Changing Scenarios of Global Oil Market

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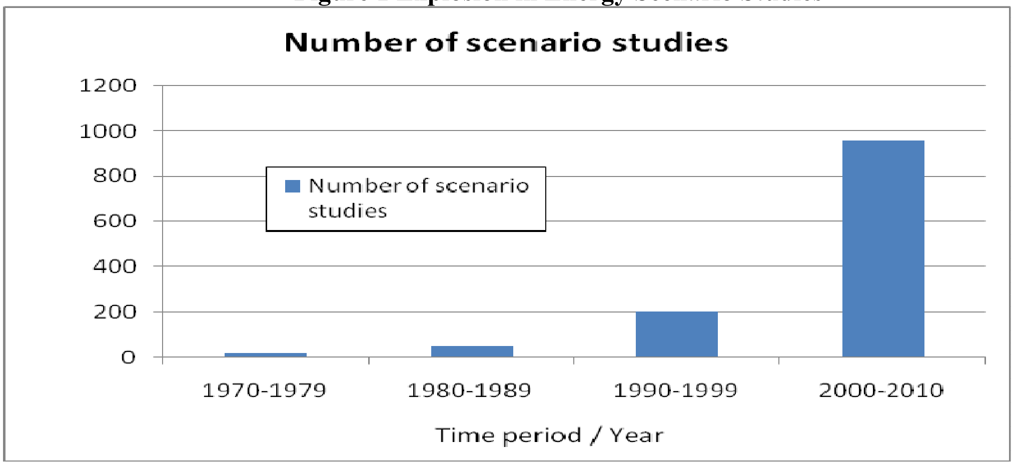
Abstract
This paper attempts a prognosis of the demand, consumption and energy intensity of oil future. Adopting 2009 as the baseline year and 2030 as the timeline, the study resorts to the use of forecasting technique to model future oil scenario. In estimating future oil consumption, correlation analysis is run for the set of data generated and power laws that show best-fit lines are derived. United Nation's (UN) middle variant scenario for ascertaining 2030 population sizes for Five oil-rich countries, namely Saudi Arabia, Russia, Iran, Nigeria and Mexico while World Bank projections are used to ascertain 2030 Gross Domestic Products (GDP) for these five countries. The study predicts that oil consumption over the forecasting period is expected to increase across board, barring the adoption of renewable energy policies and increased technological advances. The increase in oil consumption is likely to be driven by increased population growth and the expected acceleration of the economies of the countries studied. An implication for these likely trends is that increase in oil consumption is expected to worsen greenhouse gas (GHG) emissions and lead to worsening outcomes for the environment.
Keywords: oil consumption, oil forecasts, energy policies, oil prices, Energy efficiency

1 Introduction
While scenarios have become increasingly important for purposes of long-term planning within the global energy market, most models deployed for such purposes have been associated with several shortcomings. Those which attempt to address all the weaknesses inherent in projecting trends in an environment of uncertainty typically call for the definition of multiple endogenous variables, and their building-in into the model, a process which typically takes a lot of time before the model can be operationalized. For example, International Energy Agency's (IEA), World Energy Outlook (WEO) model incorporates sixteen thousand equations which have been refined for decades (Martinot et al, 2007). This paper attempts to formulate a model, on the basis of which oil demand, its consumption and intensity can be forecasted for the year 2030, using the business as usual scenario.

2 Literature Review
Blomgren et al (2011, p.4) define scenarios as the "focused description of different futures." Within the global energy markets locale, scenarios have been used for purposes of foretelling or predicting the likely end-state of energy systems, with a view of planning for better outcomes (Nielsen and Karlsson, 2007). According to Makarov (2009), scenarios not only help to simplify the complexity inherent in the global energy market, they also provide a compass by which future uncertainties can be navigated; and thus the basis upon which insightful decisions regarding long-run energy use can be made. In a review of energy scenario studies carried out between 1970 and 2010, Goldthau (2012) assert that the use of energy scenarios has grown exponentially, not only thrusting it as a mainstream forecasting and planning tool within the domain of the global energy market but also as a major area of discourse in energy literature. While there were only 24 studies on energy scenarios between 1970 and 1979, Gorelick (2009) found that the number of energy scenario studies had increased to 48 between 1980 and 1989, to 203 between 1990 and 1999, and to 957 between 2000 and 2010. In total, more than 1232 energy scenario studies have been carried out, attesting to the growing importance of this as an energy management tool (Alquist and Kilian, 2010). The explosion in the energy scenario literature can be graphically depicted as shown in figure 1 below.

