# CARBON DIOXIDE INTENSITY TOWARDS CARBON-NEUTRAL GLOVE INDUSTRY

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## ABSTRACT

Despite the heightened urgency of curbing carbon emissions around the world, the healthcare sector in general, and the glove manufacturing sector in particular have received very little attention from the sustainability community in terms of their contribution to the global carbon footprint especially during this pandemic. Producing more products with lesser resources is crucial in view of the growing scarcity of natural resources. Greenhouse gas emissions (GHG) are one of the major causes of climate change. As environmental related issues are part of the sustainability areas of concerns, industrial players are required to oversees climate change in the company and reports accordingly. It is important to manage and implement environmental initiatives to improve operational eco-efficiency and reduce carbon footprint from company. Industrialist should recognise the importance of enhancing operational eco-efficiency as it improves competitiveness in terms of cost reduction and reduces environmental liabilities. An important step in emission reduction efforts is quantification of the emissions based on the inventory or scope segregation and identification of the specific sources of emission. The aim of this paper is to conduct GHG gas emission assessment in glove manufacturing plant. The results will inform plant owners and decision-makers about the major point source of emissions, which in turn, will reveal the operational requirements that should be prioritized for intervention. In conclusion, F24 contributed to 547.64 t CO2e / 1000 pcs of gloves in 2021 majorly by scope 3.

# ABSTRAK

Walaupun semakin mendesak untuk membendung pelepasan karbon di seluruh dunia, sektor penjagaan kesihatan secara amnya, dan sektor pembuatan sarung tangan khususnya telah menerima sedikit perhatian daripada komuniti kemampanan dari segi sumbangan mereka kepada jejak karbon global terutamanya semasa wabak ini. Penghasilan lebih banyak produk dengan sumber yang lebih rendah adalah penting memandangkan kekurangan sumber asli yang semakin meningkat. Pelepasan gas rumah hijau (GHG) adalah salah satu punca utama perubahan iklim. Memandangkan isu berkaitan alam sekitar adalah sebahagian daripada bidang kemampanan yang membimbangkan, pemain industri dikehendaki mengawasi perubahan iklim dalam syarikat dan melaporkan dengan sewajarnya. Adalah penting untuk mengurus dan melaksanakan inisiatif alam sekitar untuk meningkatkan kecekapan eko operasi dan mengurangkan jejak karbon daripada syarikat. Pengusaha industri harus menyedari kepentingan meningkatkan kecekapan eko operasi kerana ia meningkatkan daya saing dari segi pengurangan kos dan mengurangkan liabiliti alam sekitar. Satu langkah penting dalam usaha pengurangan pelepasan ialah pengkuantifikasian pelepasan berdasarkan inventori atau pengasingan skop dan pengenalpastian sumber pelepasan tertentu. Matlamat kertas kerja ini adalah untuk menjalankan penilaian pelepasan gas GHG di kilang pembuatan sarung tangan. Hasilnya akan memaklumkan pemilik loji dan pembuat keputusan tentang punca utama pelepasan, yang seterusnya, akan mendedahkan keperluan operasi yang harus diutamakan untuk campur tangan. Kesimpulannya, F24 menyumbang kepada 547.64 t CO2e / 1000 pcs sarung tangan pada tahun 2021 terutamanya mengikut skop 3.

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## LIST OF SYMBOLS

| | | |
|---|---|---|
| % | - | percentage |
| in. | - | inch |
| ft | - | feet |
| m | - | meter |
| $m^3$ | | cubic meter |
| t | | tonne |
| $CO_{2\text{-}eq}$ | | Carbon Dioxide equivalent |

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| UTM | - | Universiti Teknologi Malaysia |
| kW | - | kiloWatts |
| LPG | | Liquefied Pressurised Gas |
| USA | | United States of America |
| GDP | | Gross Domestic Profit |
| FiT | | Feed in Tariff |
| MW | | Megawatt |
| GW | | Gigawatt |
| TNB | | Tenaga Nasional Berhad |
| HP | | Horsepower |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

According to the First Law of Thermodynamics, "energy can neither be created nor destroyed" which was the accepted empirical principle. at the least efficient industrial motor systems. Efficiency improvements are practically available everywhere in the system. Hence, replacing compressed air-driven tools by motor-driven ones can improve energy efficiency (If, 2013). Hypothetically, the world will never come up short on its energy sources. In any case, the accessibility of energy in its different physical forms, which have been aimlessly devoured by civilization through generations, can and will reduce. This applies specifically to the energy sources from exhaustible mass, for example, petroleum product and minerals. Therefore, the scrupulous use of these energy sources instrumented by efficient technologies is crucial to the existence and sustainable growth of any nation, and more so for a developing country. Importantly, energy efficiency technology offers a powerful and cost-effective tool for achieving a sustainable energy future.

