Investigating Factors Affecting Renewable Energy Consumption in Louisiana

Krishna H. Koirala and Aditya R. Khanal
Department of Agricultural Economics and Agribusiness , Louisiana State University

Selected Poster prepared for presentation at the Southern Agricultural Economics Association (SAEA) Annual Meeting, Orlando, Florida, 3-5 February 2013

Investigating Factors Affecting Renewable Energy Consumption in Louisiana

Krishna H. Koirala and Aditya R. Khanal

Department of Agricultural Economics and Agribusiness , Louisiana State University

Abstract

This study investigates the long and short-run factors influencing renewable energy consumption in Louisiana using a time series data over five decades. A cointegration and error correction model is used to evaluate time series data. Results suggest that renewable energy consumption is positively associated with income, while negatively associated with prices of coal energy and petroleum products in the long run.

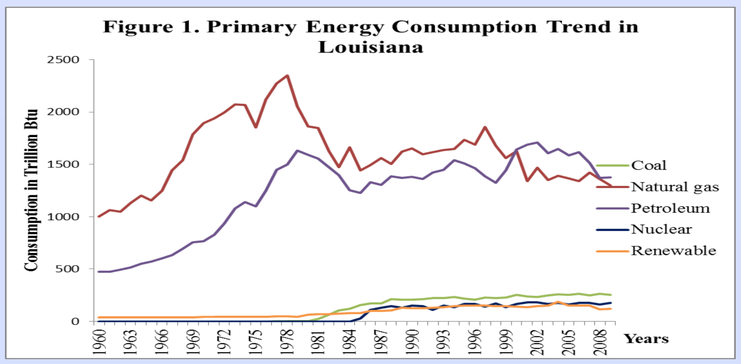
Problem Statement

Volatile nature of non-renewable energy prices, especially oil prices, has contributed to the recent interest in renewable energy in the United States. Mitigating climate change and achieving greater energy security through increased domestic renewable energy production are two major priorities in the United States. These prioritized policies are one of the important reasons of rapid expansion in demands of renewable energy sector. However, only a small production share (8%) is from renewable energy sources. In this scenario, factors driving demand for renewable energy sources are of inherent interest. The questions such as “which factors determine the consumption trend?”; “How price and income factors are influencing the consumption pattern of renewable energy sources over time?” draw greater attention for policy level implications.

Introduction and Objectives

- Interest in renewable energy has historically been associated with increasing energy prices, primarily oil, as a governing factor for bioenergy market demand (Abt et al., 2010). Renewable energy consumption, the world’s fastest growing form of energy, increases by 2.8 % per year.
- The economic recession, climate change concerns, and volatile nature of non-renewable energy prices are major motivators for a number of countries to embrace energy efficiency alternatives as a way to create new local jobs, lower energy bills, and promote environmental sustainability (Bartuska 2006).
- Louisiana is rich in crude oil and natural gas. Oil and gas deposits are found in abundance both onshore and offshore in State-owned waters. Louisiana has substantial bioenergy potential in comparison with other States due to its productive agriculture and forestry industries. Consumption of renewable energy is fairly stable till 1980s in Louisiana. After 1980, consumption is in increasing over years (see figure 1).
- The objective of this study is to investigate changes in renewable energy consumption, and to identify factors associated with renewable energy consumption in both short and long run.

Figure 1. Primary Energy Consumption Trend in Louisiana



Data and Methodology

A cointegration and error correction model is used for the analysis of time series data from 1970 to 2010. Data was collected from U.S. Energy Information Administration (EIA). Cointegration has emerged as a powerful technique for investigating common trends in multivariate time series, and providing a sound methodology for modeling both long-run and short-run dynamics in a system (Engle and Granger 1987). An important implication of cointegration between prices of two interrelated commodities in that pairs of such variable should not diverge from one another to a great extent in the long run (Dicky and Fuller 1979). A *error correction* model is restricted *vector autoregressive* (VAR) designed to use with non-stationary series that are known to be cointegrated. The error correction has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variable to converge to their cointegrating relationships while allowing for short-run adjustment dynamics.

Empirical Specifications

Augmented Dickey-Fuller Test

$$\Delta X_t = \propto_0 + \propto_1 t + \beta_0 X_{t-1} + \sum_{i=1}^{k} \beta_i \Delta X_{t-i} + \epsilon_t$$

Where Δ is the first difference operator; x_t is a time series variable, t is the time trend; k denotes the number of lags used and $\boldsymbol{\epsilon}$ is the error terms and βs are parameters (Maddala and Kim 1998).