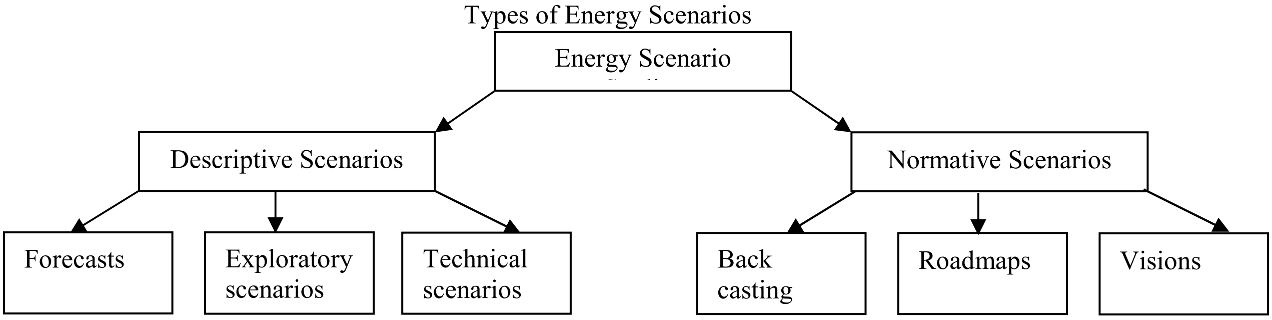
Figure 1 Explosion in Energy Scenario Studies



In an analysis of these 1232 energy scenario studies, Gorelick (2009) identified six different approaches which energy scenarios can take. These include: forecasts, back casting and roadmaps, explanatory studies and visions, assessments or evaluations of prior scenarios, use of existing models, and methodology development. Of these, Blomgren et al (2011) found forecasts, back casts, and roadmaps to be the most popular of all approaches. The basic defining characteristic of all forecasts is the adoption of a base state as the starting point, and the use of one or more parameters to foretell a future end state. Back casting and roadmaps on the other hand involve starting of with a defined end state and then working back to identify the measures required in order to achieve that ideal or visualized end state. Where forecasts end up enumerating 'expected' end states and back casting ends up enumerating 'wished for' futures, exploratory and vision studies deploy scripted and narrative approaches to identify several possible future end-states, through the concurrent use of many parameters (Jeffer and Schwienfort, 2011; Robert and Lennert, 2010; Huss and Honton, 1987).

A number of other frameworks (the 'developing methodology' approaches) which present and test potential energy scenario methodology with the aim of developing new or alternative future scenario approaches have also been enumerated in energy scenario literature. Others (assessments of prior scenarios) simply review already formulated scenarios. Martinot et al (2007) and McDowell and Eames (2006) classify energy scenario studies into 'descriptive' and 'normative' categories. Within the descriptive category, they identified forecasts, exploratory, and technical scenarios. Within the normative category, they identified backcasting, roadmaps, and visions. Figure 2 below summarizes the different types of scenarios enumerated in literature:

Figure 2
Types of Energy Scenarios



a. *Modeling Tools Used in Scenario Analysis*.