Rubber industry and rubber products are the one of significant industry that is huge to the portions of the nation's economy such as Malaysia and Thailand due to be the base industry to make numerous earnings per year. In addition, the amount of high demand of product usage from rubber industry and rubber products leads to both of the pattern of utilization and exportation extend persistently. At that point, the rubber industry and rubber products have the capabilities of competing with the foreign countries in the world market as that industry is still the major industry that the

government should affirm to encourage and support. Rubber industry and rubber products are held to be the business that devour energy in the significant level and will be in an enlarged level of energy utilization depending on the development of the economy. If consider in the field of energy dimension, thus it is necessary to find the way to encourage and support energy consumed efficiently. If not, the influence to the saving of energy, still improves the potential in the competition with other countries out there in the global market. (Potential Energy Saving of Malaysia Manufacturing, 2014). Figure 1.1 shows Thailand contributes 33.4% if world largest rubber producer and Malaysia 3.8%.

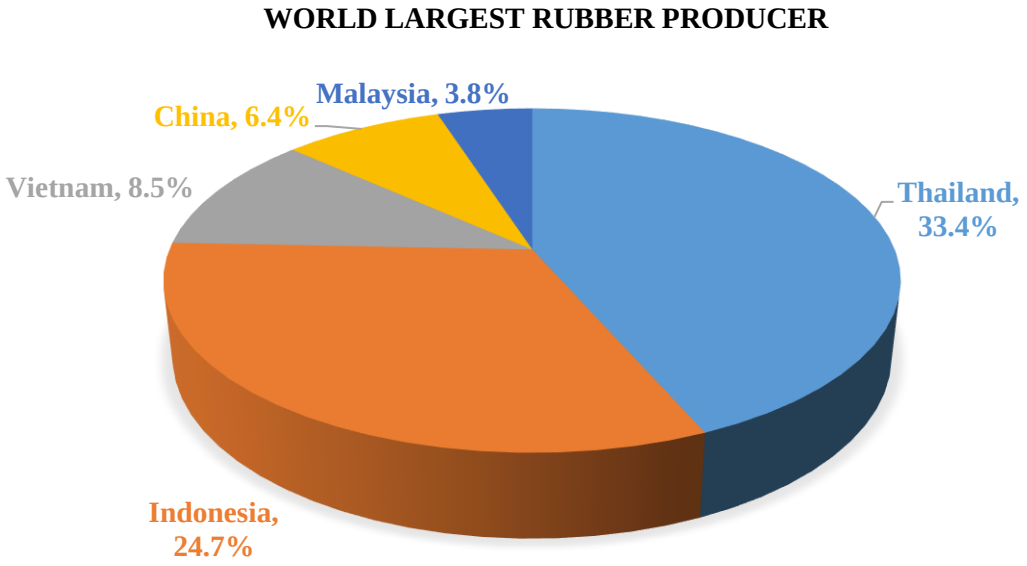


Figure 1.1 World largest rubber producer

Latex products; tires and tire-related products; and industrial and general rubber products are Malaysian's rubber producing industries, which comprises more than 510 manufacturers. The quick development of these has empowered Malaysia to become the world's biggest purchaser of natural rubber latex. Production plants of general rubber products consist of production lines of 800 to 1200m in length, and are typically spread out in various levels or buildings. The fundamental processing steps

for rubber products are: mastication, mixing (mills, internal mixers, cooling mills), further processing (pre-warming, processing in extruders, processing on calendars), and vulcanization (Saidur & Mekhilef, 2010).

In spite of, one of the largest rubber industries in Malaysia is glove industry and Top Glove Corporation Bhd. established in 1991 and headquartered in Malaysia is the world's largest manufacturer of gloves. What started as only a local business enterprise with 1 factory and 1 glove production line, has today captured 26% of the world market share for rubber gloves. The company has manufacturing operations in Malaysia, Thailand and China. It also has marketing offices in these countries as well as USA, Germany and Brazil and exports to over 2,000 customers in 195 countries worldwide. Top Glove offers a comprehensive product range, which now includes a non-glove segment comprising condoms, dental dams and exercise bands, fulfilling demand in both the healthcare and non-healthcare segment.

