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# Ekonomi Energi:
## Pemodelan Empiris untuk Analisis Kebijakan

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# Apa itu “Model”?

- Model adalah deskripsi sederhana dari sebuah sistem yang digunakan untuk menjelaskan bagaimana sesuatu bekerja atau untuk menghitung apa yang mungkin terjadi jika sesuatu dilakukan (Hornby, 2000)

- Model sebagai suatu kerangka kerja formal untuk mewakili fitur dasar dari sebuah sistem yang kompleks (Samuelson dan Nordhaus, 1998)

- Beberapa definsi lain bisa dilihat pada Begg, Fischer, dan Dornbusch (2000)

# Apa itu Model Ekonomi?

Di bidang ekonomi, model didefinisikan sebagai konstruksi teoretis yang mewakili proses ekonomi dan melalui satu set variabel dan satu set hubungan logis atau kuantitatif antara keduanya.

Sebuah model hanyalah sebuah kerangka kerja yang dirancang untuk menunjukkan proses ekonomi yang kompleks. Kebanyakan model menggunakan teknik matematika untuk menyelidiki, berteori, dan mencoba menyesuaikan teori ke dalam situasi ekonomi.

# Mengapa Ekonom membutuhkan “model”?

Ekonom menggunakan pendekatan ilmiah untuk mengatasi masalah ekonomi (menjelaskan proses ekonomi dan memeriksa masalah ekonomi)

Ekonom menggunakan model untuk mendapatkan pemahaman yang lebih baik tentang bagaimana sesuatu bekerja, untuk mengamati pola, dan untuk memprediksi hasil stimulasi.

Ekonom menggunakan model ekonomi dengan alasan:

- Model ekonomi memiliki kerangka teori yang konsisten untuk menganalisis masalah-masalah kebijakan
- Model ekonomi dapat membantu lebih banyak pertimbangan intelektual dalam memilih kebijakan
- Model ekonomi lebih bersifat melengkapi, bukan menggantikan proses penyusunan kebijakan

# Jenis-Jenis Model

- Stochastic models

  Model Ekonometrika

  DSGE

- Non-stochastic mathematical models

  Model Optimisasi

  Model Keseimbangan Umum

- Qualitative models

# Jenis-Jenis Model

## Model Ekonometrika

- Dapat digunakan untuk menjawab pertanyaan ketika suatu variabel ekonomi memiliki dampak terhadap variabel yang penting:

  *- Apakah tarif akan menurunkan volume perdagangan? Seberapa besar?*

- Alat untuk memberikan proyeksi namun sebagian besar tanpa informasi mengenai struktur ekonomi.

## Simulasi Model

- Untuk menjawab pertanyaan: “Bagaimana jika” dan “Perkiraan Dampak”:

  - Model Keseimbangan Parsial dan Model Keseimbangan Umum.

# Model Ekonometrika

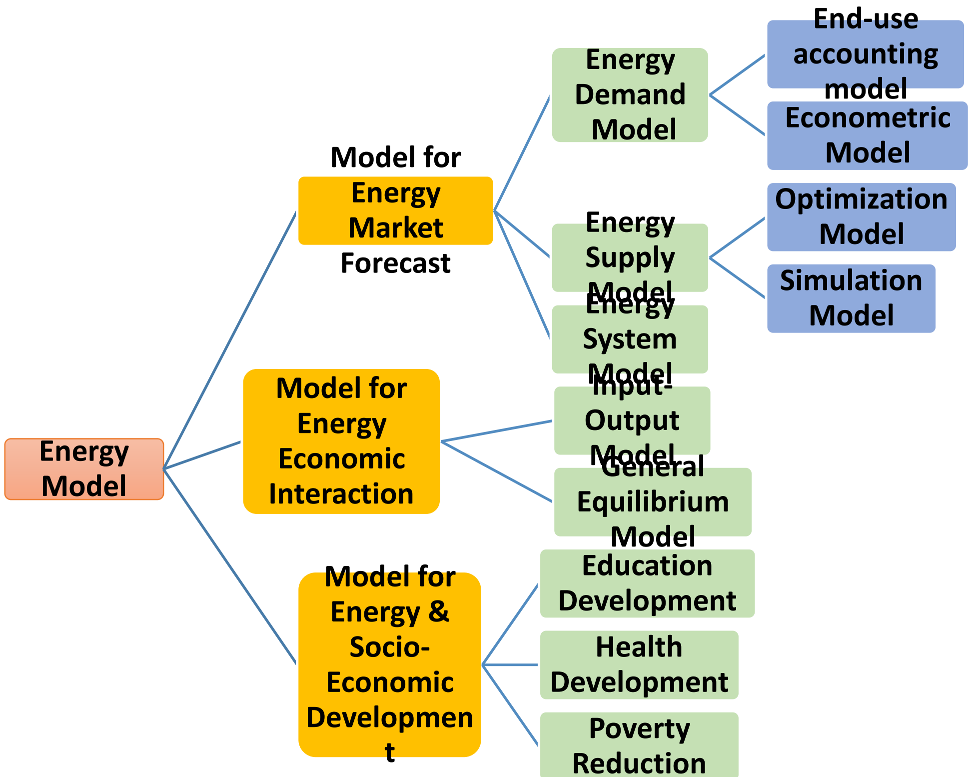
Kerangka Pemodelan Berdasarkan Jenis Data

- Time Series
  - Single Variable: Dekomposisi, ARIMA
  - Persamaan Tunggal: RLS/RLB, ARCH/GARCH, ECM, LDV
  - Sistem Persamaan: SUR, VAR, VECM, Simultan
- Cross Section
  - Persamaan Tunggal
  - Sistem Persamaan
  - Spatial Econometrics
- Panel/Pool
  - Panel Regression
  - Panel Cointegration
  - Dynamic Panel
  - Spatial Econometrics

