Analysis of Causality Relationship Energy Consumption and CO₂ Emissions to Economic Growth based on the LEAP Model (Case Study of Energy Consumption in Indonesia 2010-2025)

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Abstract. This study discusses scenarios and analyzes the causal relationship of energy consumption and CO_2 emissions to economic growth in Indonesia period 2010-2025. The modeling scenario is divided into 6 sections, namely BAU scenario, High scenario, Low scenario, High-Low scenario, Low-High scenario and Policy scenario. The result of scenario data is processed by performing statistical data modeling and econometric period 2010-2025. The research method used interpolation method and causality testing method. The tools are used in this research is LEAP and EViews. LEAP is used for energy modeling as well as CO_2 emissions and EViews is used to manage data, analyze econometrics and statistics. The results of this study show that economic growth, energy consumption and CO_2 emissions at 6 scenario indicate fluctuated competitive growth. This study proves that only 1 scenario has direct causality relationship that is only energy consumption which statistically significant influence economic growth in Policy scenario. For economic growth and CO_2 emissions there are 4 scenarios that have direct causality (BAU, High, High-Low, Low-High scenario), 1 scenario has no causality relationship (Low scenario) and 1 scenario has two-way causality relationship (Policy scenario).

Keywords: **Energy Economic; Economic Growth; Energy Consumption; CO₂ Emission.**

1 Introduction

Causality relationship research has been widely carried out by researchers as a step in planning and as a tool in management decisions. The research on causality relationships in the energy sector has been carried out by various countries by considering various parameters in the scope of energy consumption, energy costs, environment, emissions, population growth, economic growth, finance etc. In determining the causality relationship, the researchers used granger causality to determine the direction of the causality relationship. Empirical evidence shows that causality relationships have a relationship with policies and have a direct impact on the policies implemented [1].

Various causality studies have been widely published and have different time, location, parameters and methodologies [2-23]. This study discusses the scenario and causality analysis about energy consumption, CO_2 emissions and economic growth in Indonesia based on scenario 2010-2025. Data used period 2010-2016. The data is calculated based on the Growth Model 2010-2025 rule. The calculation result of growth rate is interpreted causality of economic growth and energy consumption as well as economic growth and CO_2 emission.

The results of this study can be used as the foundation of policy making especially in the energy field. Policies can be reviewed from energy conservation, emission reduction and economic performance [24]. The policy scenario from this research can makes it possible to realize low carbon / low carbon community projects with use of efficient fuels, stabilize the economic growth and low carbon emissions with use environmentally friendly technologies.

2 Theory and Methodology

2.1 Research parameters

The energy sector has an important role in life in society. Energy sector is one of the important sectors for development and economic growth in Indonesia. All sectors of industrial, transportation, household, commercial and other sectors can not be separated from energy needs.

Energy is the ability to do work that can be heat, light, mechanics, chemistry, and electromagnetics. Energy Source is something that can produce Energy, either directly or through conversion or transformation process. Energy Resources are natural resources that can

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be utilized, both as a Source of Energy and as an Energy [25].

Energy consumption in Indonesia is categorized into five sectors, namely household sector, industrial sector, commercial sector, transportation sector and other sectors. Indonesia's total energy consumption from 2010-2016 is experiencing an increasing rate of growth. Three big of energy consumption is household sector, industrial sector and transportation sector. Total Indonesian energy consumption (Thousand BOE) from 2010 (1,048.00), 2011 (1,151.40), 2012 (1,230.10), 2013 (1,148.50), 2014 (1,170.20), 2015 (1,145.00), 2016 (1,130.60) [26].

Indonesia's economic growth shows improved performance in the last few decades. This is a result of government policies that are able to demonstrate effective and efficient national development so that people can enjoy better economic progress after the Asian crisis. However, Indonesia's economic growth in several years experienced a slowdown but not significant. This happens because of slowing investment and infrastructure constraints. In the international context, there are lower commodity price pressures that cause growth slowdown [27].

