Rethinking Regional Energy Policy Do Threats Matter in Supply and Generation Process?

Paul Ojeaga and Phillip Alege and Adeyemi Ogundipe

Covenant University Ota Nigeria, Covenant University Ota Nigeria, Covenant University Ota Nigeria

16. October 2013

Rethinking Regional Energy Policy
Do Threats Matter in Supply and Generation Processes?

Phillip Alege[1]
Paul Ojeaga[2]
and
Adeyemi Ogundipe[3]

Department of Economics and Development Studies
Covenant University
Km10 Idiroko Road
Ogun State
Nigeria

Abstract

The study investigates potential threats to energy security and sustainable electricity production from a regional perspective, after identifying a host of factors that are likely to affect sustainable energy production and supply using seemingly unrelated regression estimation, which produces efficient estimates. Our results show that energy security which we described as the level of diversification in regional specific energy generating sources is probably being affected by regional specific level of industrialization and domestic energy consumption. Issues of over dependence on specific sources of energy supply (particularly nuclear production sources) were also found to have a negative effect on energy security and probably increase the risk of future failure in energy supply. Energy policy was also found to have a significant effect on energy security. The impacts of various constraints on electricity production were also considered. It was found that many factors affect electricity output production in regions particularly environmental factors that affect consumption and generation.

Keywords: Energy Security, Electricity production, Seemingly Unrelated Regression

JEL Classification: F40; F50; Q20; Q47

---

[1] Department of Economics and Development Studies, Covenant University, Ota, Ogun State
Email: philip.alege@covenantuniversity.edu.ng
[2] Department of Economics and Development Studies, Covenant University, Ota, Ogun State
Email: paul.ojeaga@coveneantuniversity.edu.ng Tel No 002348175568653
[3] Department of Economics and Development Studies, Covenant University, Ota, Ogun State
Email: yemi_keke2001@yahoo.com; ade.ogundipe@covenantuniversity.edu.ng
+2348161927372

1.0 Introduction

According to the United Nations energy report 2012, World energy consumption is likely to double by the year 2050. One of the greatest challenges for stake holders and policy makers is how to meet global energy demands and keep world temperatures from increasing by over 2 degrees Celsius through the reduction of green house gases.

Promoting energy security has continually been one of top concerns, to many governments and energy security experts. Energy security can be defined as the ability to provide access to sustainable and cheap supply of energy for domestic consumption. A host of threats often affect energy supply and production some include, weak energy policies, environmental constraints that affect energy supply availability and use, regional specific industrialization rate, domestic energy consumption characteristics, regional investment in domestic innovation of alternative energy generating sources and other climatic concerns.

Over dependence on fossil fuel today continue to remain a strong threat to achieving sustained and affordable energy for both domestic and industrial uses in countries. The convenience and advantage of using gas as a means of powering electricity turbines and for heating purposes also mean that countries particularly those in the industrialized west (e.g. particularly Europe) will continue to be highly susceptible to gas supply disruption for years to come.

Over the years, energy security experts have continued to focus on energy supply issues - particularly supplies from the Middle East and the instability in the Middle East that can lead to a rise in crude oil prices for example the world oil crisis of the 1970s. The Fukishima Nuclear disaster and the gulf of Mexico Oil spillage of 2012 are also constant reminders of how vulnerable developed countries are to strong environmental threats that are likely to affect energy installations and in turn affect supply levels.

The Russo-Ukrainian gas pipeline crises of 2005-2006 also highlights how energy markets are likely to become highly susceptible to disruption in gas supply lines in times of disputes. The World Economic Forum paper “The New Energy Security Paradigm 2012”, mentions up to ten factors that are likely to affect energy security and how such concerns are likely to be addressed in the future, some of which include, energy generation diversification, investment in new technology, high commitment to research and development addressing market flexibility issues, development of good relations between suppliers and users etc.

A host of factors affect, many countries ability to provide sustainable and affordable energy for domestic and industrial use some of these include the rapid rate of industrialization, population increase and the rise in domestic energy consumption and lots of environmental constraints that affect their ability to access the needed energy for generation purposes.

Diversifying domestic generating sources will provide a great opportunity for countries to mitigate risks associated with overdependence on some specific sources. The over dependence

on fossils for instance is likely to expose non producing oil countries to the high risk associated with price increases that will follow increased demand for crude oil in the global oil market.

Other issues such as pollution also associated with the use of fossil fuel also make lots countries to be vulnerable to a high pollution and rise in green house gas emissions. Many other factors also affect different energy generating sources and addressing such constraints is likely to improve overall energy supply. One of the most efficient ways of reducing pollution and keeping world temperature below the projected 2 degrees Celsius increase is by depending on renewable energy sources for energy generation. The IEA report 2011 states that solar energy, a renewable energy source is likely to produce over 50% of world electricity by 2050.

According to the World Energy Council Report 2013 about 1.3 billion people remain without electricity today. Energy policy makers also appear to have soft pedaled on issues of carbon dioxide emissions since this was probably affecting issues of energy production and utilization among the highly industrialized countries particularly the United States of America.

Recent indications have also shown that the Kyoto protocol is not going to be realizable with the recent postponement of the full implementation till the year 2030 with the absence of the big energy consumers in the World during the 2013 Doha meeting. Since their introductions in 1988 with a series of inter governmental parleys and rounds of talks, countries have not been able to realize laid cuts in emission rates as agreed by its various conventions.

The Middle East and Africa will continue to remain a potential source for supply of energy to developed countries, the increase in energy demands in industrializing Asia and the gradually emerging countries in Africa and Latin America mean that the competition for the scare available energy resources of the earth is gradually on the increase.

On the other hand the adverse impact that harnessing energy reserves in many developing countries is likely to have on environmental conditions in these producing developing countries is also a matter of strong concern to many energy experts.

This paper studies the impact of various factors on energy security and electricity production in regions. Very few studies if any, have tried to address the issues of energy security from a regional perspective. Quite a few have also tried to study the various factors that affect electricity output production by addressing potential threats to electricity generation source using regional studies. The question we try to answer are to what extent does overdependence on some specific energy generating sources make countries vulnerable to energy supply failures? And secondly, does domestic industrialization rate and environmental constraints pose a threat to future electricity generation in regions?

In this paper the estimation method used is the seemingly unrelated estimation regression approach which produces consistent estimates based on the premise that two unrelated regression actually have correlated error terms. Allowing us to gain a more efficient estimator by estimating

the two estimators jointly as first presented, by Zellner (1962). The intuition mirrors the intuition for a single equation with serial correlation $U_{t,1}$, where the errors of a second equation $U_{t,2}$ if correlated with that of the first equation is likely lead to the production of more efficient regression estimates.

In the first equation it is assumed that energy security will depend on individual energy generating sources (coal, gas, renewable, nuclear and hydro electricity generating sources), environmental constraints to energy production and supply, regional specific industrialization rate (aggregate industrialization rate of countries in each regions), energy consumption patterns in regions, regional investment in new technology (domestic innovation rate) and regional specific energy policy.

In the second equation electricity production is assumed to depend on domestic energy consumption, industrialization rate, domestic innovation rate and regional energy policy. This study utilizes regional panel data for five regions, Africa, Latin America, the European Economic Area including Norway and Switzerland consisting of 27 countries, North America and South East Asia Pacific which consist of south East Asia mainland and other territories including China. The rest of the paper is divided into the literature review, stylized facts on energy security and electricity production in regions, theory and methodology, empirical analysis and results and the concluding sections.

