THE MACROECONOMIC MODEL CONSEQUENCES OF CONTROLLING CARBON DIOXIDE EMISSIONS

Ida Febriana[1)], Hilwatullisan[2)]

[1)] *Chemical Engineering, Politeknik Negeri Sriwijaya, Palembang, Indonesia*
E-mail:i.febriana@yahoo.com

[2)] *Politeknik Negeri Sriwijaya, Jl. Srijaya Negara Bukit Besar-Palembang, Indonesia*
E-mail:hilwalisan@yahoo.com

Abstract. It was studied the Macroeconomic Model Consequences Of Controlling Carbon Dioxide Emissions. The aims of this study is to modify a model by combining "top-down macroeconomic model" with "bottom-up model" to stabilize CO2 emissions in the atmosphere with apply energy-efficiency technology and carbon tax to minimize CO2 production. The parameters measured are carbon energy demand, carbon energy intensity, carbon tax and carbon emissions. The results showed that the energy-efficiency technology is a sufficient method to reduce carbon emissions, namely energy-related CO2 emissions grew at 5.8% per year over 1976-90 and, in future, it will from grow at 5.2% and 3.1% per year for the high and low base cases respectively. The simulations in the econometric model have shown that carbon taxes by themselves are a sufficient method for reducing carbon emissions, where in case C, the carbon emissions are the smallest at 3.7% and 1.4% for the high and low cases, because all the carbon tax revenues are invested in carbon-abating technologies.

Keywords**:** CO2 emissions, carbon tax, energy-efficiency technology

I. Introduction

The greenhouse gases cause greenhouse gas effects. Greenhouse gas effects occur when the sun light come to the Earth, some of sun light will absorb by the Earth, some will reflection back to the atmosphere. In the atmosphere there are clouds of CO_2, some of reflection of sun light will reflection back to the Earth, so temperature will be increase. Effect of greenhouse gases, example: increasing temperature, rising sea level, increasing rainfall, etc. Increase greenhouse gas is a direct impact of human activities, for instance, CO2 production from fossil fuel combustion by fertilizer plant, power plant, and chemical process industries. Since year 2000, the emission of CO2 from energy use has been estimated to increase from 40 to 110% over a period of 30 years [2].

Before the industrial revolution, concentrations of carbon dioxide in the atmosphere is 280 ppm. Since 1880, the result of increased burning of fossil fuels as an energy source, the CO2 concentration has risen by about 1.5 ppm / year so that the gas content of carbon dioxide in the atmosphere at present to 365 ppm [22]. The concentration of carbon dioxide gas will continue to increase unless the emissions from fossil fuels is limited or stopped together. In the world, two contrasting approaches in modelling are currently being used to study the economics of global warming : (1). The top-down macroeconomic models which oversimplify technological progress, while evaluating the economics of global warming; (2). The bottom-up models which evaluate technology in great detail but exlude macroeconomic linkages and economic barriers thet prevent a full realization of the technological potential identified to reduce CO2 emissions [1]. Although the importance of the synthesis of these two approaches is well recognized, the actual integration has rarely been carried out. Synthesis of result from micro-level studies and macro-models enables a more appropriate estimation of costs of policy options for carbon abatement, especially in the medium term. Developing countries such as USA, India, and Indonesia are expected to become major contributors of greenhouse gases [12]. They, much more than the industrialized economies, have increasing energy demands, and require a different framework for analysis of efforts to control carbon emisssions. For developing countries, the medium term has more relevance than does the very long term, given their developmental objectives.

Various countries are committed to reduce their greenhouse gas (GHG) emissions according to targets negotiated under the Kyoto Protocol for the first commitment period (2008-2012). More stringent emission reductions are foreseen for the second commitment period (after 2012).

An integrated gasification combined cycle (IGCC) is a technology that turns coal into synthesis gas (syngas). It then removes impurities from the coal gas before it is combusted and attempts to turn any pollutants into re-usable byproducts. This results in lower emissions of sulfur dioxide, particulates and mercury. Excess heat from the primary combustion and generation is then passed to a steam cycle, similarly to a combined cycle gas turbine. This then also results in improved efficiency compared to conventional pulverized coal.

IGCC converts coal in a complex rendering process. Two steps in the conversion process lead to IGCC's efficiency in creating coal based electricity. First, coal is converted by gasification into a synthetic gas. Heat from the gasifier is then captured as steam for use in power generation. Cleaning is next in the process. Cleaning captures much of the harmful emissions that traditional pulverized coal plants release into the atmosphere. Traditional pulverized coal plants have high rates of heat loss due to evaporation. This is essentially wasted energy, which the IGCC process captures and uses to a greater extent.