Population growth in Indonesia has increased growth. The total population of Indonesia until 2016 reached 258.7 million people with a growth rate of 2010-2016 is 1.4%. Projected with the current policy conditions, the year 2025 will experience an increase in population [28].

2.2 LEAP

LEAP is one of the best energy planning software for researcher make the projects easily. Various countries have used LEAP to conduct energy planning in the country to manage about energy resources. Ability and complete features to perform statistical data processing, analysis of climate change and energy makes the LEAP better than other energy planning software. The ease of the software interface makes it easy for users to apply research using LEAP [29].

2.2 Eviews

Eviews is software that is used to perform statistical data processing and econometric analysis. This software is widely used to conduct research. Easy software interface, helps researchers to do their work effectively and efficiently. For projects that can be done by Eviews include financial, energy, cost analysis, and macroeconomic projections etc. [30].

3 Research Model

In the scenario for this study, it is assumed based on 6 scenario models. The scenario consists of BAU, High, Low, High_Low, Low_High and Privacy scenario. Here the explanation of the scenario.
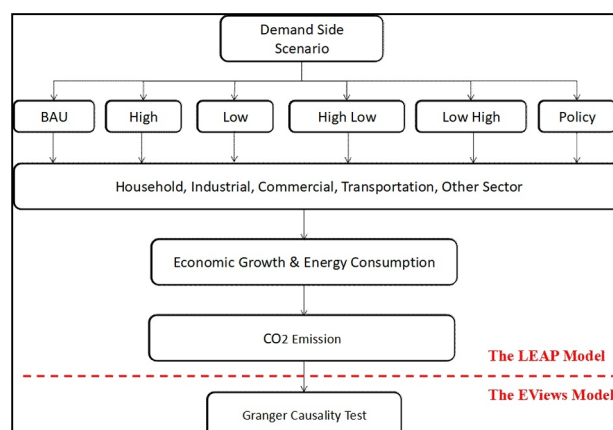

Fig. 1. Framework Scenario

Data from 2010-2016 are modeled, calculated and projected using LEAP. The result of the projection is analyzed causality relationship with Granger Causality Test method. The result of this research is the projection of energy consumption and the causality relationship between several variables.

4 Result

The projection of Indonesian energy consumption refers to calculations of BAU scenario, High scenario, Low scenario, High-Low scenario, Low-High scenario and Policy scenario. Total energy consumption is projected in 2025 from BAU scenario (1,649.8 million BOE), High scenario (2,073 million BOE), Low scenario (1,393.3 million BOE), High-Low (1,393.3 million BOE), Low-High scenario (2.073 million BOE) and Policy scenario (1,587.6 million BOE).

This study have different results with BPPT. The difference value is not too large with the policy scenario from this study. Total energy consumption BPPT from the Base scenario 1,472 Million BOE and High scenario 1,566 Million BOE [31].

4.1 BAU Scenario

Growth rate of BAU scenario 2011-2025 for economic growth (-3.47%), energy consumption (3.15%), CO_2 emission (-0.96%). This study proves statistically, there is no causality relationship between economic variable and energy consumption variable. Economic variables and CO_2 variables indicate one-way causality relationship that economic variables statistically significant influence the variable CO_2. Here is the impulse response BAU scenario.
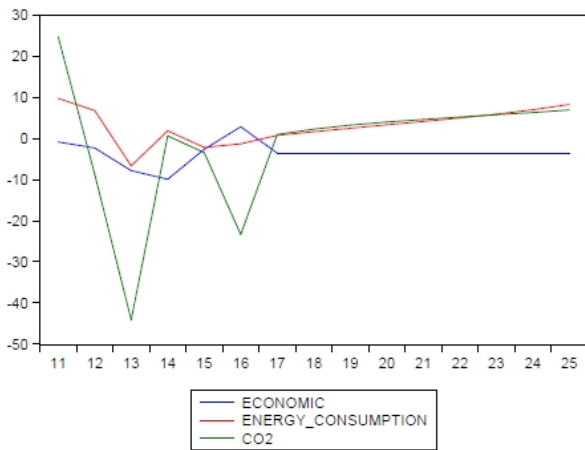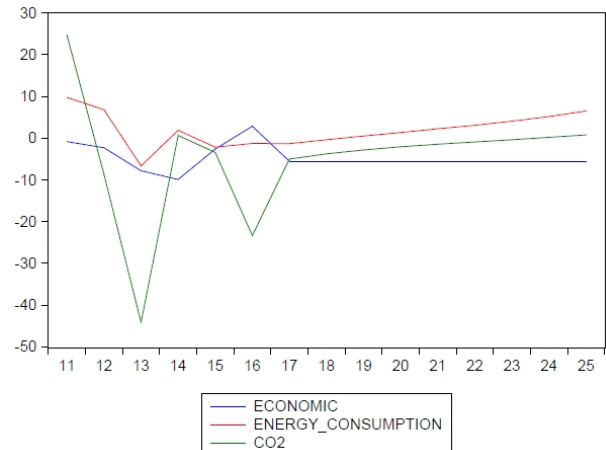
Fig. 2. Impulse response BAU scenario