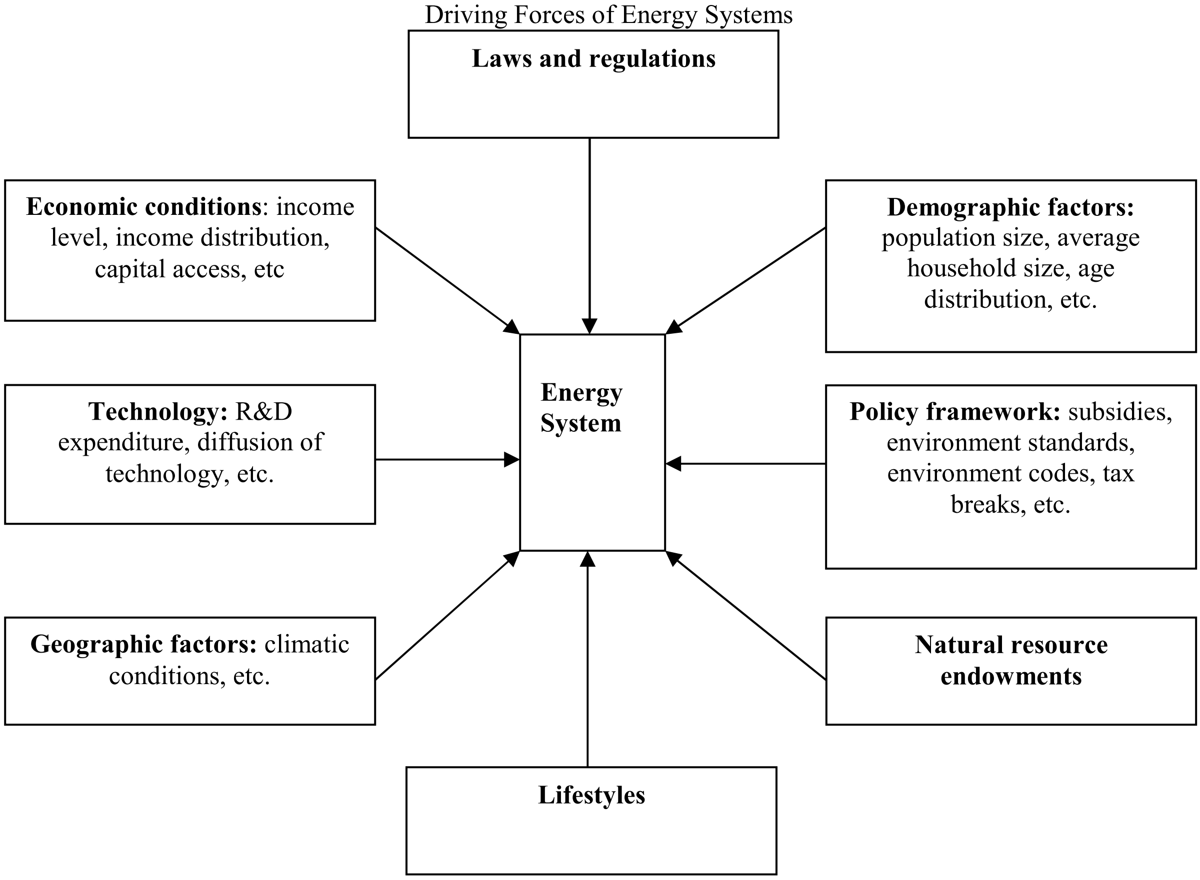
Evaluating the tools commonly deployed in scenario analysis, Nakata (2004) and Huntington and Weyant (2002) identified the use of various modeling tools, including: partial equilibrium models, general equilibrium models, simulation models, optimization models, techno-economic models, and end-use accounting models. Partial equilibrium models focus only on a particular energy product market, and attempt to predict changes in the price, production or demand for the product based on defined parameters and constraints (Von Moltke et al., 2004). General equilibrium models on their part deploy a set of composite non-linear equations to evaluate supply and demand behavioral changes in factors of production and energy products for the entire national or global economy. As such, general equilibrium models also factor in all market linkages (Ellis, 2010; Von Moltke et al., 2004).

A specific example of the general equilibrium approach is the *World Energy Outlook* (Huntington and Weyant, 2002) approach, which in the words of Martinot et al (2007, p3) "comprises 16,000 equations defining interrelationships among energy, economy, technology, investment, resources, and environment." Cost-optimization models on their part attempt to ascertain the energy types and technologies which can be used to satisfy incremental demand given the operational constraints (Alquist and Kilian, 2010). The MARKAL model is one of the most extensively cost optimization models, while the LEAP model is a notable example of the end-use accounting models (Pierce, 2012). Other models which have been extensively used include the GREEN-X and PRIMES models deployed by the European Commission; the MESSAGE model used by Greenpeace, and the MINICAM model used by the IPCC (Goldthau, 2012).

b *Timelines and Parameters.*

In their review of energy scenario studies carried out between 1970 and 2010, Blomgren et al (2011) consider the term 'future' which is central to the definition of energy scenarios to be 'fluffy' and thus endeavor to identify the different timelines associated with energy scenarios. At the very least, they found that energy scenarios encompass study periods of ten years, though most cover timeframes of between 30 and 60 years and with only a few covering the maximum timeline of 100 years (Parikh, 1998; van Vuuren et al, 2003). Rogner and Popescu (2008) have identified the major driving forces of energy systems as: economic conditions (including the level of income, income distribution, and access to capital), demographic structure (including population size, age distribution, and the average family size), geography (including climatic conditions), technology (including R and D expenditure and diffusion of technology), policy regime (including legislative interventions such as subsidies and environmental standards and codes), laws and regulations, lifestyles, and natural resource endowments. These can be summarized as shown in figure 3 below.

