Impact of Green Energy Shares Shocks on Economic Growth and Carbon Emissions in Malaysia

Nora Yusma Bt. Mohamed Yusoff and Nurul Wahilah Bt. Abdul Latif

Abstract—The aim of this paper is to measure the impact of green energy shares shocks in electricity generation on Gross Domestic Product (GDP) and environmental deprivation, caused by the changes in carbon dioxide (CO_2) emissions. To estimate the shocks of green energy shares, the study applies the dynamic test of Impulse Response Function (IRF) under the VAR methodology. The estimated results show that, in future the increasing portion of green energy's shares in electricity generation would have positive impacts on the environment, as expected. However, the hikes of utilization of green energy sources would incur more cost to electricity producers and shrivel up the growth of economies through the expansionary effect of industry's consumption and private capital spending in the economy. Thus, the study could suggest that for achieving higher economic growth, reducing oil, gas and coal especially in the consumption sectors of the economy and shifting towards indigenous resources would have a beneficial impact on the environment as well as on Malaysia's country balance.

Index Terms—Green energy shares, electricity generation, environmental deprivation, carbon emission, economic growth.

I. INTRODUCTION

Conventional energy production in Malaysia has been based around oil and natural gas.Malaysia currently has 13GW of electrical generation capacity. Power generation capacity connected to theNational Grid Malaysia is 19,023 MW, with a maximum demand of 13,340 MW as of July 2007 according to SuruhanjayaTenaga.Total electricity generation in 2007 is 108,539kilowatt hour with a total consumption of 97,113 GW h or 3,570kW hper capita. The generation fuel mix is 62.6% gas, 20.9% coal, 9.5% hydro and 7% from other forms of fuel. In 2007, the country as a whole consumes 514 thousand barrels (23.6 million tonnes) of oil daily against a production of 755 thousand barrels (34.2 million tonnes) per day. However, Malaysia only has 33 years of natural gas reserves, and 19 years of oil reserves, whilst thedemand for energy is increasing. Due to this the Malaysian government is expanding into renewable energy sources. Currently 16% of Malaysian electricity generations are hydroelectric, the remaining 84% being thermal.

Application of Green Technology is seen as one of practical solution which are being adopted by many countries around the world to address the issue of energy and environmental simultaneously. In line with that objective, a special financing scheme namely, Green Technology Financing Scheme was introduced on 1 January 2010. This will attract the private sector to participate in green technology entrepreneurship to grab new opportunities created by the introduction of the green technology policy.

A various number of empirical studies have been conducted on the short run and long run relationships between energy consumption, carbon emissions and economic growth. However, focus will be made on the most recent available literature in the field of renewable energy consumption, carbon emissions and economic growth. Tiwari (2011) applied panel-data vector autoregression (PVAR) approach to analyze the dynamic relationship between RES and NRES with CO2 emissions and GDP growth. He found that the impact of RES is to be positive on the growth rate of GDP [1].

Lotfalipour *et al.* (2010) examined the causal relationships between economic growth, carbon emissions and fossil fuelconsumption, using the Toda-Yamamoto method for Iran during the period 1967-2007. They found that gas consumption lead to economic growth [2], [3]. In the case of India, Tiwari (2011) utilized the technique of SVAR and he provides evidence to support the hypothesis that consumption of RES increases the economic growth of India [4].

On the other hand, Sadorsky (2009) used a panel data model to estimate the impact of RES (which includes geothermal, wind and solar power, waste and wood) on economic growth and CO2 emissions per capita and oil price for the G7 countries. The author found that, in the long run, real GDP per capita and CO2 emissions per capita were the main drivers of renewable energy consumption per capita [5]. Sadorsky (2009) also studied the relationship between RES and economic growth in a panel framework of 18 emerging economies for the period 1994-2003 and found that increases in real GDP had a positive and statistically significant effect on renewable energy consumption per capita [6].

Menegaki (2011) studied the causal relationship between economic growth and renewable energy in 27 European countries in a multivariate panel framework over the period 1997-2007 using a random effect model. The author found no evidence of causality between renewable energy consumption and GDP [7]. Lotfalipour, Falahi and Ashena (2010) found that carbon emissions, petroleum products and total fossil fuels consumption do not lead to economic growth [2].