Forming production process is product forming by dipping method such as rubber glove; the following chart is an illustration of the dipping process. This method, former is dipped in chemical cleaning agents, pick-up agent, solvent that slight film forming around former, then leaching, breading, curing process, and finally stripping.

Energy efficiency measures, which normally meet all three goals: they are environmentally sound, economically and thermodynamically efficient referring to improved processes or energy systems, including improving energy efficiency for example, in heating, ventilation, air-conditioning (HVAC) systems, adopting local materials and recycling materials etc. (Kluczek & Olszewski, 2017). Figure 1.2 representing on the manufacturing process rubber glove end to end which starts from the raw material transportation into the plant until gloves is produced and packed for shipment.

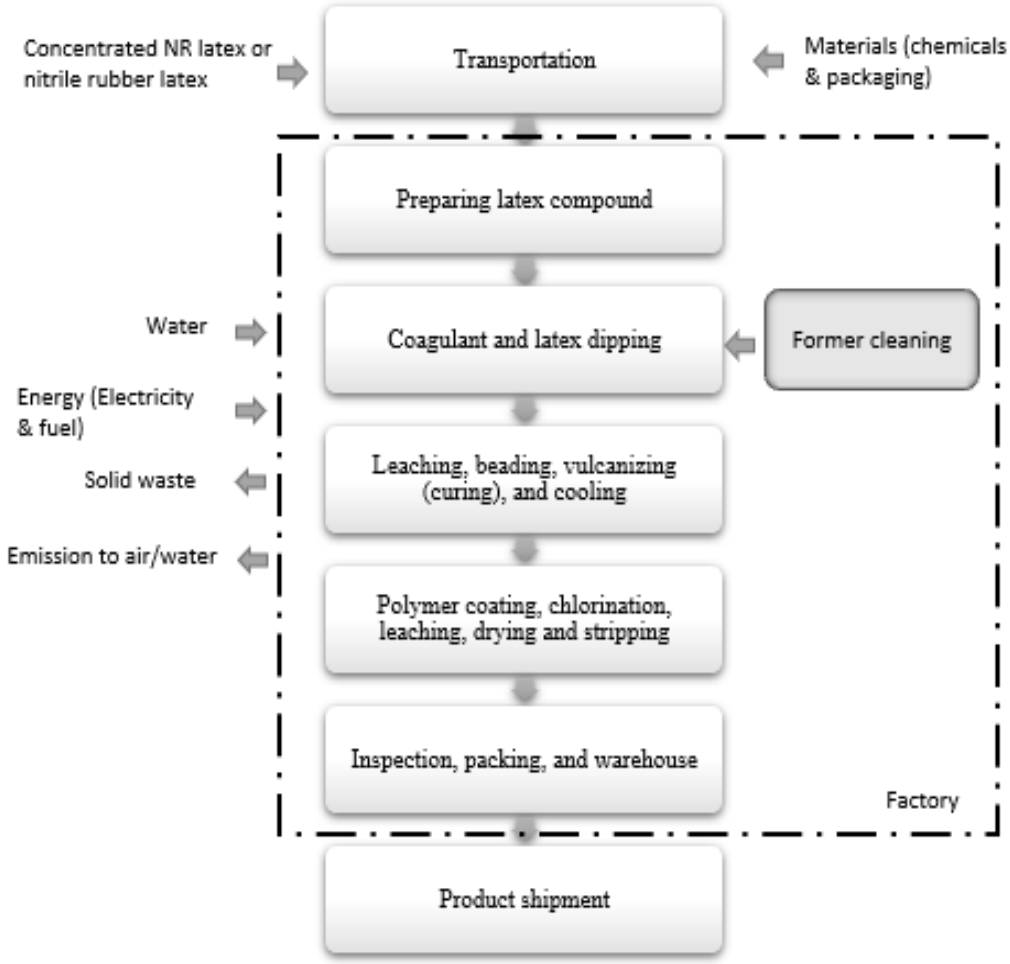


Figure 1.2 Manufacturing process of rubber glove

## 1.2 Problem Statement

Lately, there has been a rising concern about energy use and its unfavorable effect on nature. Since the most recent couple of decades, most of the developing countries have moved from horticulture towards industrialization and urbanization because of the economic growth. Gross domestic product (GDP) is defined as an aggregate measure of production equal to the sum of the gross values added of all resident institutional units engaged in production. (Azer et al., 2016). The development of the sector of industry, while promising a solid extension of the GDP, has anyway seriously influenced the capacity of the countries to preserve fuel reserves or supply.