II. THE MACROECONOMIC MODEL

Macroeconomics can be used to analyze how best to influence policy goals such as economic growth, price stability, employment and achieving a sustainable balance. Macro economics studying economic variables in the aggregate (overall). These variables include: national income, employment or unemployment, money supply, inflation, economic growth, and balance international payments. While studying microeconomics economic variables within the scope of such small companies, households. Macro economics study the major economic issues as follows:

- The extent to which various resources have been exploited in economic activity. When all resources have been exploited is called full employment situation. Conversely if there is still an untapped resource in the state of the economy means there employmentatau under unemployment / not in the position of full employment.
- The extent to which the economy is stable, especially the stability in monetary. If the value of money tends to decline in the long term mean inflation. In contrast, deflation.
- The extent to which the economy experienced growth and this growth accompanied by improved income distribution between economic growth and equity in income distribution when there is a trade off point improved the other one tends to deteriorate.

Economic activities in each country is calculated through the calculation of Gross Domestic Product (GDP) growth (Gross Domestic Product), Gross National Product (GNP) (Gross National Product), and National Income (PN) (National Income). GDP / GNP / PNN / PN can use the prevailing price and constant price.

III. INTEGRATED GASSIICATION COMBINED CYCLE (IGCC)

Coal gasification is a well-proven technology that started with the production of coal gas for urban areas, progressed to the production of fuels, such as oil and synthe tic natural gas (SNG), chemicals, and most recently, to large-scale Integrated Gasification Combined Cycle (IGCC) power generation.

IGCC is an innovative electric power generation concept that combines modern coal gasification technology with both gas turbine (Brayton cycle) and steam turbine (Rankine cycle) power generation. The technology is highly flexible and can be used for new applications, as well as for repowering older coal- fired plants, significantly improving their environmental performance. IGCC provides feedstock and product flexibility, greater than 40 percent thermal efficiency, and very low pollutant emissions. The first commercial IGCC plants, put into service in the U.S., through DOE's cooperative Clean Coal Technology program, have proven capable of exceeding the most stringent emissions regulations currently applicable to coal-fueled power plants.

IGCC plants have achieved the lowest levels of criteria pollutant air emissions (NOx, SOx, CO, PM10) of any coal-fueled power plants in the world. Emissions of trace hazardous air pollutants are extremely low, comparable with those from direct-fired combustion plants that use advanced emission control technologies. Discharge of solid byproducts and wastewater is reduced by roughly 50% versus other coal-based plants, and the by-products generated (e.g., slag and sulfur) are environmentally benign and can potentially be sold as valuable products. Another significant environmental benefit is the reduction of carbon dioxide (CO2) emissions, by at least 10% per equivalent net production of electricity, due to a higher operating efficiency compared to conventional pulverized coal- fired power plants.

IV. THE DESIGN CONCEPT OF RESEARCH

In this research, it is necessary to arrange design concept of the research to achieve its objectitves which implicates all stages of the processes of the model. In general, the stages of the research implicate the determining of the research variables, process descriptions, research procedures, and research result methods or research matrices.

For the energy sector, two base case are considered :

- Business as usual (high) case represents the historical projection energy demand.
- The alternative (low) base case represents rapid innovation in the energy sector, energy-efficient technologies 20% less than consumption at the high-case because of the low case are assumed to use energy-efficiency technology. (T.Sandeep., 2008).

As presented in the previous chapter, the study is based on several steps as follows:

1. Collect data from the study of literature from 1971 to 1990, including data gross domestic product, energy consumption, total commercial energy and fossil energy, energy related CO2 emissions, and energy intensity.
2. Make predictions of total energy consumption from 1991 to 2030.

