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DEMAND ELASTICITY OF FUEL IN BARBADOS

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Abstract

The importation of fuel is a significant component of Barbados' import bill, rising from around 7 percent of total imports in 1998 to over 20 percent in 2009. This sharp increase in the demand for energy has impacted greatly on the level of foreign reserves. In addition, as a price-taker, relying entirely on imported oil for the majority of our energy needs could prove a continuous drain on the Barbadian economy. With a view to formulating an appropriate energy policy for Barbados, this paper analyses the demand for fuel in Barbados using monthly data from 1998 to 2009. To develop such a policy, the paper estimates the elasticities of demand for fuel by employing Pesaran et al. (2001) single equation cointegration approach. The results show that the demand for fuel imports is price inelastic in the long run. The consumption of fuel is responsive to past consumption, prices, income and the number of vehicles imported in the short-run. It is concluded that a policy package including upward fuel price, investment and subsidies by government to encourage alternative energy sources could lead to reduce reliance on fuel and better control of our scarce foreign reserves.

JEL Classification: Q41; C22
Keywords: Fuel; demand, elasticity

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1. Introduction

The importation of fuel is a significant component of Barbados' import bill, rising from around 7 percent of total imports in 1998 to over 20 percent in 2009. It is now the highest category of imports, accounting for 20.8% of the import bill, surpassing food and beverages and machinery, which account for 16.9% and 14.7%, respectively, of total imports (see figure 1). This heavy reliance on fuel for energy has impacted greatly on the level of foreign reserves.

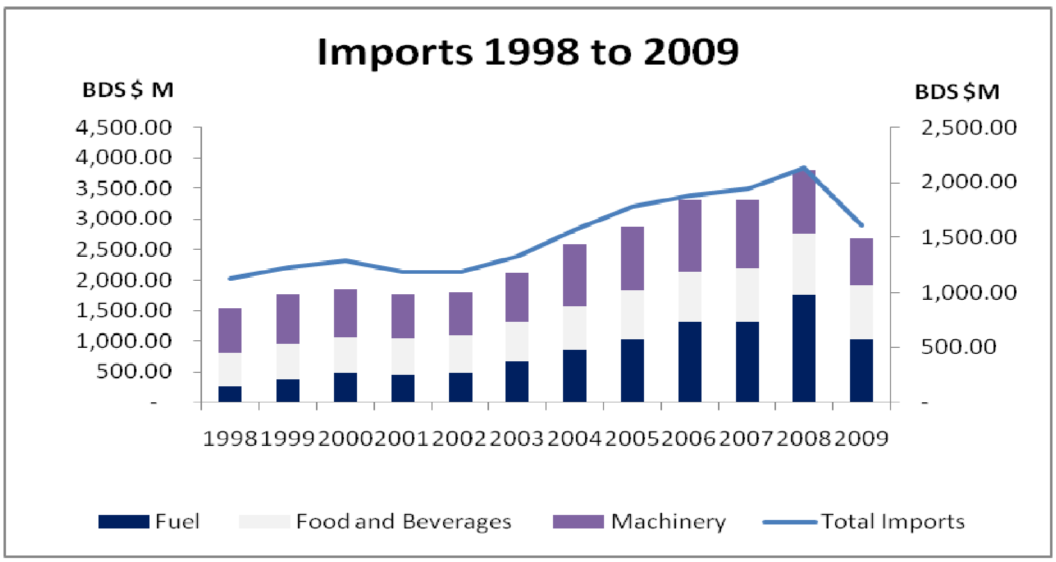
In addition, as a price-taker, depending entirely on imported oil for the majority of our energy needs could prove a continuous drain on the Barbadian economy. With a view to formulating an appropriate energy policy for Barbados, this paper analyses the demand for fuel in Barbados using monthly data from 1998 to 2009. It is different from the previous studies by Cox (1978) and Mitchell (2009) in that instead of using the international price per barrel of crude oil, it utilizes an aggregated import fuel index of the refine products, namely; gasoline, diesel and fuel oil. This index is a better measure of price in that it reflects the actual price that is paid for the refine product as oppose to unrefined crude. The use of the import price of fuel also accounts for the cost of insurance and freight paid by importers thorough the entire sample period. These cost were previously excluded from past studies in Barbados. The change in the price determination process over the sample period, where a subsidy[1] protected consumer from the full pass through of crude oil price increases is also taken into account with the use of the import price index. The study is different from the studies by Durant (1991) and Carter et al. (2009), which are confined to one section of energy demand by estimating the demand for electricity.