# Model Simulasi

- Input-Output (IO)/IRIO
- Social Accounting Matrix (SAM)/IRSAM
- Computable General Equilibrium (CGE)/IRCGE
- DRCGE
- DSGE

# Klasifikasi Model Energi




- Ada banyak klasifikasi model energi, dimana dapat dilihat dari berbagai aspek antara lain tujuan dari model yang digunakan, jenis metodologi, pendekatan matematis yang digunakan dan lain sebagainya.
- Model Energi dapat diklasifikasikan menjadi 3 kelompok, yaitu model energi untuk prediksi pasar, interaksi ekonomi, dan pembangunan sosial-ekonomi

Source: Bhattacharyya, 2011

# Model untuk Energi dan Interaksi Ekonomi

- Setiap pilihan skenario keseimbangan permintaan dan pasokan energi memiliki dampak yang berbeda terhadap perekonomian suatu negara. Analisis dampak penting untuk mendapatkan skenario yang paling tepat.
  - Dengan menggunakan model untuk menganalisis dan membandingkan simulasi kuantitatif dari berbagai kemungkinan kebijakan, diharapkan pemerintah dapat mengidentifikasi kebijakan terbaik atau kombinasi kebijakan terbaik, menghindari kebijakan yang tidak konsisten, dan mencapai *trade-off* yang optimal dari berbagai tujuan yang mungkin bertentangan satu sama lain.
- Manfaat penggunaan model simulasi akan semakin besar jika model yang digunakan bersifat multisektoral, dengan membedakan komoditas yang berbeda konsumsi dan produksinya. Jenis model ini disebut Model Dampak Luas Ekonomi.
  - Termasuk dalam kelompok model ini adalah model Input-Output, model *Social Accounting Matrix* (SAM) dan model *Computable General Equilibrium* (CGE).

# Model untuk Energi dan Interaksi Ekonomi

## Model Input-Output

- ***Output multiplier*** digunakan sebagai dasar untuk melihat keterkaitan antar sektor dalam suatu sistem ekonomi.
- Keterkaitan antar sektor tersebut meliputi keterkaitan ke depan *(forward linkage)* dan keterkaitan ke belakang *(backward linkage).*
- ***Forward linkage*** menunjukkan hubungan yang disebabkan oleh penjualan output satu sektor dengan penjualan output semua sektor dalam suatu perekonomian
- ***Backward Linkage*** menunjukkan hubungan yang dihasilkan dari penjualan output satu sektor dengan total pembelian input dari semua sektor dalam suatu perekonomian.

SpringerLink

Research Article | Published: 07 November 2020

### The drivers of energy-related $CO_2$ emission changes in Indonesia: structural decomposition analysis

Sasmita Hastri Hastuti, Djoni Hartono, Titi Muswati Putranti & Muhammad Handry Imansyah

*Environmental Science and Pollution Research* **28**, 9965–9978 (2021) | Cite this article

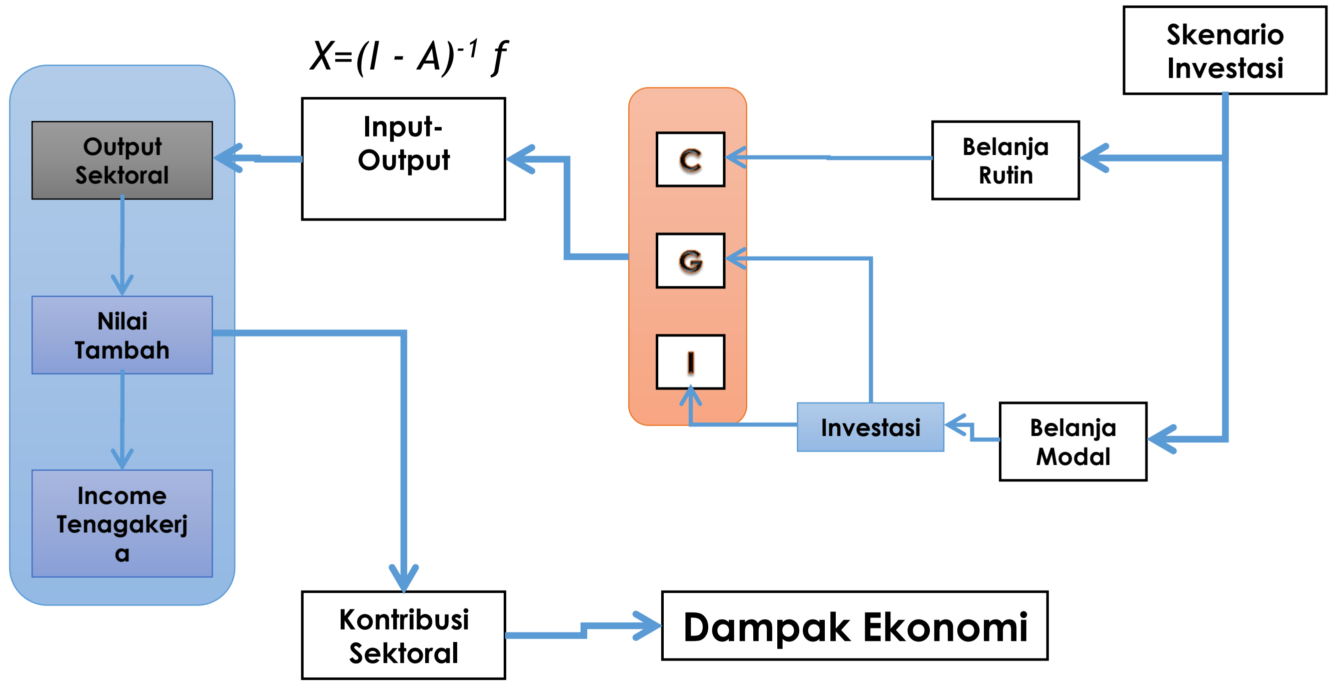
**Table 3** Driving factors of $CO_2$ emission changes