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II. DATA SOURCES AND RESEARCH METHODOLOGY

A. Data and Variables

The studywill use annual data of green energy

sources(GES_TEG), real GDP (RGDP) and carbon emissions (CO_2)in Malaysia. Yearly data on growth domestic product for 1970-2010 periods will be collected from the Department of Statistics of Malaysia. The green energy sources (GES_TEG) in electricity generation and carbon emissions weretaken from World Bank database. Furthermore, the real GDP was measured in USD constant price (2000 as a base year). All variables are logarithmically transformed and we use logarithmic differences as a proxy of growing rates. This procedure guarantees that all variables are stationary [8]. The current paper utilized the co-integration test and impulse response function (IRF), under vector auto-regression (VAR) framework. The models in this study have been estimated by using the bounds testing (or autoregressive distributed lag, ARDL) co-integration procedure. The data analysis will be conducted by using Microfit and Eviewssoftware.

B. Model Specification

In this study we focus only in two models which are *Carbon Emissions*(LCO2) and *Real GDP Growth Model* (LRGP) in order to assess the impact of green energy shares shocks in electricity generation on real Gross Domestic Product (RGDP) and carbon dioxide (CO_2) emissions for short run and long run effects.The error correction model representation of the ARDL model can be written as follows:

$$
\Delta \ln CO2_t = \beta_0 + \sum_{j=1}^{k} \beta_{11} \Delta \ln CO2_{t-j} + \sum_{j=0}^{k} \beta_{12} \Delta \ln RGDP_{t-j} +
$$
$$
\sum_{j=0}^{k} \beta_{13} \Delta \ln GES\_TEG_{t-j} + n_{11} \ln CO2_{t-1} + n_{12} \ln RGDP_{t-1} +
$$
$$
n_{13} \ln GES\_TEG_{t-1} + \xi_t ..(1)
$$

(1)

$$
\Delta \ln RGDP_t = \beta_0 + \sum_{j=1}^{k} \beta_{11} \Delta \ln RGDP_{t-j} + \sum_{j=0}^{k} \beta_{12} \Delta \ln CO2_{t-j} +
$$
$$
\sum_{j=0}^{k} \beta_{13} \Delta \ln GES\_TEG_{t-j} + n_{11} \ln RGDP_{t-1} + n_{12} \ln CO2_{t-1} +
$$
$$
n_{13} \ln GES\_TEG_{t-1} + \xi_t ..(2)
$$

(2)

The terms with the summation signs in the above equations represents the error correction dynamics while the second part (terms with ηijs) corresponds to the long run relationship; Δ denotes a first difference operator; *ln* represents a natural logarithmic; β_0 is an intercept and ξ_t is a white noise.

The dynamic interactions between the green energy shares shocks, real GDP and carbon emissions were analyzed by the IRF which are based on the VAR system. We apply the IRFs (IRF) procedures to simulate one unit standard error shock on current and future values of the variable [10]. GIRFs are more robust as compared to Cholesky decomposition and Orthogonalized IRFs which is sensitive to the ordering of the variables. Specifically, this test is used to determine the extent to which real GDP and carbon emissions responses to agreen energy shares shocks and to what extent these shocks are persistent variables.

According to Sims, if there is true simultaneity among a set of variables, they should all be treated on equal footing; there should not be any priori distinction between endogenous and exogenous variables. It is in this spirit that Sims developed his VAR model. If we performed a causality analysis test and found that we could not reject the hypothesis that there was bilateral causality between Y_t and $\underline{X}_t$ variables (Y_t affects X_t or X_t affects Y_t) then these kinds of situations are ideally suited for the application of VAR (Gujarati, 2003) [11]. Based on this motivation, the study employed the VAR model proposed by Sims (1980), to simulate a positive standard error unit shock on GES_TEG. In order to explain how a VAR is estimated we assume that each equation contains *k* lags values of *Y* and *X*[12]. In this case, one can estimate each of the following equations by OLS:

$$
Y_t = a + \sum_{j=1}^{k} \beta Y_{t-j} + \sum_{j=1}^{k} y Y_{t-j} + U_{1t} \tag{3}
$$

$$
X_t = a + \sum_{j=1}^{k} \delta Y_{t-j} + \sum_{j=1}^{k} y Y_{t-j} + U_{2t} \tag{4}
$$

where the $U_t = (U_{1t}, U_{2t})$ is the stochastic error terms for $t=1, 2.....T$, called impulse or innovations or shocks in the language of VAR. In addition, U_{1t} and U_{2t} are assumed independent and with zero mean, i.e. E (U_{1t}) = 0, k is the lag length criteria, *aanda'* are drift terms, β, γ and δ are the coefficient estimates for independent variables.