[1] The subsidies were a pricing mechanism by Government under which the Cost of Insurance and Freight (CIF) prices of fuel products were not passed on to consumers.

The paper estimates the elasticities of demand for fuel by employing Pesaran et al. (2001) single equation cointegration approach. This technique performs well in small samples and allows for direct estimation of results, even when there is a mixture of I(1) and I(0) variables.

The paper is divided into five sections. Section 2 continues with a brief review of the literature. The selected model and data are discussed in section 3, where as section 4 present the empirical methods and the results. Section 5 concludes the paper and offers some policy implications.

Figure 1:



2. Literature Review

The demand for fuel proxied by some measure of energy consumption is conventionally modeled as a simple demand function comprising variables such as price, income, a measure to capture technological change and maybe a lagged dependent variable arising from the incorporation of a stock adjustment mechanism.

Durant (1991) adopt a partial adjustment mechanism to test the demand for electricity to Barbados for the period 1966 to 1988. He starts with the premise that household electricity consumption is the product of the stock of appliances and the rate of utilisation of this stock. His findings indicate that real per capita income and the marginal price are the variables which best explain variation in average household electricity consumption.

Carter et al. (2009) use micro-level data to estimate a model of residential electricity demand for Barbados. The authors use the Heckman two-step approach (see Cameron and Trivedi, 2005 for details) to regress a variety of household characteristics on the consumption of electricity. They utilise data taken from a Residential Customer Survey done by the Power Company in 1997 and include variables such as household appliances by type (a portfolio of appliances), income per household, numbers in household, average price of electricity, marginal price of electricity information and number of bedrooms. They estimate the price elasticities to be significant and varied by household according to the energy saving devices used. The results also show the income elasticities to be insignificant.

Mitchell (2009) estimates the demand elasticities for fuel in Barbados using annual data during the period 1960 to 2005. He utilises the Engel and Granger (1997) error correction and Johansen (1992) vector error correction techniques and reports that the results are consistent to those obtained in the literature, except for income elasticity of demand which appears to be relatively low. He also finds lagged demand and prices to be significant in the short-run, whereas no relationship is found between energy demand and the ratio fuel imports to nominal GDP used as a proxy for efficiency.

Craigwell and Mitchell (2009) employ an asymmetric ECM as well as a TAR and MTAR ECM to investigate whether there is empirical evidence of price asymmetric behaviour between monthly gasoline and crude oil prices for the Eastern Caribbean Currency Union (ECCU) and Barbados during the period 2004 to 2007 using monthly data. A visual inspection reveals stickiness in ECCU and Barbados gasoline prices to the consumer. Dominica's gasoline prices to the consumer, however appear to be fairly fluid, a result of the implementation of a pass-through of crude oil to gasoline price changes observed at the start of the review period. Results of the asymmetric ECM reveals that price increases persist in Antigua and Dominica but not in Barbados. Decreases from the equilibrium between crude oil and gasoline prices are quickly adjusted in Antigua and Dominica, while in Barbados expansions above the equilibrium relationship is adjusted but at a very slow pace.

Benthem and Romani (2009) emphasise the importance of employing the end-use price rather than the international price when examining the responsiveness of energy demand. The authors investigate the relationship between energy demand, economic growth and prices in 24 non-OECD countries using a panel data set, with sector level observations from 1978 to 2003, and a flexible specification. They use recently developed methods by Griffin and Schulman (2005) to control for unobserved trends such as technical change and apply them to new data set for developing countries with extended coverage and previously unavailable end-use price data. The results of Benthem and Romani (2009) conclude that not only the income, but also price elasticity of energy demand may be non-constant as the price level varies. They also confirm that energy demand is more responsive to end-use price than international oil price change.