Cointegration Test

$$\Delta y_t = \Pi\, y_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta y_{t-i} + B x_t + \epsilon_t$$

Where, $\Pi = \sum_{i=1}^{p} A_i - I$, $\qquad \tau_i = \sum_{j=i+1}^{p} A_j$

Error Correction Model

Renewable consumption = f (coal price, natural gas price, income, price of petroleum product, nuclear energy price, renewable energy price)

Results and Discussion

Table 1: Descriptive Statistics of Variables Included in the Study

Variables	Obs.	Mean	Std. Dev.	Min	Max
Natural gas price	41	1.0984	0.1736	0.8657	1.6433
Coal energy price	41	0.7691	0.5280	0.0164	2.0083
Nuclear energy price	41	-0.1051	0.6992	-1.456	1.2794
Renewable energy price	41	0.8282	0.5852	0.1294	2.2760
Petroleum energy price	41	2.2387	0.1579	1.8670	2.7052
Income per capita	41	9.2825	0.2129	8.8794	9.6657
Renewable energy consumption	41	4.5475	0.4991	3.7281	5.2454

Unit Root Test

Unit root test is the first step to test the stability of a series. All selected seven variables were log transformed as well as adjusted with PPI. Augmented Dickey-Fuller (ADF) unit root test on the seven variables was conducted to determine the order of integration of each individual series (see table 2). The tests show that the levels of all selected variables were non-stationary at the 5 percent significance level and stationary at first difference.

Table 2: Unit Root Test Results

Variables	Level (t-statistics)	P-values	First Difference (t-statistics)	P-values
Coal price	-2.646869	0.2630*	-6.610350	0.0000**
Income per capita	-1.905859	0.6329*	-4.801732	0.0021**
Natural gas	-2.290889	0.4290*	-6.474564	0.0000**
Nuclear energy	-2.435327	0.3569*	-7.870670	0.0000**
Ren. Consumption	-1.611013	0.4678*	-7.007762	0.0000**
Petroleum products	-2.459251	0.1328*	-7.713784	0.0000**
Ren. energy price	-2.89456	0.4567*	-6.307618	0.0000**

* and ** represents variables are significant at 5% and 1% level, respectively.

Cointegration test

Based on the unit root test result, unrestricted Johansen test of cointegration was applied to examine long-run relationships between the variables. The Akaike Information Criterion (AIC) was chosen for finding out the lag order.

Table 3: Cointegration Test Results

Hypothesized no of CE(s)	Trace Statistics	P-values	Max-Eigen Statistic	P-values
None	161.0211	0.0779	44.3884	0.0673
At most 1	116.6329	0.0009*	40.07757	0.0258*
At most 2	76.65669	0.0021	32.13793	0.0382

Renewable energy consumption =

-1.2842 *Coal price + 3.610662* Income + 0.735511Natural gas
(0.51884) (1.36020) (0.56100)
+ 1.279456 Nuclear energy - 3.633386 *Petroleum product
(0.97456) (0.58894)
+ 0.210186Renewable energy price (0.210186)

* represent the variable is significant at 5% level and ( ) value shows the standard error.

Error Correction Model (ECM)

The error correction model can only be run when variable are found to be cointegrated. The error correction model provides information regarding the short-run elasticity.

Table 4: Error Correction Model Results

Variable	Coefficient	Std. Error	t-statistics	P-values
C	0.029605	0.025059	1.181385	0.2459
D(Coal)	-0.085885	0.146633	-0.585711	0.5621
D(income)	-0.425520	0.930667	-0.457220	0.6505
D(Natural gas)	-0.423442	0.205558	2.05996	0.0036*
D(Nuclear)	-0.116689	0.101947	1.144939	0.2605
D(Petroleum)	0.278298	0.165981	1.676680	0.1031
D(Renewable)	-0.311815	0.121012	-2.58333	0.0021*
U(-1)	-0.481992	0.150033	-3.21574	0.0031*

* represent the variables are significant at 5% level.

The error correction term corrects the disequilibrium of the system. Based on the results, the error correction term corrects disequilibrium at the rate of 48.19% .

Conclusion

- Cointegration test shows a long run relationship between the variables. Renewable energy consumption decreases by 1.28% with 1% increase in coal energy price.
- In a long-run, renewable energy consumption decreases by 3.64% with 1% increase in price of petroleum product. Petroleum products are used for transportation of renewable energy from production site to industry. Price increase in petroleum products increases transportation cost of renewable energy. As a result, an increase in price of petroleum product leads to decrease in demand of renewable energy.
- In the short-run, current year renewable energy consumption decreases by 0.42% with a 1% increase in natural gas price. A plausible reason is that the consumers, who were using renewable energy and natural gas, tend to shift towards coal energy. Coal and natural gas are substitutes for electricity generation in Louisiana.
- Lastly, the consumption of renewable energy increases by 3.62% with 1% increase in per capita income. This is possibly due to increased consensus about environment and the quality of oil when income of a person rises.

References

- ABT, R.C., K.L. ABT, F.W. CUBBAGE, AND J. D. HENDERSON. 2010. Effect of policy-based bioenergy demand on southern timber markets: A case study of North Carolina. Biomass and Bioenergy. doi:10.1016/j.biombioe.2010.05.007.
- BARTUSKA, A. 2006.Why biomass is important :The role of the USDA Forest Service in managing and using biomass for energy and other uses. Taken from speech at 25x’25 Summit II. Washington, D.C.
- DICKEY, D. A., AND W. A. FULLER. 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Association. Volume 74. Issue 366.
- EIA. 2012. Consumption, Price, and Expenditure Estimates. Available online at http://www.eia.gov/state/seds/
- MADDALA, G.S., AND I.M. KIM. 1998. Unit Roots, Cointegration, and Structural Change. Cambridge University Press. New York, NY.