*000 tons*

| , | Carbonization factor | Energy intensity factor | Technology factor | Demand structure factor | Demand allocation factor | Final demand (scale effect) | Total change in emission |
|---|---|---|---|---|---|---|---|
| | ($\Delta e_C$) | ($\Delta e_E$) | ($\Delta e_I$) | ($\Delta e_S$) | ($\Delta e_D$) | ($\Delta e_F$) | ($\Delta e$) |
| 1990–1995 | 717 | 441 | 1200 | 914 | − 534 | 28,544 | 31,283 |
| in % | 2.3% | 1.4% | 3.8% | 2.9% | − 1.7% | 91.2% | 100.0% |
| 2010–2015 | 500 | 65,985 | 10,755 | − 24,162 | − 1082 | 69,438 | 121,433 |
| in % | 0.4% | 54.3% | 8.9% | − 19.9% | − 0.9% | 57.2% | 100.0% |

Source: Author's Calculation (2020)

# Analisis Dampak Ekonomi



# Model untuk Energi dan Interaksi Ekonomi

*Social Accounting Matrix (SAM)*

**SAM** merupakan kerangka data yang dapat menggambarkan perekonomian secara keseluruhan dan dapat menghubungkan berbagai aspek sosial dan ekonomi di negara yang bersangkutan (Pyatt dan Round, 1990).

Heliyon

CellPress

Volume 6, Issue 6, June 2020, e04120

Research article

Comparing the impacts of fossil and renewable energy investments in Indonesia: A simple general equilibrium analysis

Djoni Hartono [a, b], Sasmita Hastri Hastuti [b], Alin Halimatussadiah [a], Atina Saraswati [b], Aria Farah Mita [a], Vitria Indriani [a]

Springer Link

Research Article | Published: 10 June 2015

Green economy priority sectors in Indonesia: a SAM approach

Lilia Endriana, Djoni Hartono & Tony Irawan

Environmental Economics and Policy Studies **18**, 115–135 (2016) | Cite this article

# Model untuk Energi dan Interaksi Ekonomi

*Computable General Equilibrium (CGE)*

- ***The general equilibrium model*** adalah model yang menggambarkan hubungan pasar dari semua barang dan jasa dalam suatu perekonomian. Setiap perubahan keseimbangan pasar, merupakan reaksi terhadap perubahan keseimbangan pasar lain, atau pasar lain adalah reaksi terhadap perubahan keseimbangan pasar.
- Pemodelan Computable General Equilibrium (CGE) adalah upaya untuk memanfaatkan teori keseimbangan umum sebagai alat untuk melakukan analisis empiris masalah alokasi sumber daya dalam ekonomi pasar (Bergman 2005).

ELSEVIER

Sustainable Production and Consumption

Volume 28, October 2021, Pages 391-404

Effect of COVID-19 on energy consumption and carbon dioxide emissions in Indonesia

Djoni Hartono [a, b], Arief Anshory Yusuf [c], Sasmita Hastri Hastuti [b], Novani Karina Saputri [b], Noor Syaifudin [d]

Energy Sources, Part B: Economics, Planning, and Policy ›

Volume 12, 2017 - Issue 12

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Original Articles

The economic implications of natural gas infrastructure investment

Aldi Martino Hutagalung, Djoni Hartono, Maarten Arentsen & Jon Lovett

Pages 1080-1087 | Published online: 21 Sep 2017

# Model untuk Energi & Pengembangan Sosial Ekonomi

**Kesehatan**

- Menghitung dampak dari transisi energi di level rumah tangga
- Terdapat hubungan positif antara penerapan energi berkelanjutan dengan kesehatan

**Pendidikan**

- Memperkirakan pengaruh transisi energi bersih pada pendidikan
- Menggunakan tahun pendidikan yang dicapai, ada hubungan positif antara transisi energi bersih dengan pendidikan

**Pendapatan**

- Mengukur hubungan antara transisi energi dan pendapatan & anggaran rumah tangga.
- Ada hubungan positif antara transisi energi dengan pendapatan.

Source: Liao et al., 2021

# Modern energy consumption in Indonesia: Assessment for accessibility and affordability

$$Ln\_EE_i = \beta_0 + \beta_1 * Ln\_NEE_i + \beta_2 * LPA_i + \beta_3 * ELA_i + \sum_j \beta_j * EA_{ji} + \sum_l \beta_l * X_{li} + \sum_k \beta_k * \alpha_{ki} + \varepsilon_i$$

multiple linear regression

Variable explanations.

