Decomposition analysis of ASEAN countries CO₂ emissions from electricity generation

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Abstract ASEAN is a group of countries in the south east asia that promotes economic political and security cooperation among its members. The demand for energy has increase by approximately 60% in the last 20 years. About 4 % of the Global carbon dioxide emission was emitted from the region in 2014 and there is an expectation that it will rise. Economy, population and share of energy mix has an effect to the carbon dioxide emission therefore understanding the driving factor is vital to have a preparation and planning for the development of the right policies. Using LMDI method, the study aims the identification of the main driving factors of carbon dioxide emission of the ASEAN during the 1974 to 2014 period. The results show that the growth in the economy have the largest impact for the increased carbon dioxide emissions followed by the energy structure and the population, however, the energy intensity helped to reduce the carbon emission. The results suggest that to have a change to cleaner energy would decrease emission. A proper management of energy through the improvements of technology would potentially be ableable to reduce the emissions.

Keywords: Decomposition analysis, ASEAN, CO₂, Emissions,Philippines

1. Introduction: Study Objectives and Methodology

This paper summarizes an analysis of the primary factors driving carbon dioxide (CO_2) emissions from electricity generation in the Association of Southeast Asian Nations (ASEAN) between 1974 and 2014. During this period, ASEAN's energy demand surged by roughly 60% in the two decades leading up to 2014, when the region contributed about 4% of global CO_2 emissions—a figure expected to rise. This is critical as ASEAN countries face the challenge of meeting growing energy needs sustainably, especially given Southeast Asia's climate change vulnerability.The study employed the Logarithmic Mean Divisia Index (LMDI) method to break down CO_2 emission changes into driving factors: economic activity, population growth, energy structure (fuel mix), and energy intensity. This detailed understanding aims to inform proactive policymaking by highlighting the long-term impacts of current energy trends. The analysis covered nine ASEAN nations (Brunei, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam; Laos was excluded due to missing data), using data mainly from the World Bank. While offering a regional view, the study notes that diverse economic development and energy resources among member states mean effective policies will likely require country-specific strategies.

2. Key Trends in ASEAN's CO2 Emissions and Energy Landscape (1974-2014)

Between 1974 and 2014, CO2 emissions from electricity generation in the analyzed ASEAN countries rose rapidly, especially from 1991 to 2014, totaling a 1389 million metric ton (mTon) increase. This highlights the growing environmental impact of the region's economic and energy growth.

In 2014, Indonesia was the largest CO2 emitter from electricity, while Cambodia was the lowest, reflecting differences in industrial scale, population, economy, and energy mix. Brunei Darussalam's emissions, for example, were mainly from natural gas, unlike most other members who relied more on coal and oil.

A significant shift occurred in power generation: natural gas usage surged from 3.6% of the energy mix in 1980 to 45% in 2014, and coal reached approximately 33% by 2014, while oil use declined. Though moving from oil (partly to reduce emissions) is positive, the substantial rise of coal challenges decarbonization efforts. Investments in coal and gas infrastructure could create a "lock-in" effect, slowing a shift to renewables. By 2014, many ASEAN nations had similar CO2 emission shares due to comparable energy use patterns developed over the prior two decades. Indonesia's status as the top regional emitter underscores its pivotal role in ASEAN's collective emission reduction success.
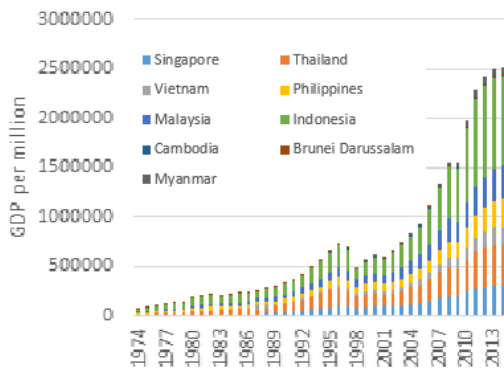
Figure 1. Gross Domestic Product per million of ASEAN countries (LAO being excluded) extracted form world bank 2019