4.2 High Scenario

Growth rate of High scenario 2011-2025 for economic growth (-2.27%), energy consumption (4.76%), CO_2 emission (5.79%). This study proves statistically, there is no causality relationship between economic variables and energy consumption variable. Economic variables and CO_2 variables indicate one-way causality relationship that economic variables statistically significant influence the variable CO_2. Here is the impulse response High scenario.
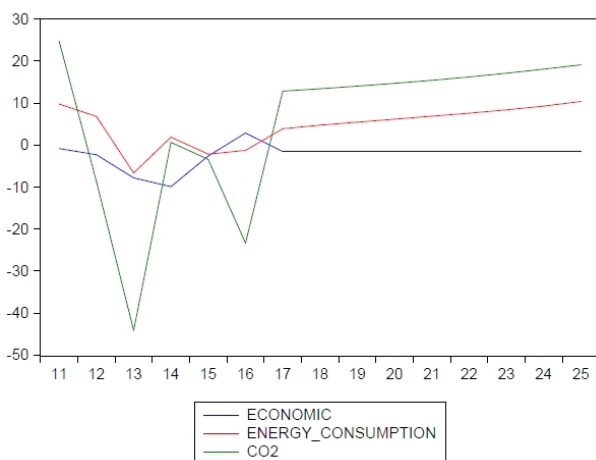

Fig. 3. Impulse response High scenario

4.3 Low Scenario

Growth rate of Low scenario 2011-2025 for economic growth (-4.67%), energy consumption (1.99%), CO_2 emission (-4.63%). This study proves statistically, there is no causality relationship between economic variables and energy consumption variable. Economic variables and CO_2 variables statistically does not occur causality relationship. Here is the impulse response Low scenario.

Fig. 4. Impulse response Low scenario

4.4 High-Low Scenario

Growth rate of High-Low scenario 2011-2025 for economic growth (-2.27%), energy consumption (1.99%), CO_2 emission (-6.9%). This study proves statistically, there is no causality relationship between economic variables and energy consumption variable. Economic variables and CO2 variables indicate one-way causality relationship that only economic variables statistically significant influence the variable CO_2. Here is the impulse response High_Low scenario.
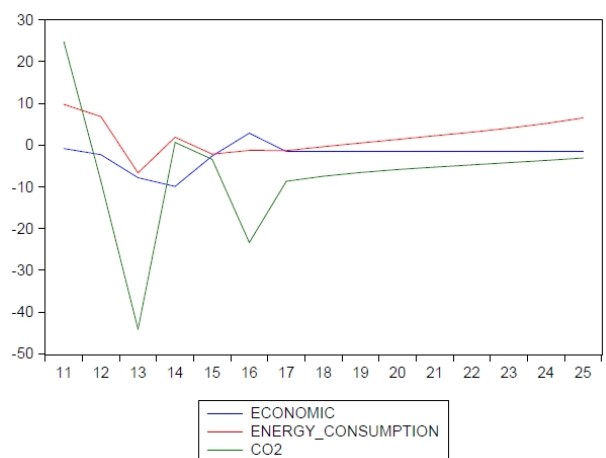