2.0 Literature Review

Past studies (Cohen et al 2011) show that diversifying energy supply sources, particularly gas supply sources can have a positive effect on sustained and guaranteed access to energy supply for countries in the European Union even though there have not been much changes for crude oil. Other Causal empirical studies such as Bryce (2008) also suggest that diversification in energy has been on the increase particularly in the United States.

Other papers particularly Lefevre (2004) have also investigated global supply of energy from the supply side of energy consumables used in generation, and suggest that global energy security in the future can be measured as the ratio of supplier exports to its domestic utilization needs. Coq and Palseva (2004) and Newman (2004,2007) state that domestic demands of oil producers are not likely to pose a threat to future energy security, on the short run arguing that consumers are likely to switch to other producers. The 1973 energy crisis was largely responsible for the strategic blue print of many developed countries particularly the United States which according to LaCasse and Plourde (1995) was to put, energy security at the heart of energy policy agenda of industrialized countries. Rosendahl and Sagen 2009 argue that while cost of transporting gas from production point to consuming destinations have fallen over the years, the trade in natural gas has risen dramatically with spot price increase of over a factor of 10 in the last decade.

Timisina and Vasetsky (2009) study the effect of inter-fuel substitution between oil and gas using cross country data and find very little inter-fuel substitution between oil and gas but find a considerable inter-fuel substitution effect between electricity and oil. This was quite true as almost about 23% of total electricity output in the United States is produced from natural gas generating plants alone.

Little work has been done in trying to study the impact of threats to abrupt disruption of energy supply from regional and quantitative analysis point of view. Few empirical studies if any have tried to examine the effects of threats to energy supply on electricity output generation and energy supply in general. The EU Green Paper 2001 states that energy security is the guaranteed supply of energy from production points to destination consumption locations. Other papers such as Awerbauch, Stirling, Jansen and Beurskens (2004) define energy security in terms of portfolio diversity and green house gases (GHG) reduction concerns. They argue extensively that consumer countries should hold portfolios free of cost risk associated with the hikes in fossil fuel prices.

Awerbach and Berger (2003) also argue that cost in this case determines returns, and that cost are in fact the inverse function of returns, therefore optimizing portfolio cost is not likely to affect results making cost to have no effect on generating mix. In tradition with past literature energy security is defined in this paper as the amount of diversity in the energy generation process in regions using a score variable for regional specific dependence on different energy generating plants such as Nuclear, renewable, coal, gas and hydro electric generating capabilities.

The effects of various generating sources were weighed on energy security to identify issues of over dependence on specific energy sources in regions. Other possible constraints and threats to energy supply and generation mentioned by previous scholars such as environmental constraints, industrialization rate, domestic consumption characteristics and regional specific investment in domestic technology since the cost of acquiring technology overseas is often more expensive were also investigated, see The World Economic Forum paper “The New Energy Security Paradigm 2012” for details and further discussion of threats to energy security.

3.0 Some Stylized Facts on Energy Security and Threats to Electricity Production in Regions

In this section we explain with facts how vulnerable regions are to threats in the generation and supply process. Consistent with past literature the level of diversity in energy generation is on the increase see Lacasse and plourde (1995) see Fig. 1 and table 1 below. The United States has the

Table 1 Regional fact on energy security, generation and threats to electricity production

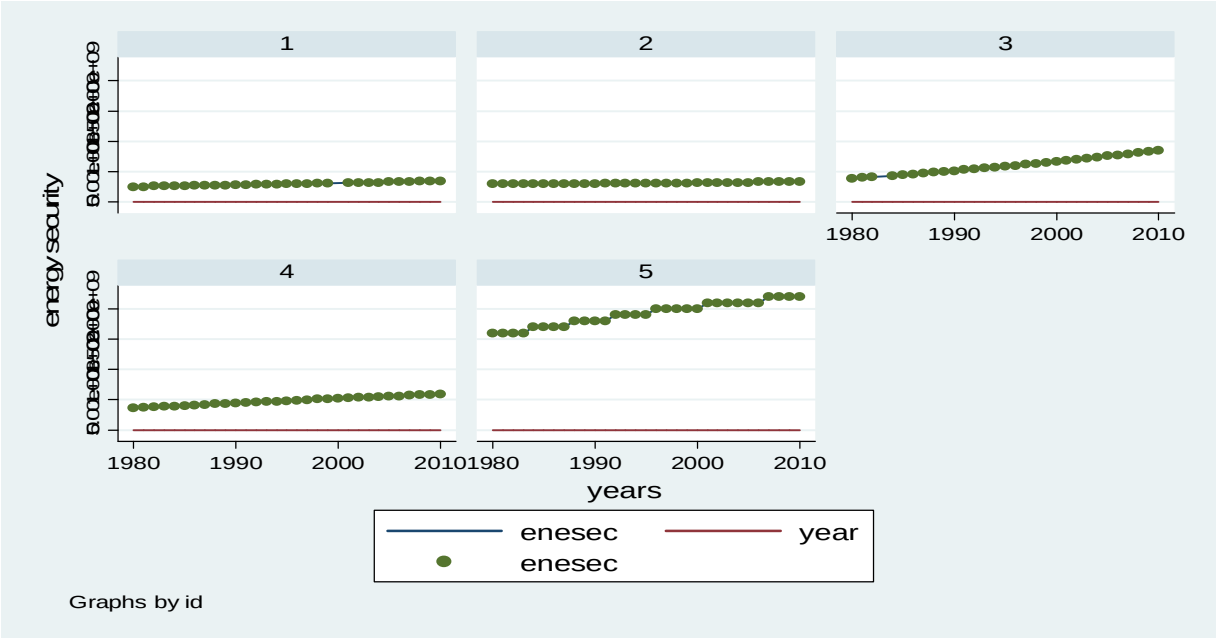
	Level of energy diversification in regions		Total electricity output production (KwH)		Industrialization rate		Regional investment in domestic innovation		Environmental factors		Energy Consumption rate (KwH)		No. of major countries
Region/year	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	
North America	4	5	4.6e+12	4.8e+12	32188	46660	4831	4763	0.217	2.225	1.3e+6	1.4e+7	3
European (EEC)	3	4	2.9e+11	4.9e+11	19850	37444	4560	4660	0.65	0.19	3.1e+6	3.2e+6	27
Africa	2	3	.32e+10	.42e+09	3920	2130	366	633	8.42	16.54	6631	65410	61
Latin America	2	3	1.0e+12	1.3e+12	3986	4654	498	565	13.30	15.61	291704	330000	26
South East Asia	3	4	1.73+12	4.3e+12	3900	33000	3088	3072	15.05	29.44	2e+5	3.1e+5	5

Source: Authors' compilation

Note: Energy security is represented by the level of diversification in regions, while environmental factors are measure using average world temperature and access by proximity to energy generation resources. Energy consumption and electricity output are measured in Kilo Watts Hours this is compiled by author from data obtained from data market of Iceland.