Figure 2. Plots of different indicator that contributes to CO2 emissions

3. Primary Factors Driving CO2 Emissions: An LMDI Decomposition

The LMDI decomposition analysis pinpointed key drivers of CO2 emissions from ASEAN's electricity sector:

- **Economic Growth (Activity Effect):** The primary driver of increased CO_2 emissions.
- **Energy Structure (Fuel Mix Effect):** The second largest contributor, mainly due to greater reliance on carbon-intensive fuels like coal.
- **Population Growth (Population Effect):** Consistently pushed emissions up due to a steadily increasing populace.
- **Energy Intensity (Intensity Effect):** Helped mitigate emissions, indicating progress towards energy efficiency (less energy per GDP unit). However, this was outweighed by economic growth and fuel mix changes.

The 1997 Asian financial crisis caused a temporary CO_2 dip (approx. 3800 kilotons) from reduced economic activity. Concurrently, poor energy sector management during the crisis negatively impacted energy intensity, increasing its emission contribution by about 8000 kilotons. This highlights how economic shocks can disrupt energy management and negate efficiency gains.

4. Conclusions and Strategic Policy Directions

The analysis concludes that economic growth (GDP) and increasing population are the primary forces behind rising CO2 emissions from electricity generation in ASEAN, with economic activity exerting a considerably larger influence. The structural shift in the energy mix towards more carbon-intensive sources also plays a significant role. Conversely, improvements in energy intensity have served as a mitigating factor.
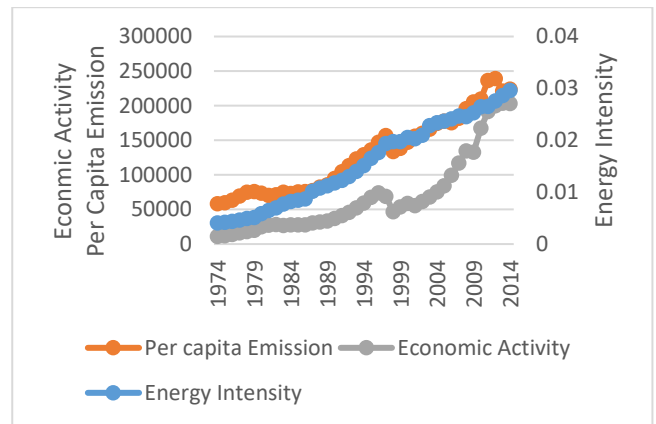
The findings suggest that transitioning to cleaner energy sources and enhancing energy efficiency through technological advancements are viable pathways to reduce emissions. Key policy recommendations derived from the study include:

1. **Improving energy management planning** to strategically integrate more clean and renewable energy sources into the regional power structure.
2. **Promoting energy efficiency** through ecological industrial development, thereby reducing the energy intensity of economic activities.
3. **Providing robust incentives** to support the deployment and competitiveness of renewable energy technologies.

Effective implementation and governance of these policies are as crucial as the policies themselves, as underscored by the negative consequences of "improper management" during the 1997 crisis. An overarching imperative is the adoption of proper energy management practices to achieve higher-level economic growth sustainably, especially in the context of an increasing regional population. Therefore, policies that foster innovation and continuous improvement in energy sources are deemed essential for the long-term environmental and economic well-being of ASEAN nations. The regional scope of the analysis also implicitly calls for enhanced cooperation among ASEAN member states in navigating the energy transition and formulating climate policy, complementing individual national efforts. Ultimately, the study points towards a long-term vision where sustainable practices and economic development are pursued concurrently through strategic energy choices and technological innovation.

References
1. World Bank. "C02 Emissions (Metric Tons Per Capita)." *World Development Indicators*, The World Bank Group, 2015, data.worldbank.org/indicator/EN.ATM.CO2E.PC.
2. Ang BW. The LMDI approach to decomposition analysis: a practical guide. Energy Policy 2005;32:1131–9.

3. Weisbrot, Mark (August 2007). *Ten Years After: The Lasting Impact of the Asian Financial Crisis*. Center for Economic and Policy Research.
4. International Energy Agency (IEA), 2014. CO2 Emissions from Fuel Combustion, 2014 ed.