3. Methodology and Data

3.1. Model specification

Generally, when specifying the demand for fuel equation, it is conventional to model demand as a function of income and price. Other determinants such as technological change and price of substitutes may also influence demand. Moreover, energy demand is mostly a derived demand and the quantity consumed therefore is strongly conditioned by the stock of energy consuming durable goods (Lescaroux and Rech, 2008). The consumption of petroleum in Barbados is driven by many sectoral factors. Fuel oil is consumed mainly by the electric company and to a lesser extent in the manufacturing sector. The demand for fuel is conditioned on the desire of firms and household for electricity to power energy using appliances and machinery. Carter et al. (2009) modelled the electricity demand for individual appliances using survey data. This data is however not available for the purpose of this study therefore a trend variable to proxy technological progress is adopted. The intuition is that over time technological advancement ensures a lower level of energy use by households and firms alike, compared with previous periods. Fuel oil is imported mainly for used by the electric company for generating electricity, gasoline is imported mainly for used by while diesel is also used in the transport sector but is sometimes used by the electric company as a substitute for fuel oil in their maintenance process. The model for energy demand is defined as follows:

$$V = f(\overset{-}{P}, R\overset{+}{G}DP, \overset{+}{N}V, \overset{-}{T}) \quad (1)$$

where

V_t = volume or barrels of fuel consumed in period t.

P_t = price of fuel in period t.

NV_t = number of vehicle imports in period t

$RGDP_t$ = real GDP or income in period t.

T = time trend to capture technological progress.

The model is estimated using monthly data over the period 1998 to 2009. The total number of barrels of gas, diesel, aviation jet and fuel oil imported is used as a measure of fuel consumed and is taken from the Central Bank of Barbados' monthly survey of Barbados National Oil Company Limited (BNOCL). The Price is an aggregated index of fuel prices compiled by (Jones and Moore, 2008)[2]. The number of vehicles imported is obtained from the Central Bank of Barbados trade database and covers motorcars, vans, trucks, buses and other transport vehicles. Real GDP a proxy for income is taken from the Central Bank of Barbados Annual Statistical Digest. The quarterly estimates of GDP are decomposed into monthly figures for the review period using Econometric View 7, low to high frequency conversion method.

Consumer theory posits that the quantity of fuel consumed (V_t) should be inversely related to the price of fuel (P_t), and positively related to the level of income ($RGDP_t$). As the level of imports (NV_t) increases and adds to the stock of vehicles, it is expected that the demand for fuel will increase. The trend variable (T) is a measure of technological progress and anticipated to be negatively related to fuel demand, that is, over time technological advancement may result in a lower level of energy use by households and firms.

[2] Individual price indices were constructed for gasoline, diesel and fuel oil using prices per barrel obtained from the monthly survey of BNOCL. The individual indices were combined to arrive at an aggregated fuel index.

3.2. Econometric Approach

The model is estimated using the Unrestricted Error Correction Model (UECM) approach proposed by Pesaran et al. (2001), where short- and long-run effects are estimated jointly from a general autoregressive distributed-lag (ARDL) model. Pesaran et al. (2001) refers to this as the ARDL approach to cointegration modeling. This approach has two main advantages over the other common procedures to cointegration analysis, mainly the Engle and Granger two-step approach and the Johansen maximum likelihood framework. The first advantage stems from the fact that the other methods focused on the estimation of long-run relationships among I(1) variables, which inevitably involves a certain degree of pre-testing and thus introduces a further degree of uncertainty into the analysis of relationships between levels (Cavanagh et al., 1995; Pesaran et al., 1996; Pesaran et al., 2001). Moreover, their widespread use has led to the common misconception that long-run relationships exist only in the context of cointegration among integrated variables (Greenidge, 2006; Loayza and Ranciere, 2006). With the UECM, cointegration analysis can be conducted irrespective of whether the explanatory variables are I(0), I(1) or a mixture of both. The second advantage is that this technique improves upon the other methods since it is better at handling small sample and dynamic sources of bias. Pesaran and Shin (1998), Pesaran et al. (2001) and Haug (2002) show that the OLS estimators of the short-run parameters in the UECM are $\sqrt{T}$-consistent and the long-run coefficients are super consistent in small sizes.