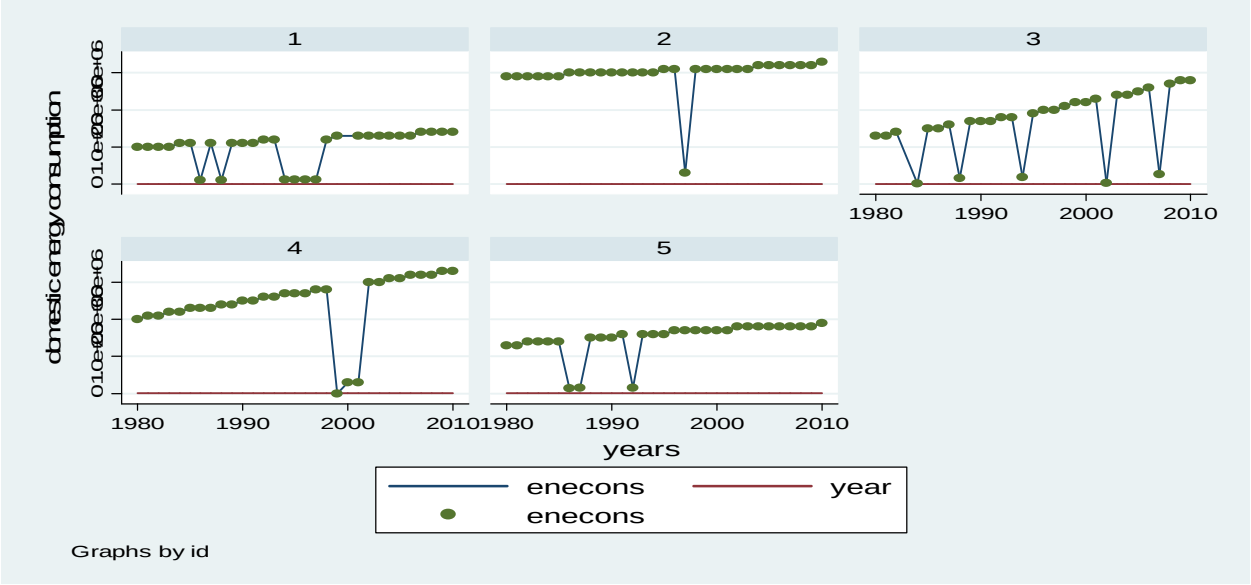
most diversified energy generation system, while Europe remains most affected by environmental limitations in the electricity generation process. Energy consumption rate is on the

Fig. 1 Energy Security in regions



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

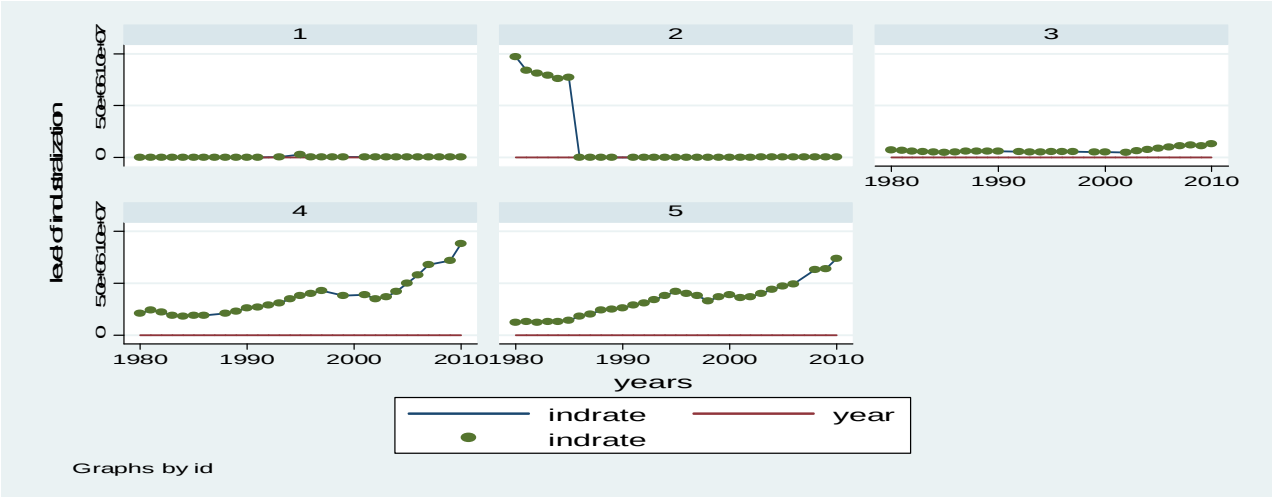
Fig.2 Domestic Energy Consumption patterns in regions



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

increase in all regions. While energy consumption in Africa, seems to be on the increase, this increase is not significant due huge supply cut-off due to current impending infrastructural challenges despite continuous investment in developing generation and supply infrastructure see Table 1 and Fig.2.

Fig. 3. Industrialization trends in regions



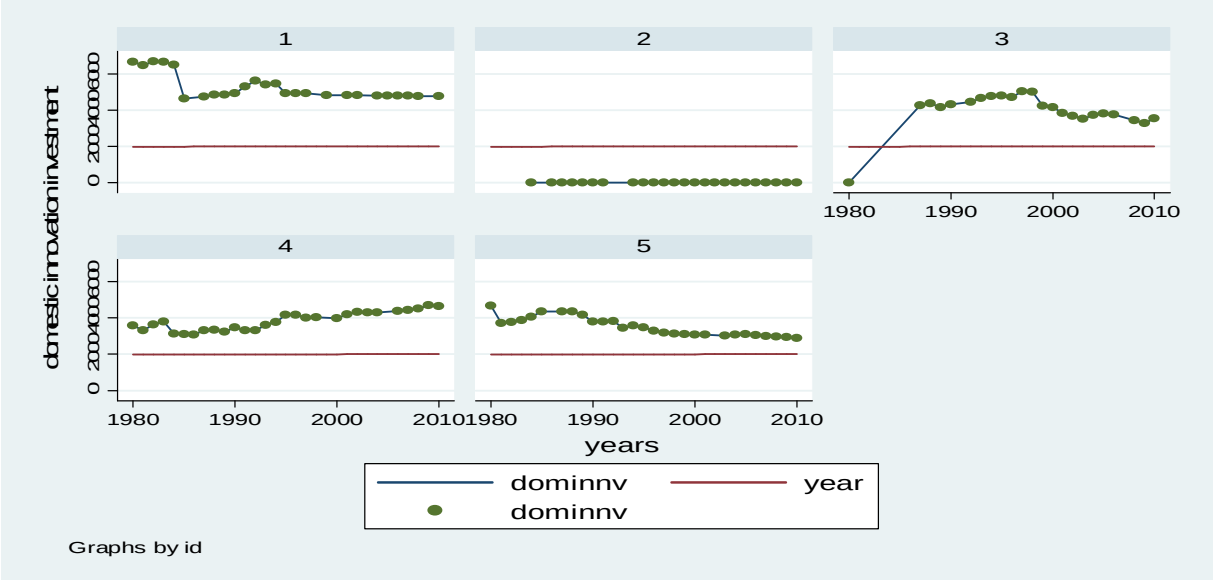
Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

The rapid industrialization in Latin America, South East Asia and also in some emerging African countries starting in the early 2000s, see graphs 3,4 and 5 respectively in Fig 3, also means that

the competition for the world resources is on the increase despite the slowdown in the industrialization development of the highly developed countries in Europe and North America. see graphs 1 and 2 in Fig. 3.

Investment in domestic technology in regions is also ongoing with a steady rate of investment in Europe and North America and continuous improvement for Latin America and Africa. North America particularly the United States and Canada have some of the the largest number of Wind generating plants in the World after China see Renewable Global Status 2006 – 2012 report. Asia is presently experiencing a slowdown from the massive investment of the 1990s in generation technology, but still maintaining steady investment in the development of improved generation sources.