Figure 3
Driving Forces of Energy Systems



In line with the energy system drivers outlined by Rogner and Popescu (2008) and Martinot et al (2007) have attempted to identify the parameters which are most commonly used in energy studies. They found that the most commonly used parameters in the global energy market include: economic indicators such as the GDP, population metrics such as the population size, energy demand, energy intensity, the policy framework governing energy use, technology, the cost of energy, and the price of carbon. These are considered to be the major driving forces in the global energy market.

c) *A Review of Some Recent Energy Scenarios.*

Building on the scenario types, modeling tools, timelines, and parameters discussed in the preceding subsections; a number of energy scenarios have been formulated. Three of the most recent and acclaimed ones are reviewed in this section, including: OPEC's *WOO (World Oil Outlook) scenario* (2010), IEA's *WEO (World Energy Outlook)* scenario (2011), and Shell's *Energy Scenario to 2050* (2011).

OPEC's WOO scenario uses 2010 as the baseline period, and encompasses several timelines, including

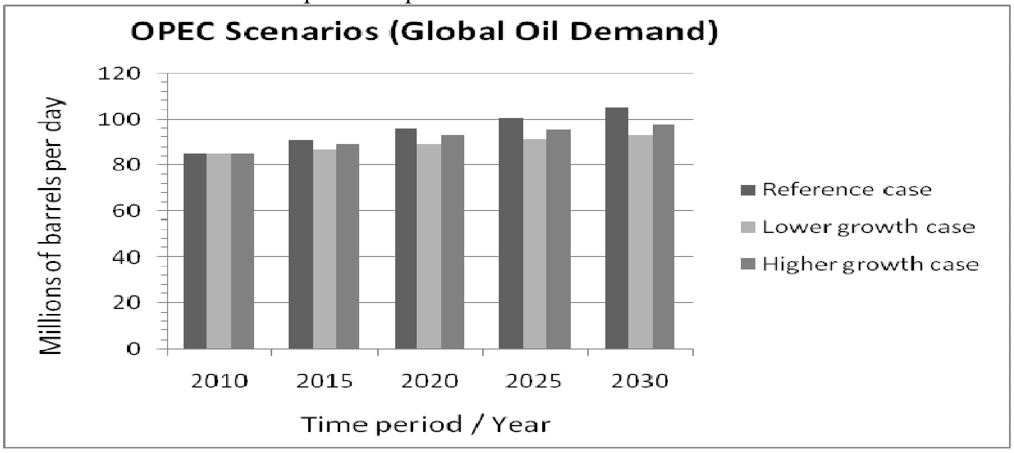
2015, 2020, 2025, and 2030. Some of the driving forces for the energy systems it considers include GDP and population (OPEC, 2010). Apart from the reference case (the baseline year), OPEC's WOO scenario also projects two other futures: the lower growth, and higher growth scenarios. For oil, it projects the following demand and supply conditions in the reference, higher growth, and lower growth scenarios: The three scenarios are shown in the form of line graph in figure 4 below:

Table 2
OPEC'S Oil Scenario to 2030 (in million barrels per day)

REFERENCE CASE					
	2010	2015	2020	2025	2030
Global oil demand	85.5	91.0	96.2	100.9	105.5
Non-OPEC Supply	51.9	53.9	55.7	56.6	57.5
OPEC crude supply	29.3	30.8	33.2	36.0	38.7
LOWER GROWTH CASE					
Global oil demand	85.5	87.2	89.6	91.4	92.9
Non-OPEC Supply	51.9	53.4	54.5	54.9	55.4
OPEC crude supply	29.3	27.5	27.8	28.2	28.1
HIGHER GROWTH CASE					
Global oil demand	85.5	89.4	92.8	95.5	97.9
Non-OPEC Supply	51.9	53.4	54.5	54.8	55.4
OPEC crude supply	29.3	29.6	31	32.4	33.2

Source: OPEC, 2010.

