Industrial development and greenhouse gas emissions in Indonesia

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Abstract. The manufacturing industry is the main source of Indonesia's economic growth. Its contribution to national GDP (gross domestic product) in 2012 is 22%, and it is expected to reach 30% in 2035. On the other hand, the industrial sector consumes energy which produces greenhouse gases. In 2017, the final energy consumption of the industrial sector was 232 million BOE (barrels of oil equivalent), slightly below the transportation sector, which was 362 million BOE. This study analyses the relationship between economic growth in the industrial sector and greenhouse gas emissions. Data for the period 2002-2018, with a cross section of 8 manufacturing industry subsectors, was analysed using regression models. The results of the analysis show that economic growth is positively related to greenhouse gas emissions, namely in the chemical fertilizer and rubber goods industries; cement and non-metal minerals industries; as well as raw metals iron and steel industries.

1. Introduction
Since 2004, Indonesia has been included in the group of middle income countries. According to the classification of the World Bank [1, 2] middle income country (MIC) is a group of countries with a GNI (gross national income) per capita between USD 1,036 to USD 4,045. Indonesia's GNI per capita in 2004 was USD 1,080 (category lower MIC), and continued to increase to USD 3,730 in 2013. Between the periods 2014-2019 there were fluctuations with an increasing trend. The highest per capita income occurred before the covid 19 pandemic, which was USD 4,063 in 2019. Although in 2020 it decreased to USD 3,870 per capita [3], but still in the upper MIC category.

Several countries in Latin America that are included in the MIC, experience the middle income trap (MIT) phenomenon [4]. Labor costs in MIC have increased, making it difficult to compete with low-wage countries. While labor productivity in MIC is still low, it is unable to compete with high-technology countries [5]. As a result, the commodities produced by MIC are not competitive in the world market. Investors withdraw their investment, consequently there is no economic growth.

To avoid MIT, [6] suggested that Indonesia should maintain economic growth above 6 percent. While [7], reveal that countries that can escape from MIT, have a growth in industry share of GDP (gross domestic product) 1.79%, countries that do not leave MIT have growth in industry share of GDP -0.04%. Spurring the growth of the manufacturing sector was also chosen by the government of Indonesia (GOI) to escape MIT. A strong manufacturing sector will directly improve the structure of the trade balance and employment patterns, which in turn will encourage economic growth [8].
GOI's efforts to develop the manufacturing sector have resulted in economic growth that is always above the world average. In 2019, Indonesia's economic growth reached 5.02%, while the world's was only 2.9%. The contribution of the manufacturing sector to national GDP (gross domestic product) is expected to continue to increase. In 2012 the contribution is 22%, and it is expected to reach 30% in 2035.

On the other hand, the industrial sector consumes energy which produces greenhouse gases. In 2017, the final energy consumption of the industrial sector was 232 million BOE (barrels of oil equivalent), slightly below the transportation sector, which was 362 million BOE. This study analyzes the relationship between industrial development and greenhouse gas emissions.

2. Research Method

This study uses national energy consumption panel data from the series of period 2002-2018 and a cross section of 8 manufacturing industry subsectors. Data were obtained from BPS (Badan Pusat Statistik: Central Bureau of Statistics Republic of Indonesia), Ministry of Energy and Mineral Resources and other related literature available online. Greenhouse gases emission is represented by CO₂ emission which is the dominant greenhouse gases. Researchers have pointed out that greenhouse gases present in the atmosphere consist of CO₂ (76%), sulphur dioxide SO₂ (7%), CH₄ Methane (13%), and nitrous dioxide N₂O (3%) [9], and the rest Fluorinated gases (CFCs, HCFs) 1% Hence to capture greenhouse gases the CO₂ emission approach is used [10]; [11]; [12]. CO₂ emissions (CEm) are calculated using the following formula:

\[ CEm = EE \times EC \] (1)

EE = equivalent energy (refer to Table 1)
EC = energy consumption (BOE)

Energy that is widely used by many industries in Indonesia is oil product, natural gas, and electricity. Only few industries use hydropower, geothermal, solar energy, wind energy or biomass. In 2019 energy use for electric generation consisted of coal (60.5%); gas (23.11%); new renewable energy (12.36%); and oil (4.03%) [13]. Therefore, the greenhouse gases emissions calculated in this paper are 3 dominant energies used by industry, with EE as shown in Table 1.

| Type of energy | ton CO₂ TJ⁻¹ |
|----------------|-------------|
| Oil            | 71.90 [14]  |
| Natural gases  | 56.10 [15]  |
| Electricity    | 81.69 [15]  |