The ARDL representation of equation 1 is:

$$\Delta lV_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i}\Delta lV_{t-i} + \sum_{i=0}^{m} \beta_{2i} lP_{t-1} + \sum_{i=0}^{m} \beta_{3i} lRGDP_{t-1} + \sum_{i=0}^{m} \beta_{4i} lNV_{t-1} + \lambda lV_{t-1} + \alpha_1 lP_{t-1} + \alpha_2 lRGDP_{t-1} + \alpha_3 lNV_{t-1} + \alpha_4 T + \varepsilon_t \quad (2)$$

where the variables are all expressed in natural logarithmic form. The terms β_1,

β_2, β_3 and β_4 are the short-run coefficients, while λ, α_1, α_2, α_3 and α_4 are the level effects and thus the long-run coefficients are computed as - (α_i / λ) where λ is the speed of adjustment to the steady state. ε_t is a disturbance term that subscribe to all the classical assumptions.

Investigation of the presence of a long-run relationship amongst the variables of equation (1) is tested by means of the ARDL bounds testing procedure by Pesaran et al. (2001). The variables are said to be cointegrated if the coefficients on the lagged level variables are jointly significant. In other words, if the null hypothesis as represented by Ho: $\lambda = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ is rejected a long–run relationship exists among the variables. An F-test with a non-standard asymptotic distribution is used to test the null hypothesis. Pesaran et al. propose two sets of critical values to test for cointegration when the variables are I(0) or I(1). These two sets of critical values refer to two polar cases but actually provide a band covering all possible classifications of the regressors into I(0), I(1) or even fractionally integrated. If the calculated F-statistic lies above the upper level of the band, the null is rejected, indicating cointegration. If it falls below the lower level of the band, the null cannot be rejected, indicating the no cointegration. If the calculated F-statistic falls within the band, a conclusive inference cannot be made.

4. Results

In estimating Equation 2, a general-to-specific approach is used in order to reduce it to a more parsimonious representation. The model is estimated first using 13 lags given the frequency of the data being monthly. The diagnostic tests performed on the general model indicate that it is well determined. Table 2 presents the final parsimonious long and short-run representation. It is from this 'specific' model that cointegration is tested and determinants of fuel consumption identified.

The F-statistic for the ARDL cointegration test is computed using the restriction explained in section 3.2. This number is then compared to two sets of critical values computed by Pesaran et al. (2001). In Table 1 the bounds test shows that a long-run equilibrium exists among the variables since the F-statistic is greater than the upper bound at 5% level of significance.

Table 1: Bounds Test Results

F-Statistic	Lower Bound Critical Value	Upper Bound Critical Value	Cointegration
F(2,122)=6.192	4.94	5.73	Yes

Notes: The critical value bounds are obtained from Table CI (iii) (unrestricted intercept and no trend; with one explanatory variable) in Pesaran et al. (2001). The critical values above are at 95% level of confidence.

Using the general to specific approach, the proxy for technological progress did not make it into the specific model. Nonetheless, the model performs well as it explains approximately 58% of the variation in fuel consumption and as mentioned earlier it satisfies the relevant diagnostic checks. Figure 2 shows the goodness of fit, illustrating how well the model fits the data.

The findings of the regression indicate that not all the variables have both short and long run impacts on the dependent variable. The estimated results show that real income, price, the lagged fuel demand and the number of imported vehicles are all significant in the short-run. There appears to be no relationship between fuel demand and income in the long run, a result consistent with the study by Reiss and White (2005) and more importantly Carter et al. (2009) who found the income effects to be statistically insignificant for Barbados and that the effects of income may have been captured by choices of appliances rather than utilisation. The finding that income is not a factor in the long run may be due to the fact that nearly 50 per cent of fuel imported is used for electricity. Past micro studies have shown that electricity usage is not a function of income but rather a choice of appliances. The plot of real income and fuel consumption shown in figure 3, also indicate no real relationship between income and fuel demand during the period 1998 to 2009. Price is the only variable significant in the long run with a coefficient of 0.30 %, less inelastic than that estimated by Mitchell (2009) and may reflect the use of prices of the refined product rather than the international price per barrel of crude oil. The cointegrating variable has a coefficient of 0.31 indicating that it may take about 4 months for fuel consumption to adjust to its long run equilibrium after a shock that causes disequilibrium.