3. Make predictions of energy consumption from 1991 to 2030.
4. Make predictions of GDP from 1991 to 2030.
5. Make predictions of price elasticity for energy demand from 1991 to 2030.
6. Make predictions of carbon energy demand from 1991 to 2030.
7. Make predictions of energy intensity from 1991 to 2030.
8. Make predictions of carbon emissions from 1990 to 2030

$$Qt = 0.7329 * Ec + 1.4286 * Eo + 1.7 * En$$

9. Analizing carbon emissions for high and low case

For the Policy scenario (Carbon tax), these will be done in several steps :

1. From data predictions of high and low case, we make predictions of the real price elasticity of carbon energy data by entering a carbon tax (11% tax).
2. Make predictions of GDP from 2010 to 2030 (-2.3% for all case)
3. Make predictions of energy consumption from 2010 to 2030,
4. Make predictions of carbon energy demand (case A, case B, and case C) data from 2010 to 2030
$$CE_t = A\, CEPR_t^{\alpha}\, GDP_t \exp(\gamma T)$$
5. Make predictions of carbon emissions (case A, case B, and case C) data from 2010 to 2030
$$Qt = 0.7329 * Ec + 1.4286 * Eo + 1.7 * En$$
6. Analizing carbon emissions for case A, case B, and case C

V. RESULT AND DISCUSSION

The energy situation in India over the last two decades. Primary energy can be classified as commercial energy and traditional energy [1]. In India, traditional sources of primary energy are significant contributors to the total energy supply and are estimated to account currently for 40%-50% of total primary energy consumption (government of India, 1991; Hall, 1991). Between 1971 and 1991,commercial energy consumption increased at an average rate of 5.5% per ear, while fossil fuel consumption rose at 5.6% per year.

TABLE 1. GROWTH RATES FOR GDP, CARBON ENERGY AND CO2 EMISSIONS IN THE BASE CASE (%)

	Data period (1976-1990)	Forecast period 1991-2005	Forecast period 2005-2015	Forecast period 2015-2030	Forecast average 1991-2030
GDP					
High	4.9	4.71	3.93	4.11	4.24
Low	4.9	4.71	3.90	4.19	4.21
Carbon energy demand					
High	5.9	5.81	4.82	4.49	5.03
Low	5.9	5.14	3.70	1.51	3.42
Carbon energy intensity					
High	0.9	0.93	0.86	0.45	0.81
Low	0.9	0.15	-0.39	-2.40	-0.9
Carbon emissions					
High	5.8	5.7	4.7	4.52	4.89
Low	5.8	4.6	3.1	1.09	2.91

To predict the value of GDP is assumed always increased with increasing the constant, whose value is obtained from data in previous years. To predictions of price elasticity of demand is assumed to decline as influenced by technology that will be used in the future, such as energy-efficiency. For the case of low, consumption of fossil fuels is assumed to 20% (T. Sandeep., 2008) less than consumption at the high-case because of the low case are assumed to use energy efficiency technology.