| Variables | Explanation | Units |
|---|---|---|
| Dependent variable | | |
| *Ln_EE* | Energy expenditure (in natural logarithm)<br>Household total energy spending | IDR |
| Independent variable/main variables | | |
| *Ln_NEE* | Non-energy expenditure (in natural logarithm)<br>Subtraction of the household total expenditure and the total number of energy expenditure in a year | IDR |
| *LPA* | LPG accessibility<br>1 = household use LPG, 0 = household does not use LPG | Dummy |
| *ELA* | Electricity accessibility<br>1 = household use electricity, 0 = household does not use electricity | Dummy |
| Other energy accessibility (EA) | | |
| *CGA* | City-gas accessibility<br>1 = household use city-gas, 0 = household does not use city-gas | Dummy |
| *KEA* | Kerosene accessibility<br>1 = household use kerosene, 0 = household does not use kerosene | Dummy |
| *GEA* | Generator's fuel accessibility<br>1 = household use generator's fuel, 0 = household does not use the generator's fuel | Dummy |
| *CCA* | Charcoal accessibility<br>1 = household use charcoal, 0 = household does not use charcoal | Dummy |
| *FWA* | Firewood accessibility<br>1 = household use firewood, 0 = household does not use firewood | Dummy |
| Control variables (*X*) | | |
| *HHM* | Household members<br>Total number of household members | Person |
| *HHA* | Head of household's ages<br>Age of head of household | Years |
| *HHG* | Head of household's gender<br>1 = male, 0 = female | Dummy |
| *EDU* | Head of household's education<br>1 = head of a household have a secondary school degree or above, 0 = other | Dummy |
| *EMP* | Head of household employment<br>1 = head of a household has a full-time occupation, 0 = other | Dummy |
| *AGR* | Head of household agriculture worker<br>1 = head of household works in the agricultural sector, 0 = other | Dummy |
| *Ln_IFS* | In-house floor size (in natural logarithm)<br>Size of in-house floor | m2 |

# Modern energy consumption in Indonesia: Assessment for accessibility and affordability

$$Ln\_EE_i = \beta_0 + \beta_1 * Ln\_NEE_i + \beta_2 * LPA_i + \beta_3 * ELA_i + \sum_j \beta_j * EA_{ji} + \sum_l \beta_l * X_{li} + \sum_k \beta_k * \alpha_{ki} + \varepsilon_i$$

Energy spending drivers at the national level in 2008.

| 2008 | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Ln_nee | 0.615*** | 0.570*** | 0.517*** | 0.529*** | 0.526*** | 0.480*** | 0.480*** | 0.475*** |
| | (0.000108) | (0.000126) | (0.000150) | (0.000149) | (0.000150) | (0.000156) | (0.000158) | (0.000159) |
| lpa | | 0.214*** | 0.224*** | 0.215*** | 0.215*** | 0.188*** | 0.187*** | 0.184*** |
| | | (0.000235) | (0.000234) | (0.000229) | (0.000229) | (0.000220) | (0.000222) | (0.000221) |
| eia | | 0.247*** | 0.253*** | 0.245*** | 0.245*** | 0.211*** | 0.211*** | 0.201*** |
| | | (0.000333) | (0.000334) | (0.000335) | (0.000335) | (0.000338) | (0.000338) | (0.000339) |
| cga | | 0.318*** | 0.319*** | 0.310*** | 0.310*** | 0.286*** | 0.286*** | 0.284*** |
| | | (0.000831) | (0.000826) | (0.000810) | (0.000810) | (0.000799) | (0.000799) | (0.000797) |
| kea | | 0.268*** | 0.257*** | 0.256*** | 0.256*** | 0.253*** | 0.253*** | 0.250*** |
| | | (0.000224) | (0.000219) | (0.000216) | (0.000216) | (0.000210) | (0.000210) | (0.000209) |
| gea | | 0.813*** | 0.815*** | 0.814*** | 0.813*** | 0.801*** | 0.801*** | 0.804*** |
| | | (0.000877) | (0.000873) | (0.000878) | (0.000877) | (0.000881) | (0.000881) | (0.000883) |
| cca | | 0.121*** | 0.109*** | 0.103*** | 0.102*** | 0.086*** | 0.086*** | 0.091*** |
| | | (0.000605) | (0.000604) | (0.000604) | (0.000604) | (0.000601) | (0.000602) | (0.000602) |
| fwa | | 0.043*** | 0.017*** | 0.003*** | 0.001*** | −0.018*** | −0.018*** | −0.007*** |
| | | (0.000177) | (0.000175) | (0.000174) | (0.000174) | (0.000173) | (0.000175) | (0.000181) |
| hhm | | | 0.037*** | 0.036*** | 0.034*** | 0.030*** | 0.030*** | 0.030*** |
| | | | (0.000051) | (0.000051) | (0.000051) | (0.000049) | (0.000050) | (0.000050) |
| hha | | | | 0.004*** | 0.005*** | 0.003*** | 0.003*** | 0.004*** |
| | | | | (0.000005) | (0.000005) | (0.000005) | (0.000005) | (0.000006) |
| hhg | | | | | 0.043*** | 0.038*** | 0.038*** | 0.033*** |
| | | | | | (0.000222) | (0.000216) | (0.000216) | (0.000220) |
| Ln_ifs | | | | | | 0.143*** | 0.143*** | 0.145*** |
| | | | | | | (0.000129) | (0.000130) | (0.000130) |
| edu | | | | | | | 0.004*** | −0.001*** |
| | | | | | | | (0.000172) | (0.000173) |
| emp | | | | | | | | 0.065*** |
| | | | | | | | | (0.000220) |
| agr | | | | | | | | −0.052*** |
| | | | | | | | | (0.000162) |
| Obs | 57,542,620 | 57,542,620 | 57,542,620 | 57,542,620 | 57,542,620 | 57,542,620 | 57,542,620 | 57,542,620 |
| R-squared | 0.430 | 0.472 | 0.477 | 0.485 | 0.486 | 0.499 | 0.499 | 0.501 |

All models use survey weights and include province-year (province-round) fixed effects. All models passed the sensitivity analysis. Robust standard errors in parentheses.