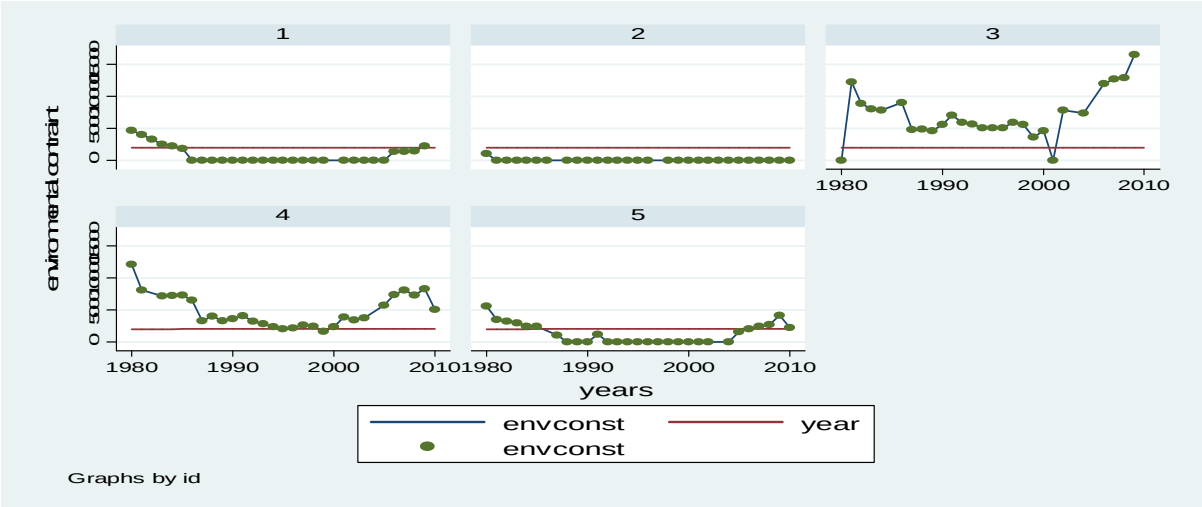
Fig. 4 Investment in domestic innovation in regions



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

Availability of energy resources and access to interruptible energy generation supplies is likely to hit Europe most owing to extreme cold winter temperatures and dependence on gas supply

Fig.5 Environmental associated threats to energy production



Note: the regions are graphed by identity(id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

from Russia and other external sources. Conditions in North America seem to be improving slightly in the 2000s with President Obama's recent approval in 2011/2012 of more drilling rights particularly on the US soil.

Facts show about 19% of the world electricity production comes from renewable energy sources with hydro electricity production alone accounting for about 16% of world electricity production (see International Energy Agency Report 2011), even though we also separate hydro electricity production as a production unit to examine its impact on energy security and total output production in this paper. Hydro electricity production is on the increase in North America, Europe and Latin America particularly, with decreases recorded for Asia and Africa see Fig. 6.

Production from renewable energy sources has been on the increase due to its relatively cheapness in recent times see Fig. 7, even though we record sharp declines for Latin America and South East Asia Pacific in the late years of the last decade. Wind energy sources currently supply about 238000MW of electricity worldwide, (see IEA Report 2011) making continuous improvement in renewable energy a strategic issue for regions.

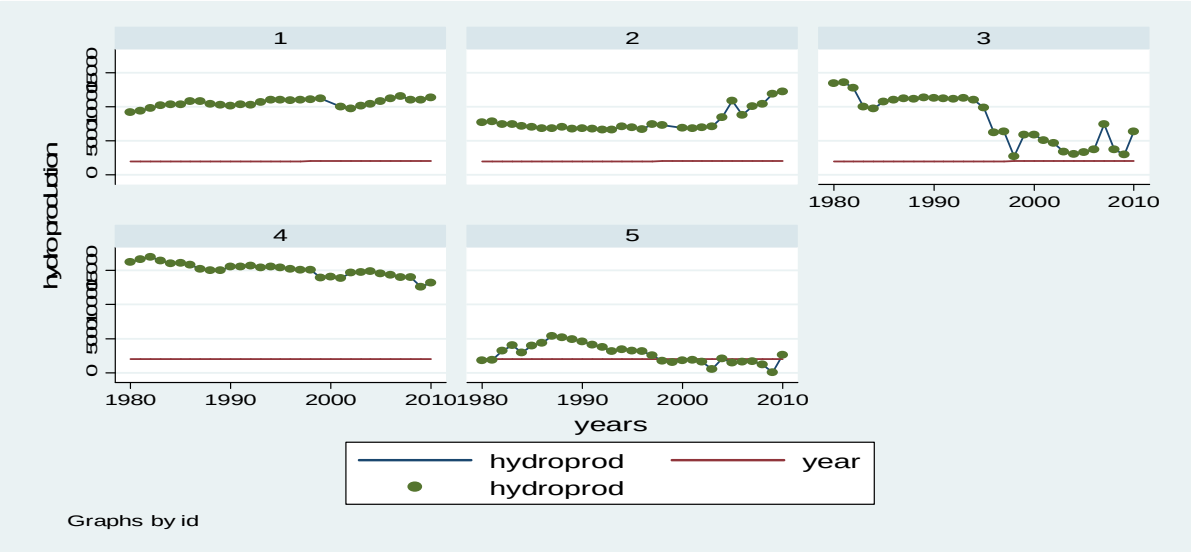
Nuclear generation has been on the decline this can probably be attributed to the presence of other safer and less hazardous way of producing electricity see Fig. 8. Europe in particular has continued to diversify its electricity generation capabilities away from nuclear sources with a dramatic decrease in production from the mid 2000s this can be attributable to need for relatively cheaper methods of production and the relative cheapness in recent renewable energy technologies.

The use of Gas production plants is also on the increase in South East Asia partly due to the industrialization growth in China leading to high domestic electricity consumption rate. The industrialization rate in Asia and emerging countries in Africa and Latin America mean that

competition for World fossils derived energy resources is on the increase. This has strong implication for Asia which is most likely to be affected by cuts in gas supply in the years to come (see fig. 9).

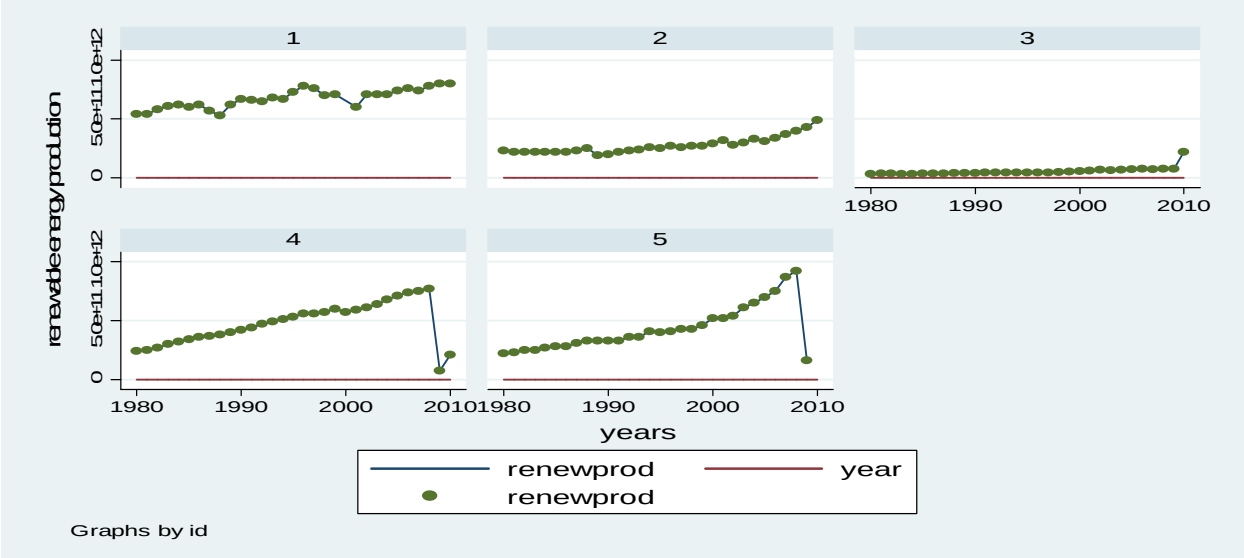
The use of coal producing plants is on the increase in Africa see Fig 10. Asia still depends quite substantially on coal electricity production while North America and Europe seem not to be increasing the use of coal in their generating capabilities.