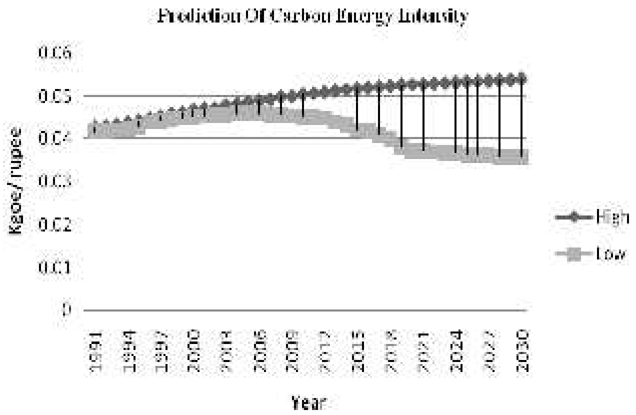

Figure 1. Prediction of energy intensity in India

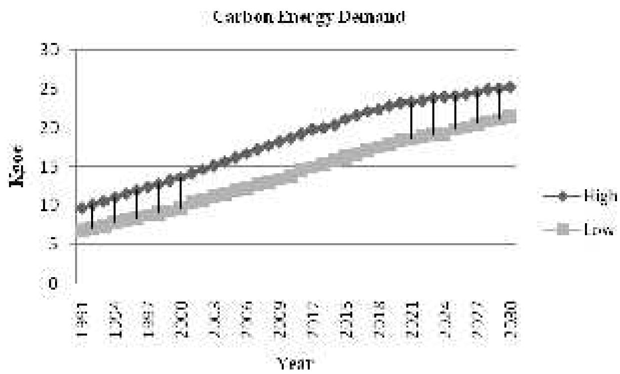

Figure 2. Prediction of carbon energy demand in India

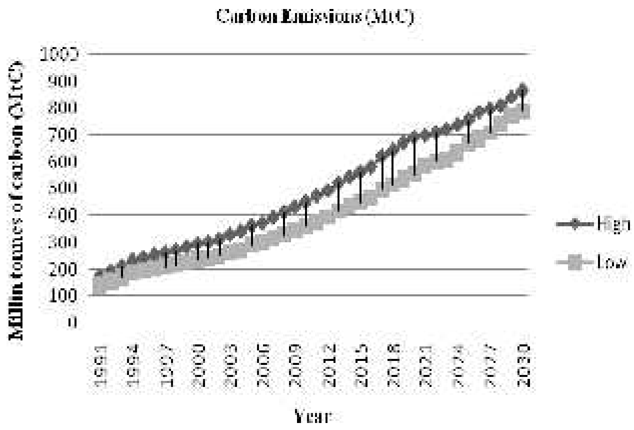

Figure 3. Prediction of carbon emissions in India

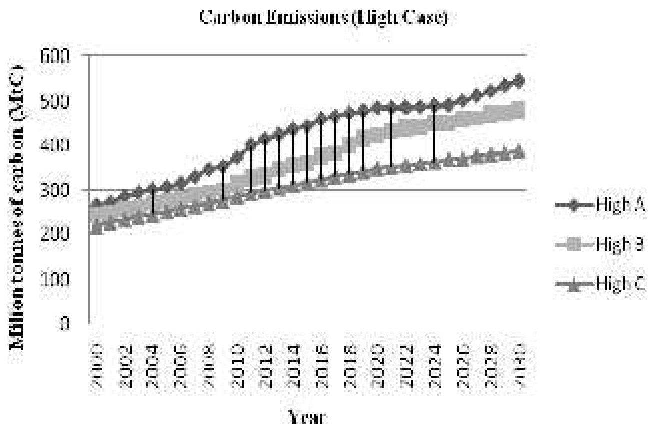

Figure 4. Prediction of carbon emissions for high in case A, B, and C in India

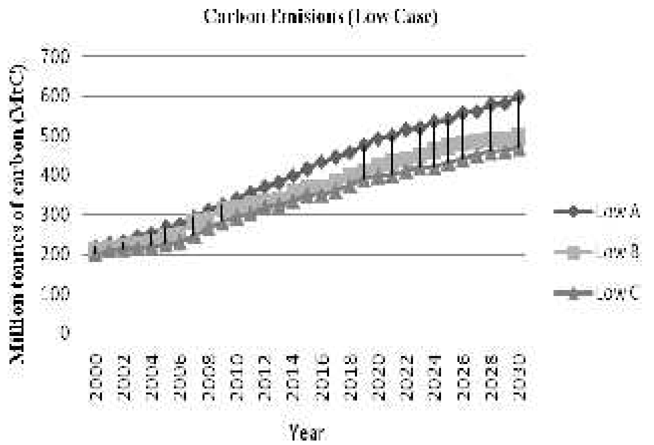

Figure 5. Prediction of carbon emissions for low in case A, B, and C in India

The simulation of the econometric model have shown that the carbon tax is a method that is sufficient to reduce carbon emissions. The remainder of the reductions in carbon energy demand for case A result from the direct and indirect price effects. The decrease in carbon energy demand for cases B and C includes the additional impact of reductions in carbon emissions that result from investment in carbon abating technologies. This is indicated from data can be see, in case C, the carbon emissions are the smallest at 3.7% and 1.4% for the high and low cases, because all the carbon tax revenues are invested in carbon-abating technologies.

VI. Conclusions

Base on the result of this research we get the conclusions, that are :

1. The simulations of the econometric model have shown that the combination of the top-down model and the bottom-up model by incorporating energy-eficiency technology is a method that is sufficient to reduce carbon emissions. This is indicated from data processing and can be seen, energy-related CO2 emissions grew at 5.8% per year over 1976-90 and, in future, will from grow at 5.2 % and 3.1 % per year for the high and low base cases respectively.
2. The simulation of the econometric model have shown that the carbon tax is a method that is sufficient to reduce carbon emissions. This is indicated from data can be seen, in case C, the carbon emissions are the smallest at and 3.7% and 1.4% for the high and low cases, because all the carbon tax revenues are invested in carbon-abating technologies.

Nomenclature

:The price elasticity of carbon energy demand
γ : A parameter that relates to the trend term
β : Ratio of carbon energy intensity
λ : Technological response to a change in energy prices

Acknowledgment

If anyone wants to develop this research by using the model of C + + or something else then you should do some modifications, namely: to get better results should be added other data like the price level in the economy (CPI), so that more accurate data obtained, and try to be applied to the industrial sector in Indonesia.

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