*** $p < 0.01$.

# Model untuk Energi & Pengembangan Sosial Ekonomi

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Energy Policy
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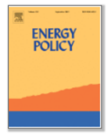


## The state of energy poverty in Indonesia and its impact on welfare

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## A Multidimensional Energy Poverty in Indonesia and Its Impact on Health

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**ABSTRACT**

*Developing countries, such as Indonesia, still experience difficulties in terms of accessing electricity and meeting the need for clean energy for cooking. Therefore, it is important to measure energy poverty holistically. This study aimed to find empirical evidence regarding multidimensional energy poverty in Indonesia and its impact on health. Energy poverty and health had become a serious concern in the global world, including in Indonesia. However, empirical studies in proving multidimensional energy poverty and its impact on health are still very limited. This study uses a simultaneous equation model with Two-Stage-Least-Square (2SLS) regression method and measuring multidimensional energy poverty through two aspects, namely accessibility and affordability. Results show that low accessibility to electricity leads to a lower health condition and the higher the ratio of energy consumption to total consumption, the lower a household's health condition. The result from the multidimensional energy poverty measurement also shows positive causality with the households' health condition.*

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## Household Multidimensional Energy Poverty: Impact on Health, Education, and Cognitive Skills of Children in Ghana

Elizabeth Nsenkyire, Jacob Nunoo, Joshua Sebu & Omowumi Iledare

# Pemodelan Energi lainnya



## What drives energy consumption in Indonesia's manufacturing industry? An analysis of firm-level characteristics



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Energy and Buildings
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## Investigation on household energy consumption of urban residential buildings in major cities of Indonesia during COVID-19 pandemic

Usep Surahman [a], Djoni Hartono [b], Erni Setyowati [c], Aldissain Jurizat [a]

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Energy for Sustainable Development
Volume 57, August 2020, Pages 57-68

## Modern energy consumption in Indonesia: Assessment for accessibility and affordability

Djoni Hartono [a, b], Sasmita Hastri Hastuti [b], Audhi Ahmad Balya [b], Wahyu Pramono [c]

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Renewable Energy
Volume 81, September 2015, Pages 308-318

## Multi-objective optimization model for sustainable Indonesian electricity system: Analysis of economic, environment, and adequacy of energy sources

Widodo Wahyu Purwanto [a], Yoga Wienda Pratama [a], Yulianto Sulistyo Nugroho [b], Warjito [b], Gatot Fatwanto Hertono [c], Djoni Hartono [d], Deendarlianto [e], Tetsuo Tezuka [f]

# Indonesia's National Energy Policy:
# The Role of Carbon Tax

**Djoni Hartono, Witri Indriyani (UI) - Beta Iryani (BPS) - Ahmad Komarulzaman (UNPAD) - Anda Nugroho (MoF) - Robi Kurniawan (MEMR)**

# Introduction

## Indonesia Energy and Emission Targets

- The 2030 United Nations Agenda for Sustainable Development and the Paris Agreement provide a global blueprint for sustainable development related to clean energy and sustainable life
  - 7th and 13th sustainable development goals (SDGs); affordable and clean energy and climate action
  - Paris Agreement; keeping a global temperature rise below 2°C (3.6°F) and limit temperature rise to 1.5°C (2.7°F).
- As one of the most polluted countries (IQAir, 2019), Indonesia is committed to increase its renewable energy mix supply as well as reduce its emission
  - General Plan of National Energy (RUEN) : reducing energy intensity up to 1% annually and achieve 23% of renewable energy (RE) mix by 2025 (RUEN, 2017)
  - law 16/2016 of Indonesia national determined contribution (INDC) : Indonesia commits to reducing emissions up to 29% in 2030 and up to 41% under the conditional scheme

# Overview of Indonesia Actions on Energy Policy

## National Energy Policy (KEN)

Based on (Patunru & Rakhmah, 2017), GoI in 2014 made Regulation 79/2014 with 3 objectives:

- increase energy access and energy security
- increase energy efficiency
- reduce energy elasticity so that the value is less than 1

## RUEN & RUKN (DEN, 2019)

- General Plan of National Energy (RUEN) provides policy on national energy management plan & acts as an elaboration and implementation plan of KEN until 2050
- General Plan of National Electricity (RUKN) offers a general plan for developing the electricity supply system

## Implemented Policy

**Tax Policy →** address climate change issues from energy sectors, including taxes, charges, and prices

**Energy Transition →** Feed in Tariff (FiT), promotion of Renewable Energy (RE) power plants, compensated independent power producers (IPPs) a fixed and above-market price to buy RE

**Fuel Switching →** increasing the fuel tax rate and reducing fuel subsidies, adding liquid biofuels as part of RE's source for electricity generation.

# Introduction

## Carbon Tax as Fiscal Instrument

- Taxes are considered to be the best tools for environmental economists, as they can provide a uniform signal to the whole economy and equalize compliance costs (Koeppel & Ürge-Vorsatz, 2007).
- The economist and international organizations have strongly recommended the carbon tax as the most efficient instrument to reduce carbon emissions (Baranzini et al., 2000; Cuervo & Gandhi, 1998; Ojha et al., 2020; Timilsina, 2018; Tvinnereim & Mehling, 2018).

- However, it is necessary to consider revenue use, tax rates, and its adverse effects, such as consumption and employment changes when implementing a carbon tax.
- A carbon tax without other affirmative policies, such as household transfer or labor tax reduction, may hamper household consumption and employment rate (World Bank, 2019a).

# Purpose of This Study

## Purpose and Scenario

**This paper try to:**

- Attempts to investigate estimates the effect of a carbon tax on environmental and macroeconomic indicators using a recursive dynamic CGE model.
- Estimates the effect of a carbon tax on environmental and macroeconomic indicators using a recursive dynamic CGE model.