The presentation of the idea of rational utilization of energy focuses at the reduction of utilization of energy and aims the ideal utilization of all inadequate economic resources. This definition shows that measures prompting to rational utilization of energy that would have preferences over the present circumstances. It is unquestionable that energy losses in an enormous number of industries be existent, and there is potential for energy efficiency enhancements.

The sudden triggering of increase in great demand for electric power and electricity of the nation leads to the high-energy utilization rate in the Malaysia's manufacturing industry and is anticipated to increase endlessly because of prompt economic development of the country.

Over the past 30 years (from 1970 to present), the electric power consumption in Malaysia has encountered an exponential increment and such verging trend will persevere as long as economic growth of the country continues to expand. Consecutively, electrical power consumption is known as the measurement of generation of electrical energy by power plants and combined heat and power plants with the seclusion of losses due to distribution, transmission, and transformation plus own use. Under the Tenth Malaysia Plan (2011-2015), Feed-in Tariff (FiT) is designed and targeted to achieve 985MW and 2080MW by 2015 and 2020 respectively from various types of RE resources and Malaysia plans for an additional 6 GW of new generation capacity between 2015 and 2020 to meet increasing demand (Tan et al., 2013).

Moreover, a lot of energy is wasted from the industrial and other sectors such as commercials due to poor management and uncontrolled energy utilization. Inefficient energy and poor power quality are also considered as another waste from these sectors. In the future, Malaysia as a rapidly developing country will have to overcome more energy deprivations, demands and crisis. This is because humankind depend on solely on electricity to sustain lives and for survival. Energy saving has been a significant topic these days in order to diminish any undesired power wastage and manage with the power demands in every country.

Percentage approximately 7.12% as compared to previous rates, the Malaysia's electricity tariff rate has been growing over the years. The growth of the tariff is because of verging rates of coal prices over the years. In order to phase out energy subsidies to local industries, the coal is actually serves as the raw material for power plants operation. The Malaysian government has recently declared that there will, again, be another rate revision of the electricity tariff rate effective on 1st January 2014 onwards. An increase of approximately 6% to 8% and 10% for industrial consumers will be experienced by the commercial consumers as the new the electricity bills.

A major impact on the monthly utility bills that are already troublesome as the new rates was increased around 16.8% to 17.1% and not disregarding the minimum monthly charge of RM 600.00 (TNB, 2014). It is generally known that industrial consumers depend intensely on electricity in their organizations and operations and utility costs have been an important part of the operational expenses of the consumers. In this way, the revised tariff rate will undeniably place an influence on the operational expenses for the industrial sectors. Significant energy saving in the industrial sectors plays an imperious role in depressing the operational costs of the consumers.

Energy is required for all the phases in the process of rubber product and it represents the main expenses for the utilization of a few of the equipment's such as oven blower motors, compressors, and chillers. The milling, extrusion and rolling process have a moderately higher electric power utilization, which is more than half of the total consumption, while the vulcanizing process has around 80% of the total consumption in the rubber industries. Fuels that are used in forming production process are electricity, natural gas, biomass, LPG, heavy oil and diesel.

## 1.3 Objective of study

The main objective of this research is to study carbon dioxide intensity towards carbon-neutral glove industry. The specific objectives of the studies are as following:

1. To quantify carbon intensity in ton $CO_2$ per thousand pieces of gloves produced at F24, Top Glove Sdn Bhd
2. To identify the possible energy saving measures and reduction of emission strategy at F24, Top Glove Sdn Bhd

## 1.4 Significance of study

Top Glove is the world's largest glove manufacturer and it has been running for quite some time since 1991. Therefore, the industrialization and innovations that are being done progressively in the company made some of the areas not maintained properly especially electrical consumption in the industry. For that reason, energy efficiency audit can be done to come out with the most optimized way in saving electrical energy for industrial blower motors. The blower motors might be outdated and not performing efficiently, consequent investigation is required to optimize the efficiency of the motors and to have less a consumption of electricity.