Note that the VAR model as illustrated in equation (3) and (4) later will be extended to comprise 3 major endogenous economic variables which are green energy shares use (GES_TEG), real GDP (RGDP) and carbon emissions (CO_2). In order to measure the shock impact on the VAR system, first we need to identify the order of the integration of the series using a unit root test. Finally, we construct VAR model estimation and plot generalized impulse response function (GIRF) of real GDP growth and CO2 emissions from the VAR framework to simulate a positive shock to RE.

III. EMPIRICAL RESULTS AND FINDINGS

We have estimated the impact of symmetric green energy shares (GES_TEG)shocks that is a standard deviation on real GDP (RGDP) and carbon emissions (CO_2). These estimations are presented step by step as follows:

A. Unit-RootTests

This section analyzes the time series properties of the data during the period 1970-2010. We have conducted the Augmented Dickey-Fuller (ADF) unit root tests. This units-root test is performed at both levels and the first differences of ADF for all variables, as can be seen in Table I.

Table I shows that all variables have a unit root in their level, since the *p*-value for all series are not significant at all levels. Based on these estimated results, we fail to reject the null hypothesis of unit roots even at the 10% significance. However when we performed the unit root test at first difference, I (*1*), the results indicate that all variables are I (*1*) since the *P*-value is significant at 1%. This means that after we have taken the first difference of all variables, there

is no evidence of the existence of unit roots. Interestingly, however, first differences of all the variables show stationary under this test.

TABLE I: RESULTS OF ADF TESTS

	ADF	
Variables	Level	1st Diff
LCO2	-0.470645	-7.536717***
LGES_TEG	-1.349786	-5.150590***
LRGDP	-1.724655	-5.546737***

Note: *,**,*** denotes sig. level of 10%, 5%, 1%, respectively

B. ARDL Bounds Test for Long Run Analysis

The results of the ARDL bounds test in regard to Malaysia are reported in Table II. In the LCO2 and LRGDP model, with LCO2 and LRGDP as dependent variables, we note that the computed F-statistics for Malaysia is above the upper bound critical values provided by Narayan (2005) [13]. Hence, we have strong evidence to reject the null hypothesis of no co-integration at 5% and 10% significance level, respectively. It shows that there was a long run relationship between LCO2, LRGDP and LGES_TEG for LCO2 and LRGDP Model.

TABLE II: BOUNDS TEST RESULTS

F-statistics	LCO2 Model	LRGDP Model
	5.3936**	3.9950***
1% I(0)	4.770	4.614
I(1)	5.855	5.966
5% I(0)	3.435	3.272
I(1)	4.260	4.306
10% I(0)	2.835	2.676
I(1)	3.585	3.586

Notes: *,** and *** indicate 10%, 5% and 1% level of significance, respectively.

Table III presents the long run estimation results. We estimated 2 separate models, for the period of 1970 to 2010. We used the $\bar{R}^2$ criterion to find the coefficient of the level variables. The results for Malaysia indicated that there is existence of long run co-integrating relationships among the variablesin LCO2 Model as well as LRGDP Model.