**This study using carbon tax implementation (with different recycling combinations) scenarios for a better policy option**

## Contribution of the Study

**This paper may contribute to two aspects.**

- First, it adds to the existing literature on the impact of a carbon tax by employing a dynamic CGE model with detailed energy sectors. Furthermore, the dynamic CGE model could capture market reactions and structural adjustments more comprehensively, for instance, by allowing endogenous adjustment in the supply of factors and technology (Anderson, 2020).
- Second, the study provides a comprehensive simulation of emission and energy intensity by levying and recycling the carbon tax on households' lump-sum transfer, infrastructure, and renewable energy investment. In contrast to other studies focusing more on macroeconomics and household consumption changes (see Yusuf & Resosudarmo, 2015; Li et al., 2020).

The present research is essential as Indonesia is listed as the top ten largest emitter countries. Hence, its energy mix changes may significantly affect the global environmental condition, including the achievement of SDGs and the Paris Agreement.

# Methodology

## Dynamic CGE model based on ORANIG-RD for Carbon Tax Study

**Three significant mechanisms characterize the dynamic general equilibrium dynamic model:**

- Stock-flow relation between investment and capital stock (assuming a 1-year gestation lag)
- Positive relation between investment and profit rate
- The relationship between wage growth and employment

**Dynamic Computable Equilibrium based on the ORANIG-RD (Horridge, 2002) was used in this study with some adjustments**

- Allow both substitution among commodities (inter-energy substitution) and substitution between capital and energy (capital-energy substitution), following Wiandwiwat & Asafu-Adjaye (2013)
- Equation carbon tax followed MMRF green (Adams, Horridge, and Wittwer, 2002)

**Computable General Equilibrium (CGE) models have been widely recognized as appropriate empirical tools to identify the impact of carbon tax (Holmoy, 2016).**

# Scenarios

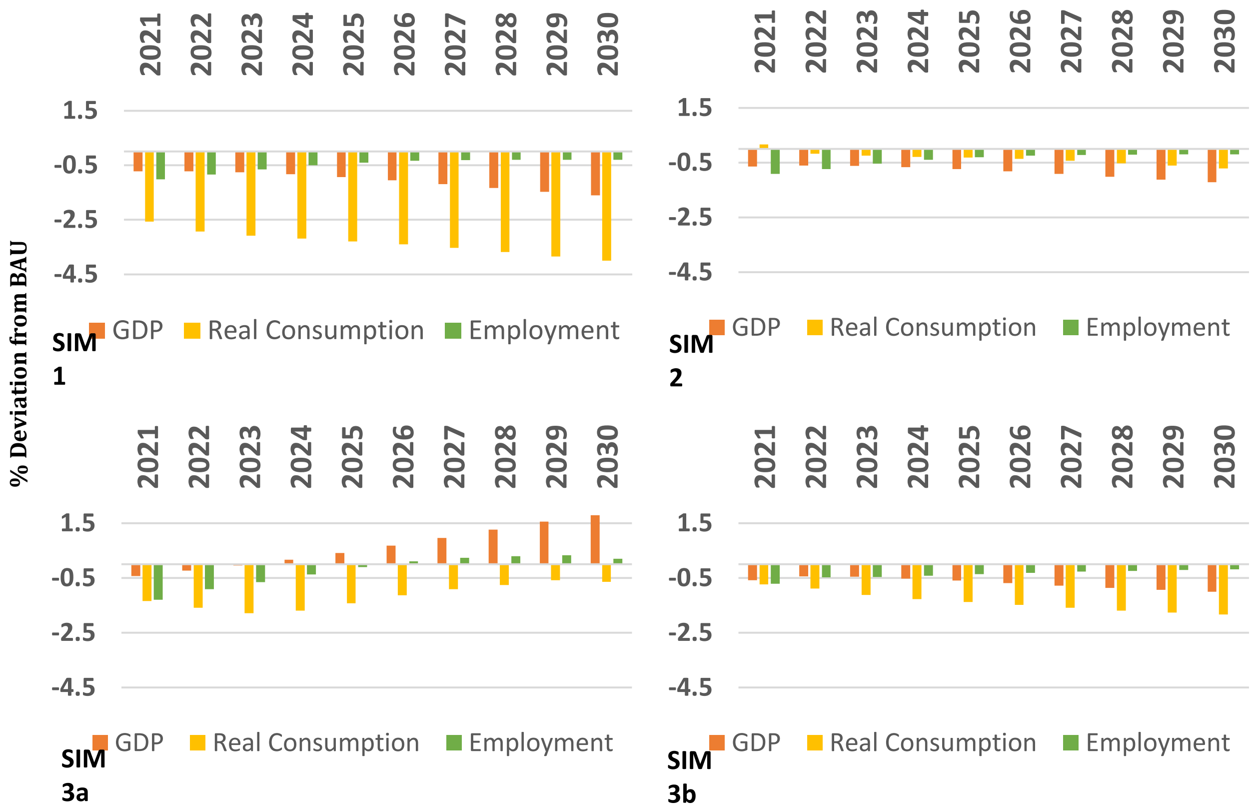
| Simulation | Shock |
|---|---|
| SIM1 | Carbon Tax USD 28.8/Ton of $CO_2$ |
| SIM2 | SIM1 + lump sum transfer (100%) |
| SIM3a | SIM1 + lump sum transfer (50%) + infrastructure investments (50%) |
| SIM3b | SIM1 + lump sum transfer (50%) + renewable energy investments (50%) |

- According to the NDC and National Strategy, Indonesia needs to reduce CO2 emissions from the energy sector by 18.8% under BAU
- After calibrating the suitable tax rate, we applied emission price at 28.8 USD/ton CO2 to achieve the CO2 emission reduction target.
    - This rate is comparable to that of previous work by Yusuf & Resosudarmo (2015) at 30 USD/ton CO2 and Dissanayake et al (2020) at 36 USD/ton CO2.