Figure 4
Graphical Representation of OPEC Scenarios:



Shell's latest Energy Scenario to 2050 considers population growth and economic growth as the major driving forces which will influence changes in energy demand and supply to 2050. The other driving force which the energy scenario considers as critical to the changes in demand and supply of energy is technology and innovation (Dickel et al, 2007). Unlike most scenarios which consider only fossil fuels (or one of the fossil fuels), the Shell scenario considers all forms of energy, including renewable and non-renewable forms. Using 2000 as the base year, the scenarios are summarized as shown in the table below:

Table 2
Shell's Energy Scenario to 2030

Estimated Increase in Primary Energy (in Exajoules per Year)				
EJ per Year	2000	2010	2020	2030
Crude Oil	155	168	195	197
Natural Gas	87	114	146	169
Coal	96	149	184	193
Nuclear	28	32	41	56
Biomass	42	55	59	61
Solar	0	1	6	20
Wind	0	1	4	10
Other Renewables (hydro, wave, geothermal, and tidal energies)	13	17	23	28
Total Primary Energy Demand	422	536	659	734

Source: Shell, 2011.

As the Shell scenario shows, the biggest increase in demand will be for fossil fuels, with demand for coal growing at the fastest rate. IEA's *World Energy Outlook* (2011) attempts to forecast future scenarios for the global energy market to 2035, using 2010 as the baseline year. It forecasts three scenarios: the New Policies Scenario, the Current Policies Scenario, and the 450 Scenario.

Under the New Policies Scenario, IEA (2011) sees global primary energy demand growing by 30% between 2010 and 2035. 90% of the incremental demand in energy comes from non-OECD countries (the largest portion of which is contributed by China). The demand for oil under this scenario rises from 87 million barrels per day in the baseline year to 99 million barrels per day in 2035, but its share of the total global energy mix reduces from 33% in the baseline year to just 27% in 2035. Global demand for natural gas rises by 1.7% every year to hit 4.75 tcm by 2035, putting it at par with coal consumption (which rises by 25% over the same period to 5850Mtce) (Jensen, 2011). The share of unconventional gas in the total global energy mix rises from 13% in the baseline year to over 205 in 2035. Global energy-related carbon emissions grow by 20% (from 30.4 gigatonnes to 36.4 gigatonnes) over the same period. The share of fossil fuels in the total energy mix falls from 81% to 75% over the period, and while all energy sources experience growth in, only natural gas increases its share of the total energy mix. To meet the required growth in supply in this scenario, investments worth $38 trillion are required.

Under the 450 Scenario, the IEA (2011) sees the fossil fuel share of the total energy mix drop from 81% in 2010 to 62% by 2035. While the demand for oil and coal rise from their 2010 levels, they will hit a plateau in 2020, and experience declines of 8% and 30% respectively by 2035 compared to their levels in the baseline year. Natural gas demand however grows by 26% over this period. To meet the energy demand under this scenario, investments worth $53.2 trillion, but comes with a lower environment footprint, better health outcomes, and lower spending on fossil fuels than in the New Policies Scenario. IEA's Deferred Investment Case (Goldthau, 2012)) is based on the assumption that investment in the upstream sector of the energy industry in North Africa and the Middle East will stand at $25.3 trillion, 30% lower than the investment in the New Policies Scenario. This scenario expects therefore the production of oil in the region to fall by 6 million barrels per day between the baseline period and 2035.

While simple cost and production functions can be used to represent economic processes during the scenario modeling process, they are unable to incorporate all economic sectors and have to leave out others. Models which incorporate all sectoral areas of the economy end up being too complex that they exclude rich technological detail (Bhar and Nikolova, 2010). Most of the models used for forecasting the consumption and supply of fossil fuels and reneweables include rich technological detail but fall short in their failure to incorporate resource depletion (with the possible exception of some dynamic optimization models) or individual economic sectors. With the exception of the AIM model, most of these models also do not "represent energy demand and technologies at the end-use sectoral level" (Greene, 2001, p.3). While MARKAL may be useful for resource depletion modeling, its resource equation is generally considered inadequate and in need of further elaboration (Gorelick, 2009).

Since cost optimization models are based on the assumption of perfect competition, and since they ignore non-economic factors which have an impact on energy trends, they often end up overstating the need for the deployment of energy efficient technologies. Generally, building a model which would incorporate all these considerations would call for the definition of multiples of endogenous variables, which is a complex process that consumes a lot of time. The challenge thus is to come up with a model which can capture all the critical details of the energy system, but which is also simple enough to use. Based on the reviewed literature this paper attempts to formulate and deploy such a model with a view of forecasting future global oil scenarios to the year 2030.