Fig. 6 Hydro generation output in years



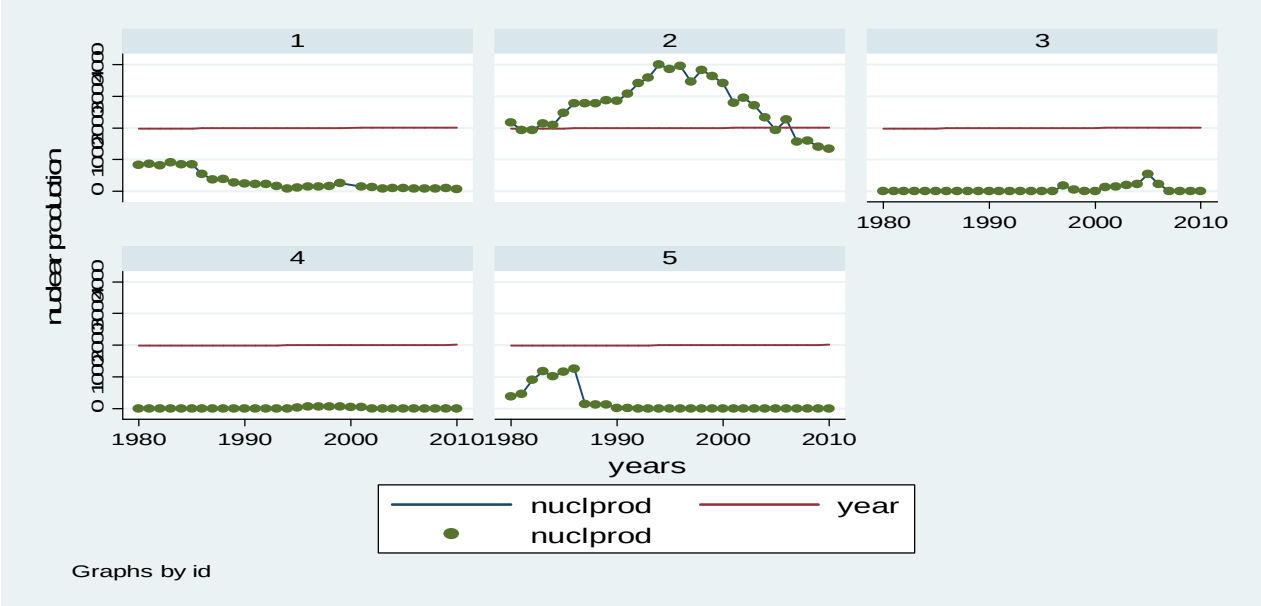
Note:The regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

Fig.7 Renewable energy generation sources generation



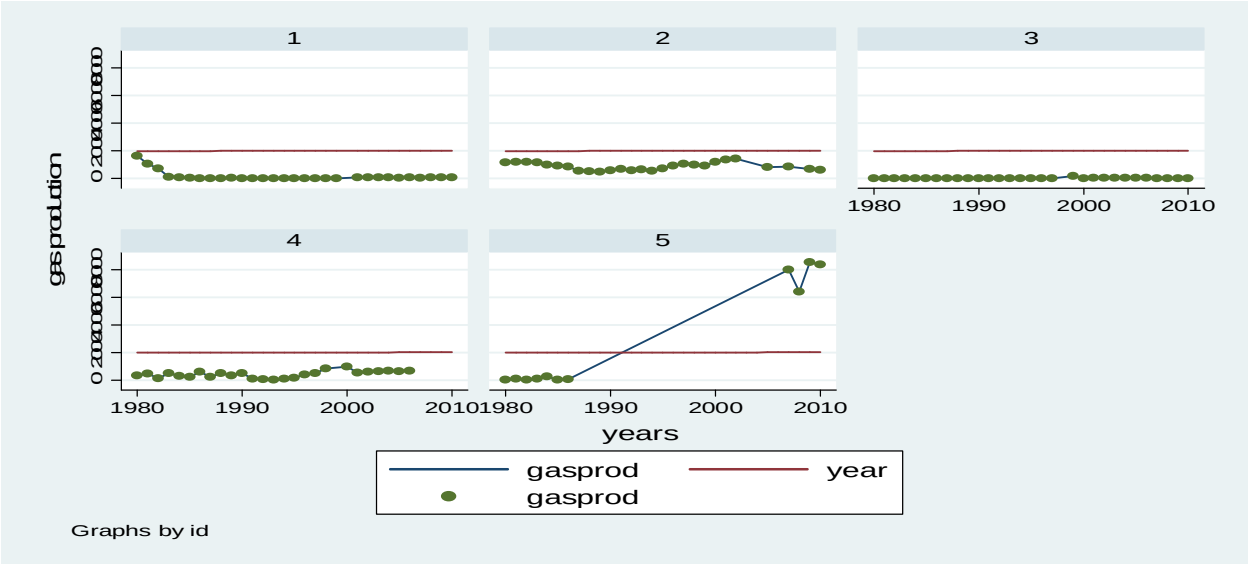
Note:The regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

Fig. 8 Nuclear source generation



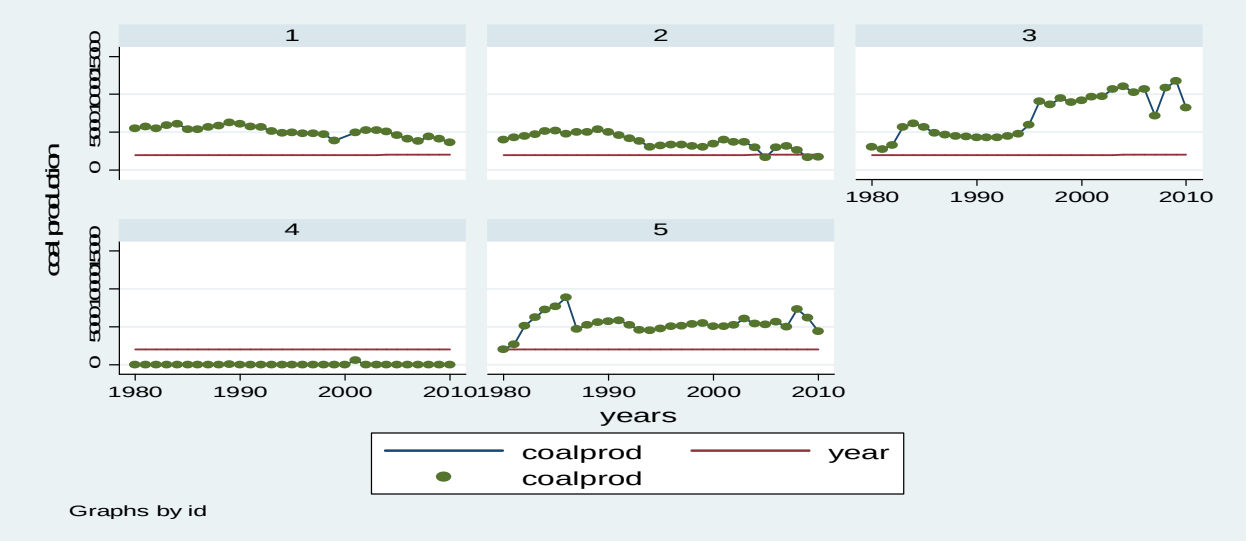
Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

Fig. 9 Gas Plants generation



Note: the regions are graphed by identity(id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

Fig 10 Coal generation source production



Note: the regions are graphed by identity (id) as follows 1-North America,2-Europe,3-Africa,4-Latin America,5-South East Asia.