# Results

## Impacts on Macroeconomic Indicators

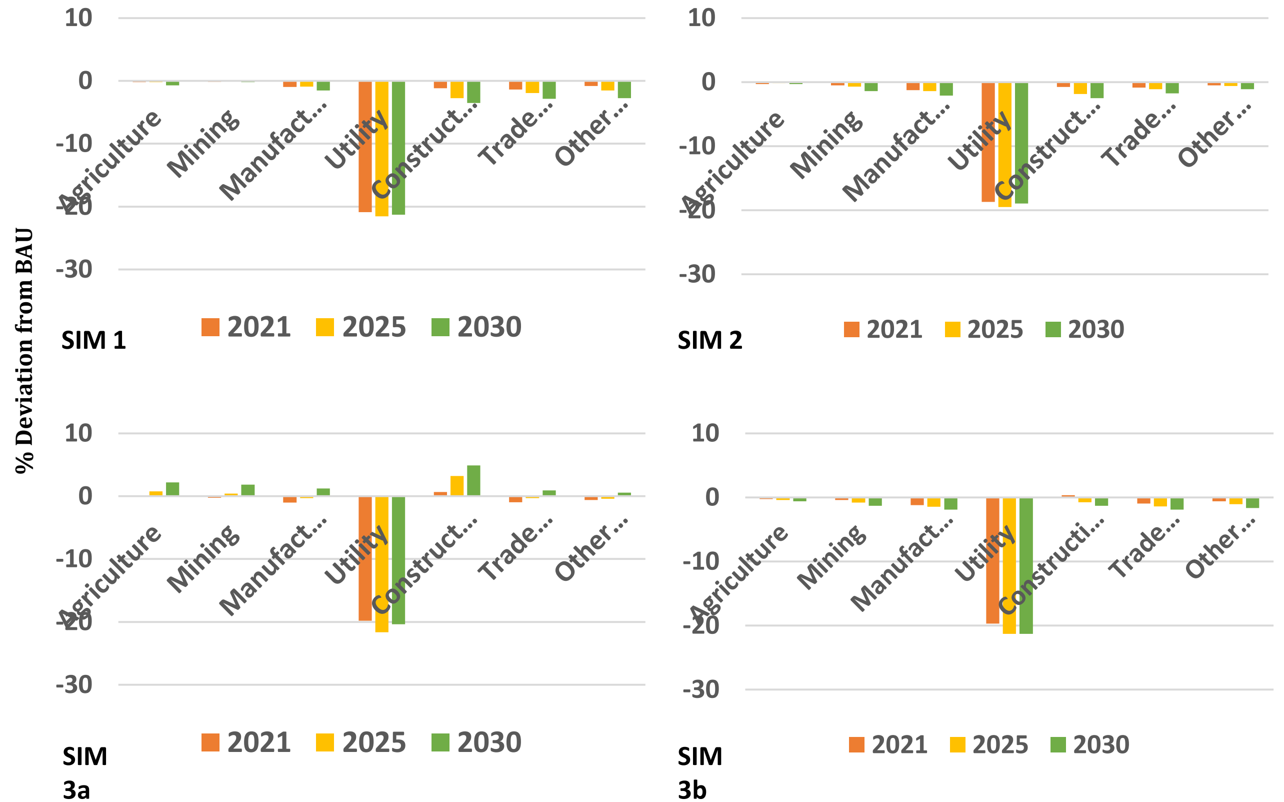
- SIM 2 demonstrates a better result than SIM 1 in terms of overall macroeconomic indicators. Transferring the entire carbon tax yield to households will encourage consumption
- Firms will undergo negative impacts from higher energy prices in the short term, indicated by a relatively large fall in employment compared to the baseline. However, employment will start to recover in the medium-term
- Compared to SIM 3a, SIM 3b has the worse macroeconomic impact; investing part of carbon tax revenue on infrastructure could have a better impact than all the other scenarios.



# Results

## Sectoral Impacts

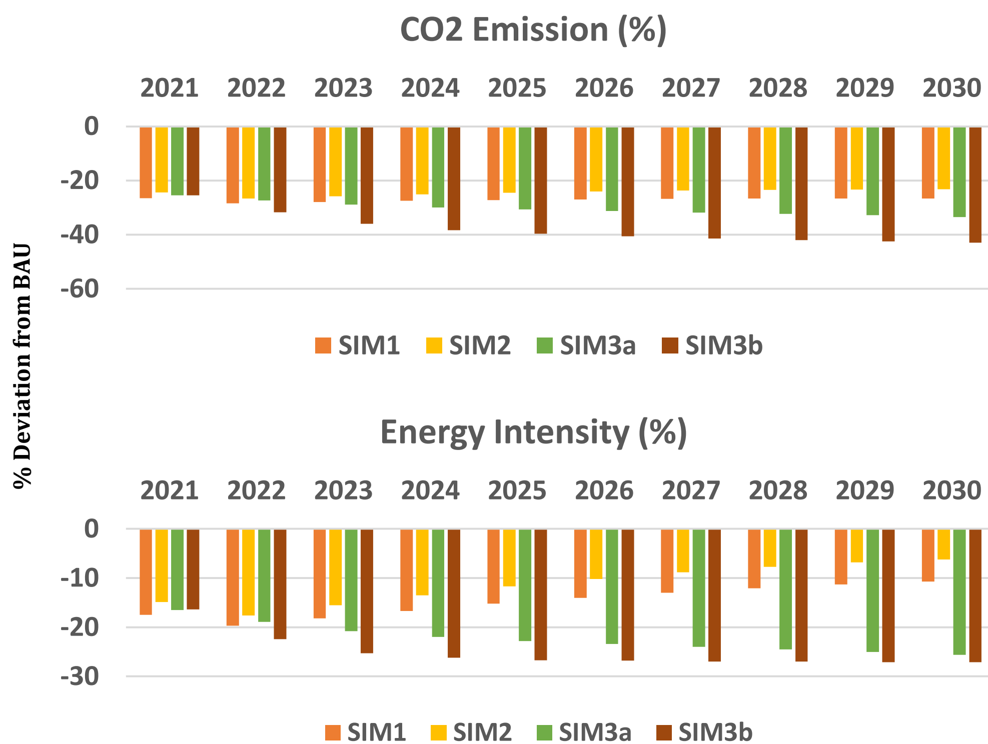
- The total allocation of carbon tax revenue to the household will have a lower impact on the utility sector, but the rate is not significantly different from other simulations.
- Carbon tax only without recycling policy has the highest negative impact at almost all simulation time.
- Albeit that simulation 3 has a relatively high contracting effect on the utility sector, the impact on the other sectors is minimal and tends to be positive in the medium and long terms.
- Thus, considering the overall effect, the allocation of carbon tax revenue on infrastructure investment might be a better option to press the negative impact of a carbon tax