In Top Glove, averagely a plant has around 100 to 110 units of oven blower motors (the main consumer of electricity). The blower motor ranges from 10 HP to 15 HP based on the oven chamber's size and size of the oven itself. Each of the blower motor has the load ampere averagely around 10 to 15 amperes. This study focusses on the oven blower motors as that equipment are more significant compared to chiller compressor.

As in overall, in line with Top Glove business direction, to produce consistently high-quality gloves at efficient low cost and 2021 as the year of Environmental, Social and Governance (ESG), it is targeted to reduce GHG emission intensity by 23% (tonnes CO2-eq/1,000 pcs gloves) to 0.024 tonnes CO2-eq/1,000 pcs gloves by 2024 (Integrated Annual Report 2020). However, there is still no clear strategy or game plan on how to reach those aggressive reduction targets. Factory 24 have been chosen for this case study with average monthly production capacity of 120,000,000 pcs gloves.

## REFERENCES


ADB (Asian Development Bank), 2016. Asian Development Outlook 2016 Update: Meeting the Low Carbon Growth Challenge. <www.adb.org/sites/default/files/publication/197141/ado2016-update.pdf> accessed 10 September 2017.

Barlow, T. B. (1949). The Rubber Industry: A Study in Competition and Monopoly. International Affairs, 25(1), 82–82. https://doi.org/10.2307/3019084

Caineng, Z. O. U., XIONG, B., Huaqing, X. U. E., ZHENG, D., Zhixin, G. E., Ying, W. A. N. G., ... & Songtao, W. U. (2021). The role of new energy in carbon neutral. Petroleum exploration and development, 48(2), 480-491.

Carbon Brief (2017). Carbon Brief Paris Climate Pledge tracker. <www.carbonbrief.org/paris-2015-tracking-country-climate-pledges> accessed 11 September 2017.

Centi, G., Iaquaniello, G., & Perathoner, S. (2019). Chemical engineering role in the use of renewable energy and alternative carbon sources in chemical production. BMC Chemical Engineering, 1(1), 1-16.

Change, I. P. O. C. (2007). Climate change 2007: the physical science basis: summary for policymakers. Geneva: IPCC, 104-116.

CNCA. Carbon neutral cities alliance. https://carbonneutralcities.org/about/. [Accessed 19 February 2020].

de Pee, A., Pinner, D., Roelofsen, O., Somers, K., Speelman, E., & Witteveen, M. (2018). Decarbonization of industrial sectors: the next frontier. McKinsey global institute, 66.

Energy & Climate Intelligence Unit. Net zero emissions race. (2020-04-12)[2021-02-19]. https://eciu.net/netzerotracker.

Fleiter, T., Worrell, E., & Eichhammer, W. (2011). Barriers to energy efficiency in industrial bottom-up energy demand models - A review. Renewable and Sustainable Energy Reviews, 15(6), 3099–3111. https://doi.org/10.1016/j.rser.2011.03.025

Gudbjerg, E., & Andersen, H. (2007). Using coatings to reduce energy consumption in pumps and ventilators. 1533–1540.

Hashim, H., & Ho, W. S. (2011). Renewable energy policies and initiatives for a sustainable energy future in Malaysia. Renewable and Sustainable Energy Reviews, 15(9), 4780–4787. https://doi.org/10.1016/j.rser.2011.07.073

Hashim, H., Ramlan, M. R., Shiun, L. J., Siong, H. C., Kamyab, H., Majid, M. Z. A., & Lee, C. T. (2015). An Integrated Carbon Accounting and Mitigation Framework for Greening the Industry. Energy Procedia, 75, 2993–2998. https://doi.org/10.1016/j.egypro.2015.07.609

IEA, Global energy-related CO2 emissions, 1990-2021, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-energy-related-co2-emissions-1990-2021)

IPCC. Special report: Global warming of 1.5 □C. (2018-10-08)[2021-02-19]. https://www.ipcc.ch/sr15/.

IRNEA. Global renewables outlook: Energy transformation 2050. (2020-04-12)[2021-02-19]. https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020.

Jawjit, W., Kroeze, C., & Rattanapan, S. (2010). Greenhouse gas emissions from rubber industry in Thailand. Journal of Cleaner Production, 18(5), 403–411. https://doi.org/10.1016/j.jclepro.2009.12.003

Kluczek, A., & Olszewski, P. (2017). Energy audits in industrial processes. Journal of Cleaner Production, 142(2016), 3437–3453. https://doi.org/10.1016/j.jclepro.2016.10.123

Lai, J. H., Yik, F. W., & Man, C. S. (2012). Carbon audit: a literature review and an empirical study on a hotel. Facilities.