Table 2: Determinants of Long-term Private Capital Flows in Barbados

$$\Delta Y = \underset{(2.95***)}{4.35} - \underset{(-5.21***)}{0.58\Delta Y_{t-1}} - \underset{(-3.74***)}{0.39\Delta Y_{t-2}} - \underset{(-2.79**)}{0.22\Delta Y_{t-3}} - \underset{(-2.17**)}{0.44\Delta P_{t-2}} + \underset{(3.21***)}{0.12\Delta NV_{t-9}} + \underset{(2.14**)}{0.08\Delta NV_{t-10}} + \underset{(2.59**)}{2.43\Delta RGDP_{t-4}} + \underset{(5.65***)}{5.63\Delta RGDP_{t-10}}$$
$$- \underset{(-2.09**)}{0.09P_{t-1}} - \underset{(-2.82***)}{0.31V_{t-1}}$$

Diagnostics Tests

$R^2 = 0.58$ $\overline{R^2} = 0.55$ $F = 16.62$ $DW = 2.128$ $NORM = 3.518$
$AR = 1.935$ $ARCH = 0.372$ $HET = 1.377$ $HET - X = 1.235$
$RESET = 0.981$

Long-run Impact Multipliers

Price	-0.303

Notes: T-statistics of regressors are shown in parentheses. ***, ** and * indicates significance at the 1, 5 and 10 percent level of testing, respectively. However, all diagnostic tests are performed at 5% level of testing. R^2 is the coefficient of determination, $\overline{R^2}$ is the coefficient of determination adjusted for degrees of freedom, *F* is the F-statistics for the joint significance of the explanatory variables. *DW* is the Durbin Watson statistic and *Norm* is the test for normality of the residuals based on the Jarque-Bera test statistic ($\chi 2$ (2)). *ARCH* is the autoregressive conditional heteroscedasticity for up to p-th order. *HET* is the unconditional heteroscedasticity test based on the regression of squared residuals on squared fitted value. Finally, *RESET* = Ramsey test for functional form mis-specification.