TABLE III: LONG RUN ESTIMATION RESULTS

Model		
Carbon Emissions Model (1)		
LCO2$_t$ = -19.6187 + **0.00197**$\boldsymbol{\Delta lnGES\_TEG_t}$ + **0.8385**$\boldsymbol{\Delta lnRGDP_t^{***}}$		
SE: (0.61518)	(0.04114)	(0.0436)
t : (-31.891)	(0.4792)	(19.221)
Real GDP Model (2)		
LRGDP$_t$ = 22.203*** + **1.0465**$\boldsymbol{\Delta lnCO2_t^{***}}$+ **0.07011**$\boldsymbol{\Delta lnGES\_TEG_t}$		
SE: (1.646)	(0.1047)	(0.07607)
t : (13.489)	(9.9916)	(0.92167)

C. Error Correction Models for Short Run Analysis

Short run estimation results in the error correction representations of LCO2 model and LRGDP models are provided in Table IV. The error correction terms (EC_{t-1}) of the LCO2 model and LRGDP model are statistically significant at the 5% and 1% level with appropriate sign (negative), verifying the established co-integrating relationships among the variables. The coefficients of EC_{t-1} measures the speed of adjustment back to the long run

equilibrium after a short run shock.

The absolute value of the coefficients of EC_{t-1} in LCO2 model is fast, indicating the fairly fast speed of adjustment to the long run equilibrium following shortrun shocks.For example, the coefficient of EC_{t-1} is 0.807 in the case of LCO2 Model. This implies that, nearly 80.7%of the disequilibria in this model of the previous year's shock adjust back to the long run equilibrium in the current year.

TABLE IV: THE ERROR CORRECTION REPRESENTATION ON THE SELECTED ARDL MODEL

***LCO2** Model (1); (1, 1, 4)*
$\Delta lnCO2_t$ = -15.835*** - 0.081586$\Delta lnGES\_TEG_t$ + 1.0076$\Delta lnRGDP_t^{***}$ + 0.658$\Delta lnRGDP_{t-1}^*$ − 0.463$\Delta lnRGDP_{t-2}$ + 0.629$\Delta lnRGDP_{t-3}^*$ − 0.8071ECT_{t-1}^{***} + ξ_t
$\bar{R}^2$ = 0.50, F-stat. = 6.649, SSE = 0.0614, EC$_{t-1}$ = -0.807, DW = 2.2
χ^2_{sc} = 1.6818; χ^2_{ff} = 0.0078; χ^2_{nor} = 1.408; χ^2_{het} = 0.0151

***LRGDP** Model (2); (3, 3, 0)*
$\Delta lnRGDP_t$ = 4.01 + 0.254$\Delta lnCO2_t^{***}$ + 0.144$\Delta lnCO2_{t-1}^*$ + 0.113$\Delta lnCO2_{t-2}$ + 0.013$\Delta lnGES\_TEG_t$ − 0.181ECT_{t-1}^{**} + ξ_t
$\bar{R}^2$ = 0.38, F-stat. = 4.278, SSE = 0.03, EC$_{t-1}$ = -0.181, DW=2.06
χ^2_{sc} = 0.208; χ^2_{ff} = 0.051; χ^2_{nor} = 3.45; χ^2_{het} = 0.595

D. Impulse Response Functions (GIRFs)

After passed the entire diagnostic and misspecification test on the VAR system, we have performed the Impulse Response Functions (IRFs) in order to simulate a standard error unit shock on GES_TEG. Fig. 1 (a) to 1 (c) shows the IRFs for one standard deviation (SD) symmetric green energy shares shocks (GES) to current and future values of endogenous variables. We conducted estimations of the IRFs over the 10-th period ahead for each endogenous variable based on the VAR system, where decomposition values converging to stable states.
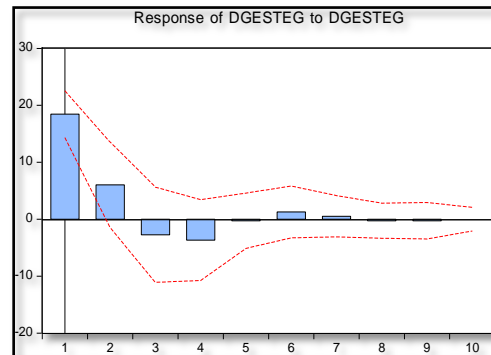

Fig. 1 (a). Response of green energy shocks (GES_TEG) to own shocks.