4.0 Theory and Methodology

Past studies have relied on different methods of evaluating country specific vulnerabilities to energy supply and generation efforts. The paper by Cohen Joutz and Loungani (2007) use a set of self constructed diversification index to measure energy diversification for OECD countries using country net production of energy as a function of net total exports by adjusting for country size and political risks that are likely to lead to energy supply disruptions using the international country risk guide (ICRG) measures for instability in countries.

Others such as Blyth and Lefevre 2004; Le Coq and Paltseva 2008, 2009; Gupta 2008 and Rubbelke 2010b, use Herfindahl- Hirschmann index (HHI) to measure energy diversification. Knox-Hayes, Brown et al 2013 attempt to study the effect of cross country energy policy on energy security from country specific respective attitude, to energy vulnerability aversion, using a multivariate linear regression model they find that energy security is affected by country specific domestic consumption and reliance on specific sources for energy generation. However only few energy scholars if any have tried to measure energy security in a quantitative manner using country specific number of electricity generating sources as score for energy security as we try to do in this study.

This study tries to examine the extent to which electricity sources often depend on host of factors such as mineral and natural resources which are often scarce for production purposes etc. for instance nuclear energy relies on substantial supply of uranium for the enrichment process for

nuclear reactors to operate, while gas generating electricity sources have now become the dominating method of electricity output production besides the use of nuclear reactors.

Other sources such as renewable energy sources (which in this case, refer to biogas and wind energy solar energy sources and at times this include hydro electricity sources which was separated in this paper) remain quite significant in the electricity production capacities of many countries. Other factors that are likely to affect energy security are country specific consumption behavior, domestic innovation and environmental constraints. Environmental constraints are likely to affect energy security and productive capacities in two ways, first temperate regions are likely to consume more electricity during winter periods owing to the need for sustained heating capacities and secondly, the presence of mineral resources in regions and the potential threats they pose to environment when exploited is also likely to affect energy security and electricity generation.

The theory presented is one in which country specific energy utilization will affect energy security and guide how countries utilize a variety of generating sources for electricity generation. Our method of identification therefore is one that states that energy security will depend on individual regional generating sources (GS), energy consumption (EC) in regions, industrialization rate (IR), regional specific environmental constraints (EC) and energy policy(EP). While electricity generation in regions will depend on countries in regions specific energy policy, energy consumption rate, industrialization rate and domestic innovation. Our model specification captures major factors that affect the dynamics of energy supply and production allowing us to investigate the dynamics of sustainable energy supply and production and potential threats that are likely to affect energy availability. We can write energy security and electricity output production in regions as a function of these factors

$$\boldsymbol{Energy\ Security\ = f(GS, DI, DC, EC, IR, EP\ )}$$

$$\boldsymbol{Electiricity\ Production\ = f(\ EC, DI, DC, IR, EP)}$$

Based on foregoing analysis, the following prepositions shall be considered in the study; i. Regions are likely to diversify the sources of energy generation to stem energy supply failures and drop in electricity output production; ii. Investment in domestic technology such as alternative energy generating sources is likely to reduce vulnerability to energy supply failures and improve output electricity; and iii. Regions are likely to consider both efficient generation methods as well as diversify energy production to stem off treats to energy production and supply.

In stating the model for the study, it is assumed that energy security depends on individual generating sources, with the number of dependable generating sources potential lowering the risks to failure in energy supply (i.e. increasing energy security) $\frac{\partial ES_i}{\partial GS_i} \geq 0$. The energy supply can

be said to depend on domestic investment DI, domestic consumption rate DC, industrialization rate IR, environmental constraint EC, and economic policy EP.

$$\frac{\partial ES_i}{\partial GS_i} = \frac{\partial \mathrm{ES}}{\partial DI_i}\frac{\partial DI_i}{\partial GS_i} + \frac{\partial ES_i}{\partial DC_i}\frac{\partial DC_i}{\partial GS_i} + \frac{\partial ES_i}{\partial IR_i}\frac{\partial IR_i}{\partial GS_i} + \frac{\partial ES_i}{\partial EP_i}\frac{\partial EP_i}{\partial GS_i} + \frac{\partial ES_i}{\partial X_i}\frac{\partial X_i}{\partial GS_i} \quad \text{..... (1.)}$$

With domestic consumption and industrialization rate having potential to lower energy security $\frac{\partial ES_i}{\partial DC_i}\frac{\partial DC_i}{\partial GS_i} \leq 0$, $\frac{\partial ES_i}{\partial IR_i}\frac{\partial IR_i}{\partial GS_i} \leq 0$ and domestic investment having the potential to increase energy security $\frac{\partial \mathrm{ES}}{\partial DI_i}\frac{\partial DI_i}{\partial GS_i} \geq 0$. For the purpose of estimation, the original model will be expressed in a reduced form as follows:

$$\boldsymbol{Energy\ Security_{i,t} = \alpha_0 + \alpha_1 GS_{i,t} + \alpha_2 X_{i,t} + u_{1i,t}} \quad \text{..... (2.)}$$

$$\boldsymbol{Electricity\ Generating\ Source_{\ i,t} = \lambda_0 + \lambda_1 EC_{i,t} + \lambda_2 X_{i,t} + u_{2i,t}} \quad \text{..... (3.)}$$

Where GS are energy generation sources (coal, gas hydro, nuclear and renewable sources) and EC is the aggregate domestic electricity consumption for countries in regions. $X_{i,t}$ is the list of other explanatory variable included in the our regression that are likely to affect energy security and electricity output production in general while other omitted variables are captured by the error term in our model specification. This assumption is based on the premise that if the error terms $u_{1i,t}$ and $\mathrm{u}_{2\mathrm{i,t}}$ are correlated using seemingly unrelated regression estimation method is likely to produce more efficient estimates reducing bias in the regressions results since the error term of the first regression equation is reduced through its interaction in a simultaneous linear regression with that in the second equation.

5.0 Data and Sources

Regional panel data from five regions, these include Africa, North America, European Union, South East Asia Pacific and Australia, spanning for a period of 1980 to 2010 thirty years were used. All data are obtained from World Development Indicator Data unless otherwise stated. See table 2 below for all data used in this paper. The dependent variables are energy security which we measure using score values assigned to regions, based on the level of diversification and infrastructure in renewable energy sources in regions with North America particularly the United States having stronger capabilities towards averting energy interruptions. Electricity Output generation by source was captured from each generation source such as Nuclear plants, renewable energy sources (particularly wind energy and biogas productions), coal powered electric plants, gas driven turbines and Hydro electric production which even though classified as renewable we separate from what we define as renewable due to strong dependence on hydro electric generating plants. These were measured in kilowatts hours (KWH).