3 Methodology.

The methodology resorts to the use of the forecasting technique and adopted 2009 as the baseline year and 2030 as the timeline in order to model a future oil scenario. From the level of oil production on country by country basis, Russia, Saudi Arabia, Iran, Nigeria and Mexico are used as the basis of the forecast. These countries when combined together represent over 35% of the global oil production. Further, the study incorporates two parameters which are considered to be adequate measures of the most important drivers of energy systems. These are population and economic conditions. The paper use the GDP as a proxy measure of economic conditions and population size as a proxy measure of the impact of demographic changes on oil consumption, the two most significant drivers of an energy system as put forward by BP Statistical Review (2010). In particular, the model restricts itself to the following trends in the oil market: changes in demand/ consumption of oil, changes in the energy intensity of oil, distribution of increases (decreases) of oil demand, and changes in per capita oil consumption.

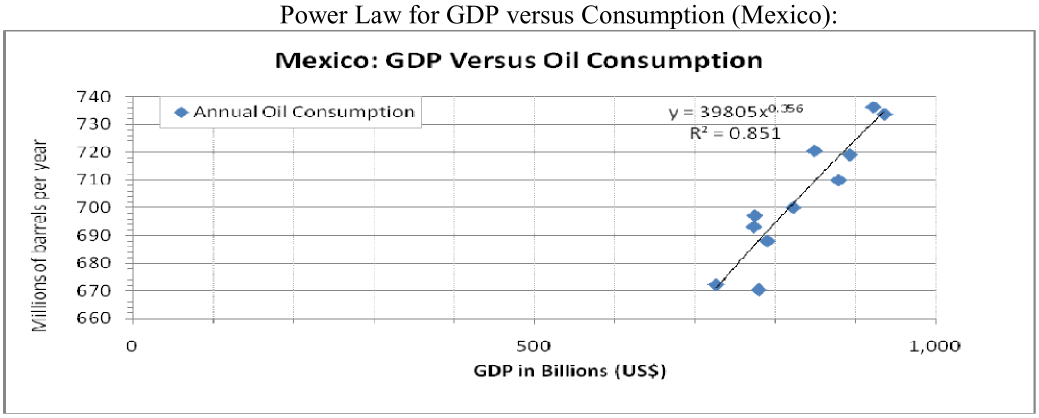
In estimating future oil consumption, this paper followed the methodology adopted by, among others, Ramachandra et al (2006), where correlation analysis are run for the set of data, and power laws that expresses best-fit lines are derived. UN's middle variant scenario for ascertaining 2030 population sizes for the five countries chosen was used and also World Bank projections are used to predicts 2030 GDPs for the five countries under study. Oil intensity is calculated as the per unit oil consumption over GDP, while per capita consumption is defined as the total oil consumption over the total population size. Data is collected through secondary means. Analysis of the trends in each of the three scenarios provides the evidentiary basis on which conclusions regarding the future direction of which oil consumption, oil intensity, distribution of oil increases, and per capita consumption trends are likely to follow.

4 Findings and Results

a) *Oil Consumption in 2030*

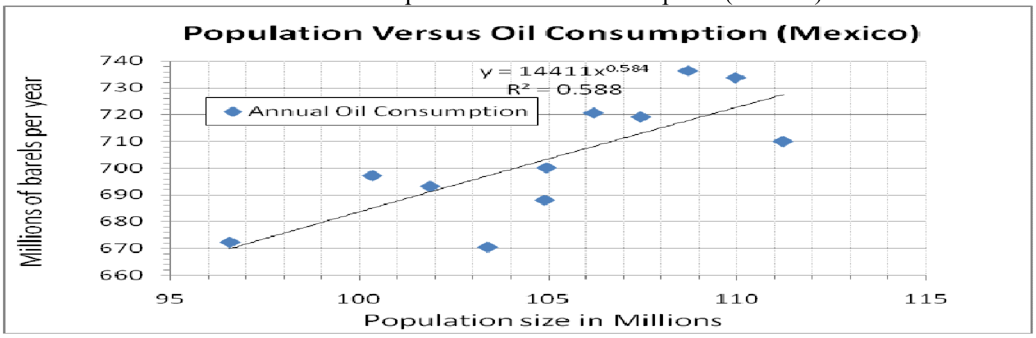
Using the Excel spreadsheet, regression analysis for the set of data is carried out, and a best fit line derived. For the relationship between oil consumption and GDP (for Mexico), this takes the power law of the form: $y = 39805x^{0.356}$, where y refers to oil consumption and x is the GDP. This can be rewritten as; Oil consumption = $39805*GDP^{0.356}$