# Results

## Impacts on Environmental Indicators

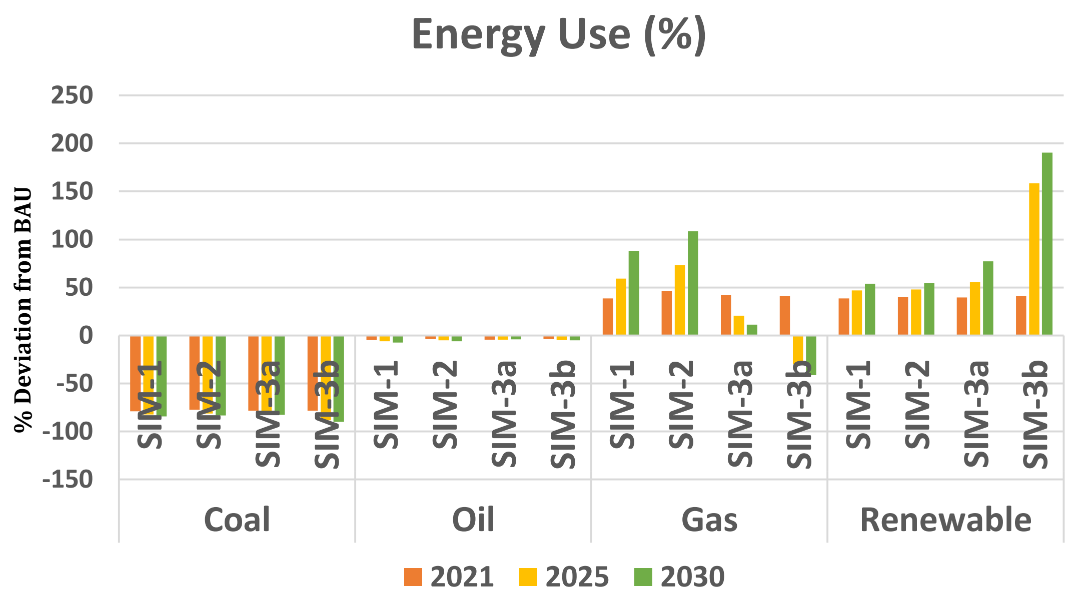
- Carbon tax implementation could have a favorable effect on environmental indicators. In general, all simulations have lower CO2 emissions (ranging from 23% to 43%) than the BAU condition
- SIM 2 has a relatively less $CO_2$ emission reduction. It seems that the rebound effect from household consumption in SIM 2 encourages energy-intensive sectors to increase their production.
- In terms of energy intensity, all the simulations imply that carbon tax implementation will significantly reduce energy intensity.
- SIM 3b is superior to all other simulations in terms of environmental indicators.



# Results

## Long-Run Impacts on Energy Use

- In all simulations, a carbon tax increases renewable energy-based consumption and decreases non-renewable energy consumption
- With a carbon tax, the price of new and renewable energy can compete with fossil energy and carbon-based fuels. Then industry, business, household, and electricity reduce their consumption of non-renewable energy by consuming more energy-efficient products and technologies or shift their consumption to relatively cheaper energy.
- SIM 3b shows an enormous positive impact on renewable energy use, i.e., up to 190%, and the largest negative impact on non-renewable energy



# Conclusions

## Key Points Note

**This study investigates the impact of carbon tax implementation on the SDGs and Paris Agreement target demonstrated in RUEN's and INDC's target.**

- The simulation shows that to achieve the CO2 emission reduction target from the energy sector by 18.8% under BAU, the **GoI needs to impose a tax rate of up to 28.8 USD/ton CO2.** However, levying the carbon tax contracts the economy; it reduces GDP, real consumption, employment rate, and sectoral output, particularly for the utility sector
- Carbon tax revenue recycling could reduce the contracting impact of the carbon tax application. **Tax revenue recycling on a mix of household transfer and infrastructure investment generates a higher GDP, higher employment rate, and less negative impact on household consumption.**
- **A carbon tax revenue recycling on household transfer and renewable energy investment is a better recycling option** for greener energies with more considerable CO2 emission reduction, 20.9% or slightly above the target in 2030 (18.8%).
- Albeit SIM 3a and SIM 3b reflect different priorities that seemed like trade-offs for each other, **investment diversifications between infrastructure and renewable energy could aim at emission reduction and economic enhancement.**

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