The list of explanatory variables were environmental constraints which was measured using number of dams, regional size and average regional temperatures that are likely to affect

electricity transmissions and consumption particularly for temperate regions were used to generate an index for environmental constraint. Regional specific investment in domestic

Table-2 Descriptive Statistics Used in the Study

Variable	Observations	Mean	Std. Dev	Min	Max
Energy Security	155	2.96	0.84	2	5
Total Energy Production in Regions	109	6790000	1260000	3300000	43000000
Production from Hydro Sources	155	8861	4464	26	16960
Production from Gas Sources	125	570	1391	0	8528
Production from Coal Sources	155	4266	2797	0	11750
Nuclear production Sources	155	660	1111.9	0	4006
Production from Renewable Sources	124	3820000	243000	310000000	920000000
Industrialization Level	154	1867753	226528.5	10000000	300000000
Energy Policy	155	1.4	0.57	1	3
Domestic Energy Consumption	154	1915535	947609.8	28.8	3300000
Level of Domestic Innovation	132	3369.689	1812.66	-4.32	6694
Environmental Constraint	144	2750.256	30.56	-0.06	16541

Note: Descriptive statistics is derived from author's dataset obtained from data market of Iceland

innovation was measured using total investment in research and development in regions in constant US dollars obtained from data market of Iceland. Regional industrialization rate was captured using regional specific GDP per capita which will be high for highly industrialized countries. Energy consumption rate was measured using total domestic consumption for countries in regions in Kilowatt Hour and finally regional specific energy policy was measured using score values for regional specific participation and implementation of the Kyoto protocol starting from 1998 when the first inter government panels were set up to 2008 to date when commitment towards emission reduction and implementation plans were emphasized, this was measured.

5.0 Empirical Analysis and Results

The empirical analysis of the study is conducted with the view of ascertaining the following: a. Overdependence on specific sources of energy generation is likely to affect guaranteed supply of energy in regions significantly; b. Regional specific investment in domestic innovation will increase energy security and access to cheap and more sustainable methods of energy production in regions; c. Energy policy is likely to affect energy supply and production in a positive manner as to improve energy security and reduce cost overall generation process in regions; d. Regional industrialization rates are likely to have a negative effect on energy security and energy output generation on regions; e. Environmental constraints and regional specific energy consumption rates is likely to have a significant effect on energy supply and production in regions.

5.1 Do Threats Matter in the Energy Supply and Generation Process?

In this section a situation where regions will have to contend with factors that we identify as constraints to sustainable energy supply to consumers is presented. This will be particularly true since countries in regions will adjust their energy policies in such a way to reduce the impact of potential threats to energy supply and production disruption. This will also be the same for the individual generating sources. Countries are likely to concentrate on both efficiency of generating sources as well as diversify energy production sources so as to reduce over dependence on particular generation sources so as to mitigate energy supply failures. This also will be true since countries will want be able to overcome gas shortages for instance as was the case of the Russo- Ukrainian gas supply interruption by overcoming such threats.

Poor policies, environmental constraints such as the unavailability of mineral and resources for energy generation, regional specific industrialization rate, the slow rate of domestic innovation, regional specific energy consumption capacities are possible major threats that are likely to make energy infrastructures in regions fail. It is assumed that the model will not suffer from misspecification since we posit that energy security will depend on our list of exogenous variable from past periods. Other issues of omitted variable bias will be captured in the error term and reduced through our seemingly unrelated joint OLS estimation method.

Therefore the use of ordinary least squares (OLS) multivariate estimation method was adopted for this study. However in other to reduce bias in regression estimates owing to issues of identification and omitted variable bias panel data was used and the errors were reduced using seemingly unrelated regression estimation (SUR) method by assuming that two closely related dependent variables in this case energy security and electricity output from different sources will produce errors that are likely to be correlated with one another allowing the interaction of these closely related errors to reduce bias in the regression and make our estimates more efficient, therefore with identical regressors, the weight variation disappears and the SUR estimator is identical to OLS. See Zellner (1962) Chen, Ullah and Takada (1995) for further discussions. The variable “year” was included to capture regional differences in energy security fluctuations and electricity output production in years.

5.2 Empirical Results

Results for the energy security as well as for the electricity production output equations are presented below in tables 1 and 2 below. Our results show that renewable energy and gas production were having a significant effect on energy security and therefore mitigating threats to energy supply failures in regions contributing 34 and 16 percentage points (see Table 1 Columns 3 and 4) to energy availability and supply efficiency.

Nuclear energy was having a negative significant effect on energy security reducing energy generation diversification in regions by 19 percentage points (see Table 1 column 5). Other factors such as environmental constraints which involve regional size for transmissions of

electricity and distribution, availability of natural and mineral resources for electricity generation and temperature constraints were having a negative effect on energy security except for the regression where we use nuclear generating source as a variable for generating source, which is particularly interesting, using different generating sources in the five regression for energy security (See Table 1 Columns 1 to 5 where environmental constraints reduce energy security by 8,9,7,4 and 1 percentage points respectively), with, its impact particularly strong, for coal production which was reasonable. Industrialization rate was also have a strong negative effect on energy security using all generating sources, this was particularly serious for nuclear generating sources (see table 1 columns 1 to 5 where industrialization rate was reducing energy security by 22,20,26,19 and 35 percentage points respectively) since this was increasing dependence on nuclear sources in developed countries with nuclear generating energy plants.

Domestic innovation and regional specific energy policy were having a positive effect on energy security. Differences in yearly output particularly due to maintenance or supply cut issues from various generating sources were probably making regions depend more on renewable energy sources since the control for annual difference only held for renewable energy generating sources.

Table 1 Regression for Energy Security

Variables	(1) Energy security	(2) Energy security	(3) Energy security	(4) Energy security	(5) Energy security
Hydro energy generation	-0.09				
	(0.06)				
Coal generation		-0.04			
		(0.08)			
Gas generation			0.16***		
			(0.04)		
Renewable energy gen.				0.34***	
				(0.05)	
Nuclear energy generation					-0.19***
					(0.05)
Level of energy consumption	-0.01	-0.03	-0.08	-0.07	-0.03
	(0.06)	(0.07)	(0.07)	(0.05)	(0.06)
Level of domestic Innov.	0.29***	0.31***	0.35***	0.19***	0.16***
	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)
Environmental constraint	-0.08***	-0.09***	-0.07***	-0.04***	-0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Level of industrialization	-0.22***	-0.20***	-0.26***	-0.19***	-0.35***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)
Energy policy	0.95***	1.11***	0.90***	0.71***	0.85***
	(0.16)	(0.18)	(0.18)	(0.14)	(0.18)
Year Effect	No	No	No	Yes	No
Observations	112	92	73	112	68
R-squared	0.71	0.67	0.79	0.80	0.77

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results where the potential threats to electricity output generation from sources were considered, show that energy consumption was having no significant effect on electricity generation from sources, while for hydro electric generation sources environmental factors such as the presence of adequate water resources were probably promoting their overall production by 6 percentage points (see Table Column 1).

However industrialization rate had a negative effect on hydro electric output generation in regions this was probably true due to the fixed nature of the water levels at various hydro electric power dams. For gas generating sources environmental constraints such as the unavailability energy resources to generate energy domestically and ease of access to the global fossil markets were probably promoting use of gas in energy generation. Domestic innovation and development of alternative generating sources were having a negative effect on gas output productions. Domestic innovation rate and industrialization rate was also reducing the use of nuclear energy generating sources since regions were probably aware of the dangers and difficulties associated with the operation of nuclear facilities and disposal of nuclear wastes.

Domestic innovation and regional specific energy policies were affecting renewable energy generating sources positively. However the greatest impediments to renewable energy generation were probably environmental constraints since the availability of scarce resources for such generation capabilities was often an issue.

