green\_paper

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November 1, 2023

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## 1 Introduction

Some shit from Sabzevar et al. (2017) and He, Dou, and Zhang (2017) on calculation of cap n trade.

## 2 Literature Review

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## 3 Method

Let be a quantity produced by the Indonesian economy which is nested with a leontief production function with energy. That is, , where is a combination of factors such as capital and labour. Let be the total energy required to produce in one period. The economy produces with a fully substitute sources:

where is the amount of clean energy used, while and are coal and gas respectively. if is a vector of prices of the three sources of energy and , producers in the economy are faced with a cost minimization problem to produce , and by extension, .

In this setting, is taken as exogenous as the consequence of the Leontief production nest. That is, factor of production is the driver of and consequently . This assumption allows the use of the cost minimization technique and observe the cost impact of idiosyncratic shock to prices.

We improve this setting by adding emission constraints. We limit total emission coming from the use of each source of energy. Next, we limit how much the total combination of emissions from these sources is allowed. This variable, then, can be set exogenously to reflect the government’s preference of emission.

Let be parameters which reflect emission generated per megawatt hour by respectively. Let be the total emission generated by the Indonesian electricity sector, Then the total emission generated by these sources is:

With the above emission constraint, we have a complete linear system as follows:

The shock of the model can come from two exogenous variables which reflects a carbon tax, or which reflects how much carbon quota is given in the economy as a whole.

The next step is to find a representative parameter. PLN (2021) is the main source of and . Perusahaan Listrk Negara (PLN) statistics is reliable since it is the sole distributor of electricity in Indonesia. According to PLN (2021), Indonesia generates 279,511.24 Gigawatt hour (GWh) in 2021. From those, around 60% are produced using coal as its main source and around 23% by some mixes of fossil fuels. Only 17% is generated by renewables, mostly hydroelectric (Lolla 2021; PLN 2021).

PLN (2021) also contains data on prices per Kilowatt hour of electricity based on sources. Total emission generated by the electricity sector is calculated based on the emission factor and how much energy source is used by the sector. Lastly, emission factor are calibrated from Febijanto (2010) and Steen (2021). The number of emission factor varies between countries and in different reports, and emission factor in this paper tries to balance those differences[[1]](#footnote-22).

Also cekidot https://www.cnbcindonesia.com/news/20220119103739-4-308598/pajak-karbon-pltu-berlaku-april-2022-picu-tarif-listrik-naik

https://publications.jrc.ec.europa.eu/repository/handle/JRC21207

https://ebtke.esdm.go.id/post/2023/02/01/3414/rencana.pengembangan.pembangkit.nasional.beri.porsi.ebt.lebih.besar?lang=id

## 4 Results and discussions

The linear setting in the previous section is trivial enough to be solved by linear programming method in Scipy (Sargent n.d.). Four different cases are considered in this paper.

| case | description | model setting |
| --- | --- | --- |
| 1 | Status quo | current share of energy use |
| 2 | carbon tax | current share but carbon is taxed |
| 3 | long-run, no target | long run changes if emission target |
| 4 | long-run with aggresive target | like case 3 but with emission reduced by 27% |

## 5 Reserves

import pandas as pd  
import numpy as np  
from scipy.optimize import linprog  
  
omega=279511240.0 #MWh  
E=619280000000.0 #KgCO2  
ba=(0,None)  
bb=(0,None)  
# Construct parameters  
c\_ex1 = np.array([1284440, 667880])  
  
# Inequality constraints  
A\_ex1 = np.array([[-1, -1],  
 [0,350]])  
b\_ex1 = np.array([-omega,E])  
  
bounds\_ex2 = [ba,  
 bb]  
  
# Solve the problem  
# we put a negative sign on the objective as linprog does minimization  
res\_ex1 = linprog(c\_ex1, A\_ub=A\_ex1, b\_ub=b\_ex1,bounds=bounds\_ex2)  
  
res\_ex1

message: Optimization terminated successfully. (HiGHS Status 7: Optimal)  
 success: True  
 status: 0  
 fun: 186679966971200.0  
 x: [ 0.000e+00 2.795e+08]  
 nit: 1  
 lower: residual: [ 0.000e+00 2.795e+08]  
 marginals: [ 6.166e+05 0.000e+00]  
 upper: residual: [ inf inf]  
 marginals: [ 0.000e+00 0.000e+00]  
 eqlin: residual: []  
 marginals: []  
 ineqlin: residual: [ 0.000e+00 5.215e+11]  
 marginals: [-6.679e+05 -0.000e+00]  
 mip\_node\_count: 0  
 mip\_dual\_bound: 0.0  
 mip\_gap: 0.0

## 6

## 7 Bibliography

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He, Ping, Guowei Dou, and Wei Zhang. 2017. “Optimal Production Planning and Cap Setting Under Cap-and-Trade Regulation.” Journal Article. *The Journal of the Operational Research Society* 68 (9): 1094–1105. https://doi.org/<https://doi.org/10.1057/s41274-016-0123-1>.

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Sabzevar, Nikoo, S. T. Enns, Joule Bergerson, and Janne Kettunen. 2017. “Modeling Competitive Firms’ Performance Under Price-Sensitive Demand and Cap-and-Trade Emissions Constraints.” Journal Article. *International Journal of Production Economics* 184: 193–209. https://doi.org/<https://doi.org/10.1016/j.ijpe.2016.10.024>.

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1. See appendix for a more complete codes and parameterisation used in this paper. [↑](#footnote-ref-22)