TJ= terajoule = 10¹² joule = 163.4521085322 BOE

The relationship between industrial development and greenhouse emissions is analysed using the following multiple regression model:

\[ \ln CEm_{it} = \beta_0 + \beta_1 \ln X_{it} + D_i \] (2)

CEmᵢₜ = Carbon emission manufacture subsector i, year t (ton)
Xᵢₜ = GDP manufacture industry subsector i, year t (billion)
Dᵢ = dummy manufacture (Capital intensive = 1; labor intensive =0)
I = subsector industry (i= 1, 2..., 8), t: year (t = 2002,... 2018)
Ln = natural log
3. Result and Discussion

3.1. Industrial and Energy Consumption

In 2008 the industrial GDP had declined due to the weakening economy in the destination countries for exporting industrial products, namely America and Europe. The increase in industrial GDP is accompanied by an increase in energy demand.

Of the five groups of energy users (i.e. industrial, household, commercial, transportation, other), industrial consumes the second largest after transportation. The average national energy consumption during the 2009-2019 period was 856,381,820 BOE per year, where energy consumption for industry is 38.22% of national consumption, other groups are household 13.57%, commercial 4.85%, transportation 39.64%, and others 3.73%. Figure 1 shows the increase in energy consumption and the GDP of the industrial sector from 2006-2018.

![Figure 1. Energy consumption trends and GDP](image)

The use of energy by the industrial sector comes from natural gas; oil products and electricity (Table 2). Electricity does not produce CO₂ emissions, but to produce electricity, a generator that consumes energy is needed. Power plants in Indonesia predominantly use fossil energy. Of the existing power generation capacity, 33.8 GWh uses fossil energy, and only 3.9 GWh uses renewable energy.

| Table 2. Energy mix by industrial sector (%) | Gases | Oil | Electricity |
|---------------------------------------------|-------|-----|-------------|
| Food, drink and tobacco                     | 7.65  | 18.57 | 73.78       |
| Textiles, leather goods and footwear        | 6.94  | 36.12 | 56.94       |
| Wooden goods and other wooden goods         | 0.28  | 34.34 | 65.38       |
| Paper and printed matter                    | 28.92 | 30.64 | 40.44       |
| chemical fertilizer and rubber goods industries | 64.44 | 8.66 | 26.90       |
| cement and non-metal minerals               | 51.53 | 25.75 | 22.72       |
| Raw metals iron and steel                   | 20.65 | 31.40 | 47.95       |
| Transportation equipment, machinery and tool.| 0.00  | 32.32 | 67.68       |

The energy used by the industrial sector for production operations is dominantly derived from electricity. There are only 2 industrial sub-sectors that predominantly use gases, namely the fertilizer, chemical & rubber goods industry and the cement & non-metallic mining industry.

3.2. Industrialization and Greenhouse Gases

Any energy that is burned by the industrial sector will produce CO₂ which is greenhouse gases. Power plants for industry, also produce CO₂ gas. In 2019 the use of energy mix (equivalent to BOE) of national power plants is coal 60.5% (for 145,908 GWh), gases 23.11%, (43,889 GWh), oil 12.36% (3,560 GWh), and biofuels 4.03% (83 GWh) [15, 16] Based on the composition of the energy mix (Table 1) and the
energy mix of power plants, CO₂ emissions from the industrial sector during the study period were 70.326 Gg (Giga gram) to 89.229 Gg. Conditions in Indonesia are relevant to other developing countries where the use of fossil energy has increased by 90% [17]. The results of the analysis using a linear regression model obtained the relationship between industrial sector growth and CO₂ emissions as shown in Table 3.

Table 3. Predictor CO₂ emission by sector

| Subsector Industry                              | Constanta  | lnGDP     | D   | R-sq |
|------------------------------------------------|------------|-----------|-----|------|
| Food, drink and tobacco                         | 16.3225*** | -0.00008  | 0   |      |
| Textiles, leather goods and footwear            | 16.9062*** | -0.11906* | 67.6|      |
| Wooden goods and other wooden goods             | 14.566     | -0.0226   | 1.5 |      |
| Paper and printed matter                        | 13.925**   | 0.0762    | 5.4 |      |
| Chemical fertilizer and rubber goods industries | 16.0325*** | 0.09336*  | 64.0|      |
| Cement and non-metal minerals                   | 13.0578*** | 0.2136*** | 99.8|      |
| Raw metals iron and steel                       | 14.6934*** | 0.11083*  | 87.9|      |
| Transportation equipment, machinery and tool.   | 10.945**   | 0.3207    | 57.3|      |
| Industrial sector (pool).                       | 10.629***  | 0.4158*** | 1.76| 24.5 |

*Significant at 10%; ** at 5%; *** at 1%

From the linear model of each industrial sub-sector, it is obtained that there is a positive relationship between GDP and CO₂ emissions in the sub-sectors of the chemical fertilizer and the rubber goods industries; cement and non-metal minerals industries; and raw metal iron and steel industries. Likewise, in the linear model of the entire industry (pool model), GDP has a positive relationship with CO₂ emissions. However, in the industry of textile, leather goods and footwear, GDP is negatively related to CO₂ emissions.