The impulse response function presented in Figure 1(a) traces the symmetric impact of one unit standard error shock of GES on its own shock. Fig. 1(b) traces the impact of a standard error unit shock of GES on Real GDP. The dynamic profiles of the impulse response suggest that the positive GES shock has an immediate effect on real GDP the next 2-nd period. As far as GES is concerned, we confirm that an increase in GES shock in electricity generation leads to an increased in the real GDP in the short run, as predicted by theory.In other words, the hikes of utilization of green energy sources would incur more cost to electricity producers via technology and input sources investment in electricity generation and shrivel up the

growth of economies through the expansionary effect of industry's consumption and private capital spending in the economy. The result suggests that real GDP responds symmetrically to GES shock as expected. However, the impact on real GDP growth becomes negative in 3-rd periods before stable or asymptotes to 0 after the 4-th period. This suggests that the symmetric impact of GES shock on the growth rate of GDP is relatively short-lived.
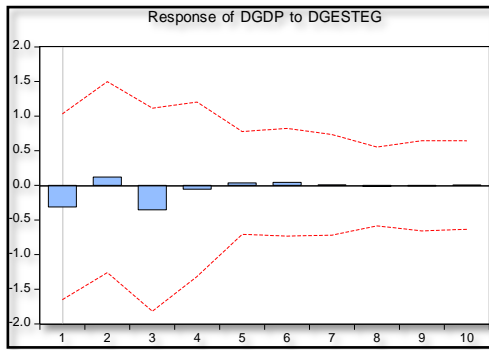
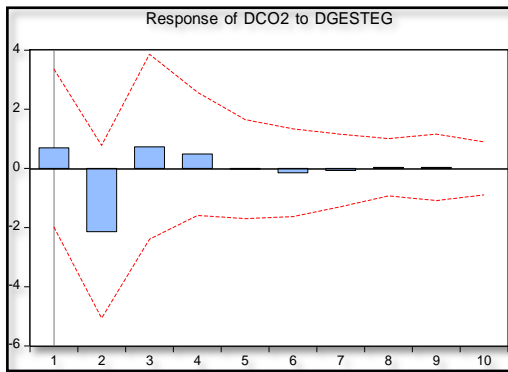Fig. 1 (b). Response of real GDP to GES_TEG.

Fig. 1 (c). Response of CO_2 to GES_TEG.

It is seen that a positive GES shock in the 1-st period has brought the instantaneous negative impact on CO_2 emission in the next 2-nd period as presented in Fig. 1(c). There is a substantial increase in the CO_2 emissions over the 2-nd period due to the reduction of green energy shares in the 2-nd, 3-rd and 4-th before becoming insignificant after the 5-the period. It clearly shows that the green energy's share has a negative relationship with CO_2 emissions, as expected.

IV. POLICY IMPLICATIONS AND CONCLUSION

Given the positive effects between green energy shares in electricity generation on CO_2 emission and economic growth, government and energy planner should confer prompt response and choose the right mechanism of energy conservation i.e. implementing new energy tax, rules and regulation that can curb fossil fuel use that unfriendly environmental. The study would suggest that for achieving higher economic growth, reducing oil, gas and coal especially in the consumption sectors of the economy and shifting towards indigenous resources mainly, hydropower and biomass would have a beneficial impact on the current account balance. This in turn could decrease the deficit in Malaysia's balance of payment position of the economy in

the future.

Therefore, there should be an effort to exploit the renewable sources of energy for consumption and production purposes, which would economize the use of these natural resources in the economy, especially in the industrial sector. This sector consumed 35.7 percent of total commercial energy in Malaysia. The extensive uses of combustion fuel in the industries have contributed massively to the emission of CO2, a greenhouse gas, into the atmosphere. These gases can exacerbate global warming and lead to environmental destruction and health hazards.

Furthermore, expenditure on green energy and energy efficiency technology should be expanded and treated as an investment in this context. This in turn could help government to reduce domestic consumption of fossil fuel, later could increase the amount available for export. Finally, it is worth pointing out that the results of this paper do no more than suggest that the adoption of expansionary fiscal policy i.e. expenditure on green investment in current and future can facilitate rapid economic growth without conveying a harmful effect to the environment. In the sense that, as long as there is a stability and persistence of environmental and economic policies within the framework, a higher expenditure on green investment in Malaysia will contribute positively in supporting the CO_2 emission reduction commitments in the Kyoto Protocol 2, as well as achieving an impressive rate of economic growth with environmentally safe.

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