Table 2 Regressions for Electricity Generating Sources

Variable	(1) Hydro production	(2) Coal production	(3) Gas production	(4) Nuclear energy production	(5) Renewable energy production
Energy consumption	0.09	0.03	0.26	-0.18	0.15
	(0.10)	(0.09)	(0.18)	(0.16)	(0.10)
Level of domestic Innov.	-0.06	0.06	-0.46***	-0.54***	0.30***
	(0.05)	(0.05)	(0.11)	(0.09)	(0.06)
Environmental Constraint	0.06**	0.0003	0.20***	0.20***	-0.12***
	(0.02)	(0.02)	(0.06)	(0.04)	(0.02)
Level of Industrialization	-0.16***	-0.03	0.10	-0.49***	-0.04
	(0.04)	(0.04)	(0.08)	(0.07)	(0.04)
Energy policy	-0.35	-0.11	0.37	0.23	0.76***
	(0.27)	(0.25)	(0.49)	(0.44)	(0.26)
Year effect	No	No	No	Yes	No
Observations	112	92	73	68	112
R-squared	0.178	0.08	0.55	0.77	0.28

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Here, a summary of the results of our empirical investigations are presented as follows:

a.) The assertion that overdependence on specific sources of energy generation is likely to affect guaranteed supply of energy in regions significantly was probably true since

reliance on nuclear generating sources were probably affecting energy diversification in a negative manner

b.) Regional specific investment in domestic innovation had a positive effect energy diversification (our measure of energy security) and also improved access to cheap and more sustainable methods of energy production in regions. This was particularly true since it reduced overdependence on gas and nuclear generation sources significantly(see table 2).

c.) Energy policy affected energy generation diversification in a positive manner but had no effect on individual energy generating sources except for renewable energy sources showing the likely priorities of regional governments.

d.) Regional industrialization rates had a negative effect on energy security and energy output generation on regions. This was likely true since increasing industrialization in regions were increasing demands for consumption of energy and causing a strain to energy generating capabilities in countries in regions

e.) Environmental constraints had a negative effect on energy security since this was probably affecting energy generation diversification in regions, however domestic energy consumption rate had no significant effect on energy diversification. This was probably true as industrial units were likely to consume more energy than domestic units.

6.0 Conclusions

In this paper an attempt was made to answer some specific questions that were introduced earlier in the study, they are: to what extent does overdependence on specific generating sources affect energy diversification which was the measure used for energy security in regions? It was found that since regions are likely to depend heavily on nuclear and gas generating sources due to industrialization rate this led to an increase in demands for energy this was probably facilitated as well by the ease of access to fossil fuels in the global market and relative cheapness of fossil driven generating sources. This study also investigated if domestic industrialization rate and environmental constraints pose a threat to future electricity supply and generation in regions. It was also found that industrialization rate does pose a threat to both energy supply and generation in regions since it had a negative significant effect on both.

Environmental constraints were found to have a negative effect on energy security and a negative effect on renewable energy generating sources but had no effect coal powered plants; it also had a positive effect on the usage of gas and nuclear generating sources. This was probably true, since regions were investing considerably on technology and trying to reduce environmental impacts on the energy generation process, issues of energy transmission and access, were probably making environmental constraints have a negative effect on diversification in regional energy supply systems particularly since renewable sources is dependent on natural resources which are finite in nature, thereby reducing energy security.

On the overall it was found that nuclear and gas dependence were not good for energy security improvements, regional energy policy had a singular and far reaching effect on both energy security and renewable energy production sources even though we do not find the usefulness of energy policy on improving other generating sources which were not surprising. It was found that countries in regions most probably the developed countries were now depending more on renewable energy sources to mitigate risk of supply disruptions.

The implication of the findings are that, threats to supply and generation process matters and emerging countries in Latin America, Africa and Asia and the developed countries in Europe and North America are likely to be most susceptible to supply disruption. Lessons from the Fukishima nuclear disaster and the oil crisis of the 1970s as well as the Russo-Ukrainian gas pipeline crisis of 2005 are imperative that diversification to cheaper and more dependable sources of electricity generation through investment in renewable energy technologies can have positive effects for regional generational processes.

The results also support IEA report 2011 which encourages the use of cheaper, cleaner and more efficient methods of electricity generation which will be useful also for developing countries particularly those in Africa that are likely to benefit most from the relative cheapness of renewable energy technologies in the near future.

References

Geden, Oliver. (2009). "EU Energy Policy", in Andris Spruds, Toms Rostoks, eds., Energy. Pulling The Baltic Sea Region Together or Apart?, pp. 12-26. Riga: Latvian Institute of International Affairs.

George, Stephen. (1991). Politics and Policy in the European Community. Oxford: OUP

Blyth, W., Lefevre, N., (2004). Energy Security and Climate Change: An Assessment Framework.
OECD/International Energy Agency Information Paper. Paris, France.

Bryce, R., (2008). The Dangerous Delusions of ''Energy Independence''. Public Affairs. New York, NY.

Cohen, G., Joutz, F., Loungani, P., (2011). Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies. IMF Working Paper No. 11/39. Washington, DC.

European Commission, (2000). Towards a European Strategy for the Security of Energy Supply. Green Paper, COM769. Brussels, Belgium.

European Commission, (2006). A European Strategy for Sustainable, Competitive and Secure

Energy. Green Paper, COM105. Brussels, Belgium.

Gupta, E., (2008). Oil vulnerability index of oil-importing countries. Energy Policy 36 (3), 1195–1211.

Hakes, J., (2008). A Declaration of Energy Independence: How Freedom from Foreign Oil Can Improve National Security, Our Economy, and the Environment. John Wiley & Sons, Inc., Hoboken, NJ.

LaCasse, C., Plourde, A., (1995). On the renewal of concern for the security of oil supply. Energy Journal 16 (2), 1–23.

Le Coq, C., Paltseva, E., (2008). Common Energy Policy in the EU: The Moral Hazard of the Security of External Supply. SIEPS Report 2008:1. Stockholm, Sweden.

Le Coq, C., Paltseva, E.,(2009). Measuring the security of external energy supply in the European Union. Energy Policy 37 (11), 4474–4481.

Lefevre, N. et al., (2009). Analysis of Impacts of Climate Change Policies on Energy Security: Final Report. Ecofys International BV. Utrech, The Netherlands.

Loschel, A., Moslener, U., Rubbelke, D., (2010a). Energy security—concepts and indicators. Energy Policy 38 (4), 1607–1608.

Loschel, A., Moslener, U., Rubbelke, D., (2010b). Indicators of energy security in industrialized countries. Energy Policy 38 (4), 1665–1671.

Loungani, P., (2009). The elusive quest for energy independence. International Finance 12 (2), 291–299.

Neumann, A., (2004). Security of Supply in Liberalised European Gas Markets. Diploma Thesis, European University Viadrina. Viadrina, Germany.

Neumann, A.,(2007). How to measure security of supply? Mimeo, Dresden University of Technology. Dresden, Germany.

Organisation for Economic Co-operation and Development (OECD), (2004). Economic Outlook No. 76. Paris, France.

Press Trust of India, (2010). Uncertainty, Volatility Still a Threat to Oil Market, Kuwait City. OPEC /http://profit.ndtv.com/news/show/uncertainty-volatility-still-a-threatto- oil-market-opec-36438S. PRS (Political Risk Services) Group, /http://www.prsgroup.com/S.

Rosendahl, K.E., Sagen, E.L., (2009). The global natural gas market: will transport cost reductions lead to lower prices? Energy Journal 30 (2), 17–39.

Sandalow, D., (2008). Freedom from Oil: How the Next President Can End the United States' Oil Addiction. The McGraw-Hill Companies, New York, NY.

U.S. Energy Information Administration, (2011a). Annual Energy Outlook 2011 with Projections to 2035, DOE/EIA-0383(2011), Washington, DC.

U.S. Energy Information Administration, (2011b). World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States. DOE/EIA Report, Washington, DC.

Van der Linde, C. et al., (2004). Study on Energy Supply Security and Geopolitics. CIEP Report, Clingendael International Energy Programme. The Hague.

Yergin, D., (2009). The Long Aftershock: Oil and Energy Security after the Price Collapse. Testimony to the Joint Economic Committee (JEC) of the U.S. Congress on May 20, 2009. Washington, DC.