Lee, C. T., Lim, J. S., Van Fan, Y., Liu, X., Fujiwara, T., & Klemeš, J. J. (2018). Enabling low-carbon emissions for sustainable development in Asia and beyond. Journal of Cleaner Production, 176, 726-735.

Liu, D., Guo, X., & Xiao, B. (2019). What causes growth of global greenhouse gas emissions? Evidence from 40 countries. Science of the Total Environment, 661, 750-766.

Marinaro, L. (2018). Landscape for Future. Ri-Vista. Ricerche per la progettazione del paesaggio, (2), 5-12.

McKane, A., Desai, D., Matteini, M., Williams, R., & Risser, R. (2009). Thinking Globally : How ISO 50001 – Energy Management can make industrial energy efficiency standard practice. Environmental Energy Technologies, 1–16. https://doi.org/http://dx.doi.org/10.2172/983191

Melillo, J. M., Richmond, T. T., & Yohe, G. (2014). Climate change impacts in the United States. Third national climate assessment, 52.

Nations, U., & Development, I. (2012). Energy efficiency in electric motor systems: Technology, saving potentials and policy options developing countries.

Energy Efficiency in Electric Motor Systems: Technical Potentials and Policy Approaches for Developing Countries, January, 34.

PAS, W. (2014). 110: Specification for Whole Digestate, Separated Liquor and Separated Fibre Derived from the Anaerobic Digestion of Source-Segregated Biodegradable Materials. British Standards Institution: London, UK, 46.

Pask, F., Sadhukhan, J., Lake, P., McKenna, S., Perez, E. B., & Yang, A. (2014). Systematic approach to industrial oven optimisation for energy saving. Applied Thermal Engineering, 71(1), 72–77. https://doi.org/10.1016/j.applthermaleng.2014.06.013

Patrawoot, S., Tran, T., Arunchaiya, M., Somsongkul, V., Chisti, Y., & Hansupalak, N. (2021). Environmental impacts of examination gloves made of natural rubber and nitrile rubber, identified by life-cycle assessment. SPE Polymers, December 2020, 1–12. https://doi.org/10.1002/pls2.10036

Saidur, R., & Mekhilef, S. (2010). Energy use, energy savings and emission analysis in the Malaysian rubber producing industries. Applied Energy, 87(8), 2746–2758. https://doi.org/10.1016/j.apenergy.2009.12.018

Sorrell, S., O'Malley, E., Schleich, J., & Scott, S. (2004). The economics of energy efficiency, Introduction. The Economics of Energy Efficiency, 14(1), 186–192.

Tang, K., & Yeoh, R. (Eds.). (2007). Cut carbon, grow profits: business strategies for managing climate change and sustainability. Libri Pub Limited.

UK Government. The Climate Change Act 2008 (2050 Target Amendment) Order 2019. 2019. http:// www. legis lation. gov. uk/ ukdsi/ 2019/ 97801 11187 654/ pdfs/ ukdsi_ 97801 11187 654_ en. pdf. Accessed 03 Dec 2020.

UNFCCC. Paris agreement. 2015.

Van Der Schoor, T., & Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. Renewable and sustainable energy reviews, 43, 666-675.

Vernon, W. D., Wyman, B. M., Hubert, R. V., & Snyder, J. R. (1981). A device for measuring volatile organic-carbon emissions from cooling-tower water. Journal of the Air Pollution Control Association, 31(12), 1280-1282.

W H Golove and J H Eto. (1996). Market barriers to EE.

WRI (World Resources Institute), 2017b. <www.wri.org/blog/2017/04/interactive-chartexplains-worlds-top-10-emitters-and-how-theyve-changed> accessed 8 September 2017.

Yew, G. Y., Tham, T. C., Law, C. L., Chu, D., Ogino, C., & Show, P. L. (2018). PT SC. Materials Today Communications. https://doi.org/10.1016/j.mtcomm.2018.12.014

Zhang, Y. J., & Da, Y. B. (2015). The decomposition of energy-related carbon emission and its decoupling with economic growth in China. Renewable and Sustainable Energy Reviews, 41, 1255-1266.