Fig. 5. Impulse response High-Low scenario

4.5 Low-High Scenario

Growth rate of Low-High scenario 2011-2025 for economic growth (-4.67%), energy consumption (4.76%), CO_2 emission (8.57%). This study proves statistically, there is no causality relationship between economic variables and Energy Consumption variable. Economic variables and CO_2 variables indicate one-way causality relationship that only economic variables that statistically significant affect the CO_2 variable. Here is the impulse response Low-High scenario.
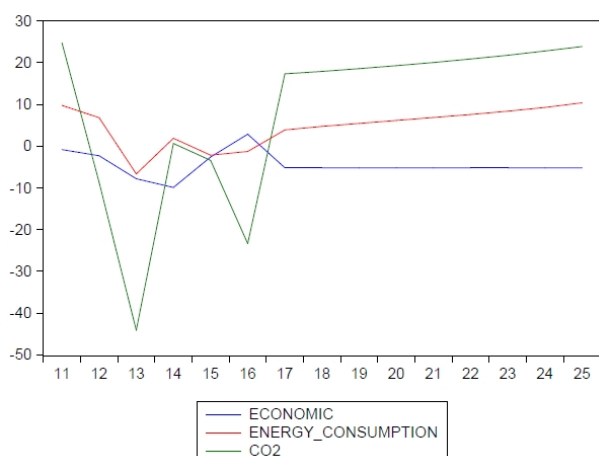
Fig. 6. Impulse response Low-High scenario

4.6 Policy Scenario

Growth rate of Policy scenario 2011-2025 for economic growth (0.9%), energy consumption (2.88%), CO_2 emission (-0.94%). This study proves statistically one-way causality relationship that Energy_Consumption variable statistically significant affect economic variables. Economic and CO_2 variable shows two-way causality between economic and CO_2 variables. Here is impulse response Policy scenario.
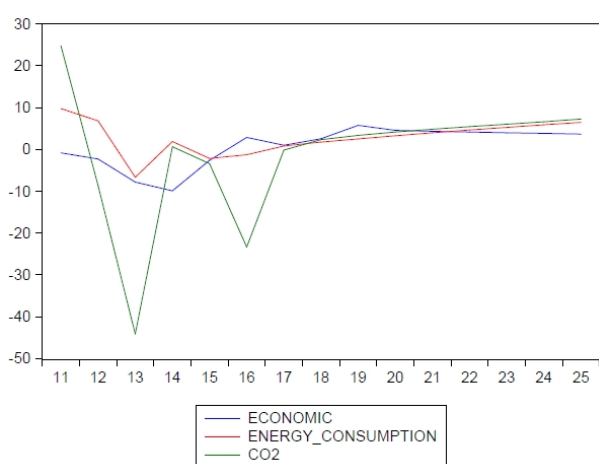

Fig. 7. Impulse response Policy scenario

5 Conclusion

The results show that economic growth, energy consumption and CO_2 emissions at 6 scenario indicate fluctuated competitive growth. This study proves that only 1 scenario has direct causality relationship that is only energy consumption which statistically significant influence economic growth in Policy scenario. For economic growth and CO_2 emissions there are 4 scenarios that have direct causality (BAU, High, High-Low, Low-High scenario), 1 scenario has no causality relationship (Low scenario) and 1 scenario has two-way causality relationship (Policy scenario).

The results of this study can developed into policy-making based on causality direction. The policy as follows maintain the stability of economic growth, develop energy-efficient infrastructure, implement energy efficiency, energy use policy, utilization of raw materials and processing using low technology emission and environmental quality improvement. For simplicity in policy formulation, policy formulation should be assessed on the basis of appropriate data. Data processing can be assisted using decision-making system so that policy can run in the direction of causality.

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