.pdf
14. Hua T, Cuijie L, Calculation of CO2 emissions from standard coal (2014). Coal Quality Technology, 29 (2): 57-60. 10.3969/j.issn.1007-7677.2014.02.019