In sub-sectors of the chemical fertilizer and the rubber goods industries; cement and non-metal minerals industries; and raw metal iron and steel industries, every 1% increase in GDP will increase CO₂ emissions by 0.09336%, 0.2136% and 0.11083%, respectively. In the industry as a whole (industrial sector), every 1% increase in GDP will increase CO₂ emissions by 0.4158%. While every 1% increase in GDP of the textile, leather goods and footwear industry will reduce CO₂ emissions by 0.12%. The negative relationship between GDP and CO₂ emissions in the textile industry, because of the fashionable nature of the textile industry. The added value in this industry, is created through the creativity of human resources that does not require energy.

4. Conclusion
Three sources of energy are used by industry in Indonesia, respectively, from the most dominant, namely electricity, gas and oil. Increasing GDP in sub-sectors of the chemical fertilizer and the rubber goods industries; cement and non-metal minerals industries; raw metal iron and steel industries; and industry sector as a whole (pool industries), will increase CO₂ emissions. Increasing in the GDP of industry of textile, leather goods and footwear, will reduce CO₂ emissions.

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References
[1] World Bank 2014 Data: Indicators. http://data.worldbank.org/indicator (checked on February 3rd 2015).
[2] World bank 2021. https://www.worldbank.org/en/country/mic/overview (checked on July 1st 2021)
[3] World bank 2020. (https://data.worldbank.org/indicator/NY.GNP.PCAP.CD?view (checked on July 1st 2021)
[4] Wilson WT 2014 Beating the Middle-Income Trap in Southeast Asia. The Heritage Foundation Report 156. (checked February 5th 2015)
[5] Pope E 2011: Latin America's Middle Income Trap. In Americas Quarterly 5 (1), checked on January 24th 2018
[6] Diop 2014. Indonesia Avoiding the Middle Income Trap. Research and analysis. July 2014 Available: https://www.gov.uk/government/publications/indonesia-avoiding-the-middle-income-trap
[7] Bulman D, Eden M and Nguyen H 2016 Transitioning from Low-Income Growth to High-Income Growth: Is There a Middle-Income Trap?. ADBI Working Paper 646. Tokyo: Asian Development Bank Institute. Available: https://www.adb.org/publications/transitioning-low-income-growth-high-income-growth
[8] Bank Indonesia 2013 Kajian Ekonomi dan Keuangan Regional. Laporan Nusantara, 8 (3), Oct 2013.
[9] Berrou A, Raybaut M, Godard A, Lefebvre M 2009 High-resolution photoacoustic and direct absorption spectroscopy of main greenhouse gases by use of a pulsed entangled cavity doubly resonant OPO, Appl. Phys. B Lasers Opt. 98 (1) (2009) 217.
[10] Grande CA, Ribeiro RPL, Oliveira ELG, and Rodrigues AE 2009. Electric swing adsorption as emerging CO2 capture technique. Energy Procedia 1 (1) pp 1219–1225, https://doi.org/10.1016/j.egypro.2009.01.160.
[11] Koytsoumpa EI, Bergins C and Kakaras E 2018 The CO2 economy: review of CO2 capture and reuse technologies, J. Supercrit. Fluids 132 pp 3–16.
[12] Olajire AA 2010 CO2 capture and separation technologies for end-of-pipe applications—a review, Energy 35 (6) 2610–2628
[13] Directorate General of New Renewable Energy and Conservation [Direktorat Jenderal Energi Baru Terbarukan dan Konservasi] 2019. Paparan Bahan Status EBT per Akhir 2019.
[14] IPCC 2006. Guidelines for National Greenhouse Gas Inventories Volume 2
[15] IESR Institute for Essensial services reform 2020. https://iesr.or.id/gunakan-kendaraan-listrik-untuk-mengurangi-emisi-co2
[16] ESDM 2020. https://www.esdm.go.id/id/publikasi/handbook-of-energy-economic-statistics-of-indonesia
[17] He JK 2015. China’s INDC and non-fossil energy development, Adv. Clim. Chang. Res. 6 (3) 210–215.