Figure 2: Goodness of Fit

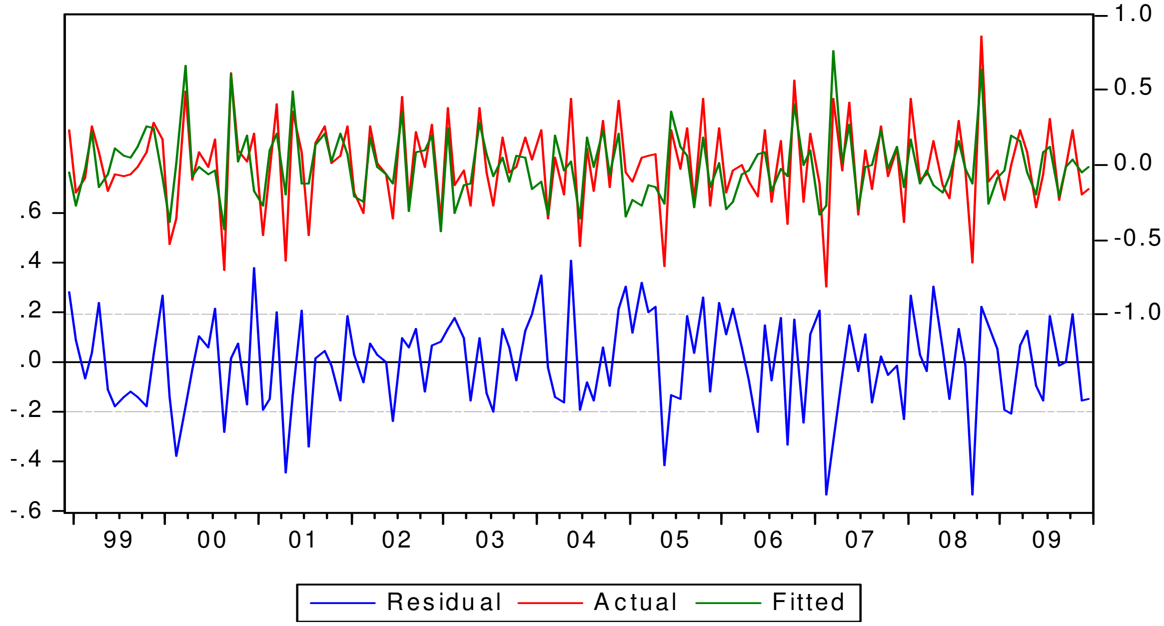
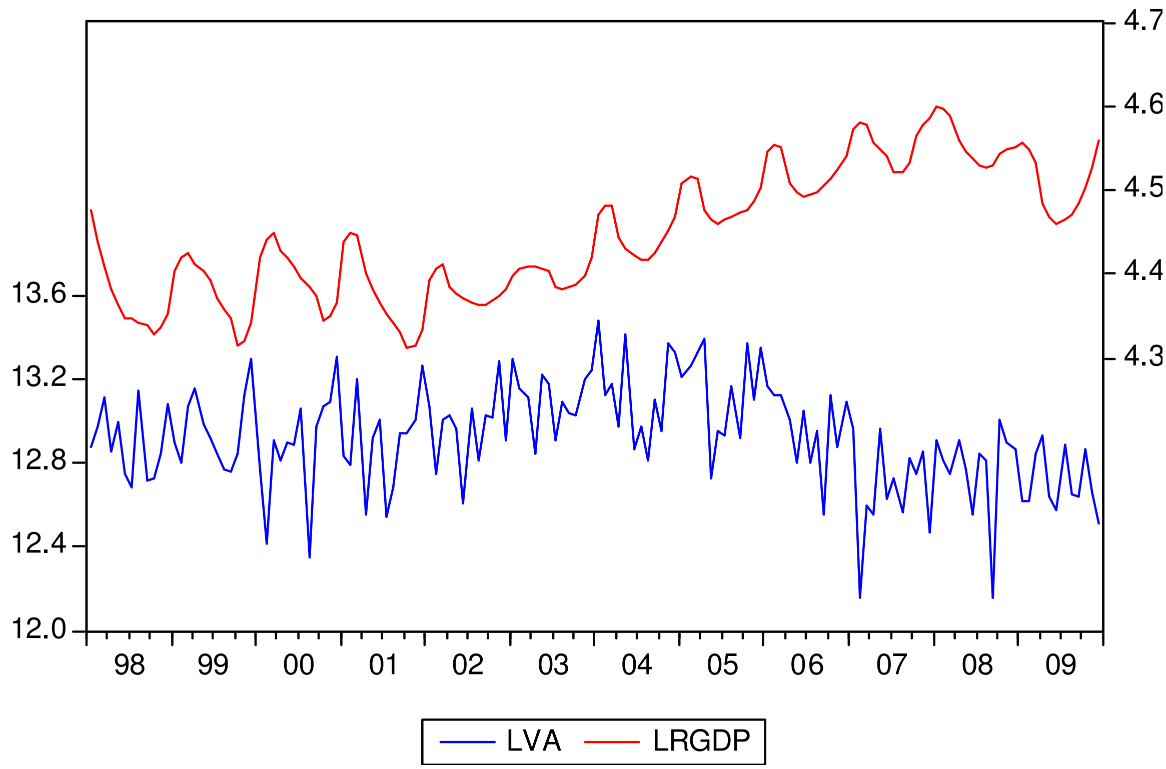


Figure 3: Real Income vs Fuel consumption



5. Conclusion

This paper attempts to model the demand for fuel consumption in Barbados using monthly data and for the first time employing a price series representing the true price paid for the refined commodity. The ARDL error correction model by Pesaran et al. (2001) is adopted and a general-to-specific approach to arrive at a well-determined model is used. The results are fairly consistent with those obtained in the literature, except for income elasticity of demands, which appears not to be significant in the long run. All of the other variables had their 'a priori' expected but not all of them were significant in both the short and long run.

The inelastic oil demand suggests that consumers are constrained by technology and a lack of energy alternatives. Therefore, fuel demand does not rise or fall, following a decrease or an increase in fuel prices in any given period. The insignificance of income may imply that despite the level of income earned the economy is burdened with relatively unchanged levels of imported fuel at which the cost may be higher or lower depending on the world price.

The removal of the subsidy by government in October 2008, which protected consumers from the full effects of insurance and freight cost, seems not to have resulted in a reduction in energy consumption even in times of recession. Given the results, it can be concluded that a policy package including upward fuel price through taxation, investment and subsidies by government to encourage alternative energy sources could lead to reduce reliance on fuel and better control of our scarce foreign reserves.

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