Figure 5
Power Law for GDP versus Consumption (Mexico):



However, GDP is not the only factor affecting energy consumption. The other major factor affecting energy consumption is population size. Repeating the same procedure, the paper derives the requisite algebraic expression for the relationship between population and energy consumption, which for Mexico is expressed through the power law of the form: $y = 14411x^{0.584}$ where y is oil consumption and x is the population size. This, again, can be rewritten as: oil consumption = $14411*population^{0.584}$. Therefore, total projected oil consumption levels for Mexico can be forecast using the formula: Oil consumption (Mexico) = $39805*GDP^{0.356} + 14411*population^{0.584.}$ Figure 6 below shows the power law for population against consumption for Mexico.

Figure 6
Power Law for Population versus Consumption (Mexico):



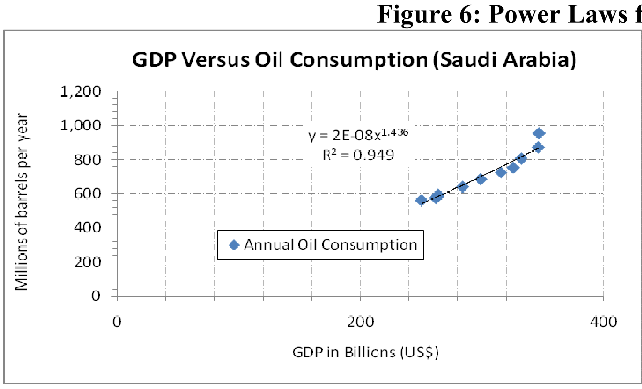
In the estimation of the coefficients which return the line of best fit, Pearson's R for the relationship between GDP and oil consumption, and between population size and oil consumption are 0.925365939 and 0.767992053 respectively, suggesting that for Mexico there is a strong and positive correlation between GDP and oil consumption and between the population size and oil consumption. This suggests that Mexico's oil consumption is likely to increase as its population size and GDP increase heading towards 2030. Same procedure for the other four countries (that is Russia, Iran, Nigeria, and Saudi Arabia) is repeated. The relationship between GDP and oil consumption and between population and oil consumption for these four countries is similarly expressed through power laws, which are presented in table 3.

Table 3
Power Laws for the Relationship between the Parameters and Oil Consumption

Country	Power law for the relationship between GDP and oil consumption	Power law for the relationship between population and oil consumption
Russia *	$y = 5E{+}07x^{0.110}$	$y = 2E{+}21x^{-1.49}$
Iran	$y = 10.01x^{0.720}$	$y = 3E{-}10x^{2.339}$
Nigeria	$y = 3E{+}06x^{0.136}$	$y = 40207x^{0.42}$
Saudi Arabia	$y = 2E{-}08x^{1.436}$	$y = 0.007x^{1.486}$

*The values for Russia are slightly overstated since the values given represent those of the Russian Federation, rather than for Russia, as reported by the BP Statistical Review (2010).

Figure 6: Power Laws for Saudi Arabia:



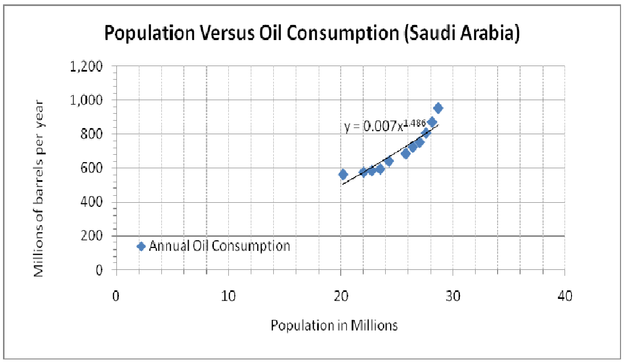


Figure 7: Power Laws for Russia:

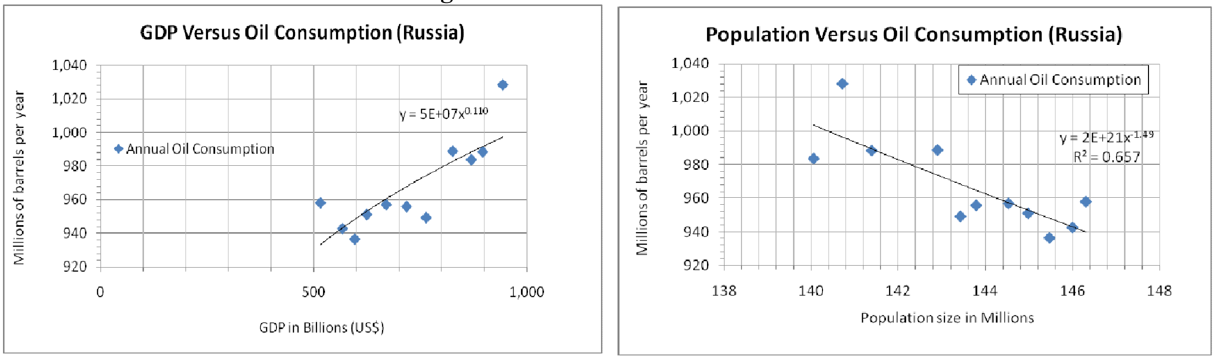


Figure 8: Power Laws for Iran:

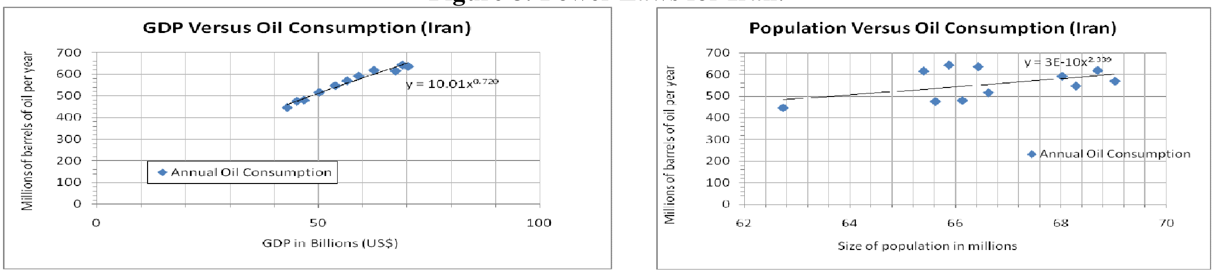
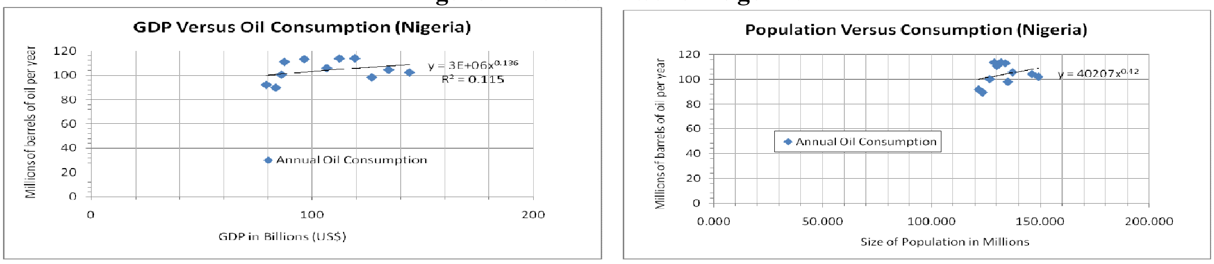


Figure 8: Power Laws for Nigeria:



Note: For the derivation of the power laws, Excel worksheet was used.

Table 4

Pearson's R for the Relationship between GDP and Population and Oil Consumption:

Country	Pearson's r for the relationship between GDP and oil consumption	Pearson's r for the relationship between population and oil consumption
Russia *	0.839130619	-0.807692609
Iran	0.980939591	0.461899245
Nigeria	0.270532943	0.277426094
Saudi Arabia	0.964500217	0.930979868

The relationship between GDP and oil consumption is positive across the board. With the exception of Nigeria where this relationship is weak, it is very strong for all the other countries. In the case of the relationship between oil consumption and population size, the results are mixed: positive and strong for Mexico and Saudi Arabia, negative and strong for Russia, and positive but weak for Iran and Nigeria. Thus, Russia is likely to witness increasing demand for oil in spite of its declining population, while strong demand for oil in Saudi Arabia and Mexico is likely to be driven by strong increases in the size of the population. In Nigeria and Iran, while population increases are expected, their impact in fuelling oil consumption will not be strong.

By definition, income elasticity of demand is the percentage change in consumption arising from a corresponding percentage change in income. Therefore, the power to which the dependent variable x in the power laws is raised represents the income elasticity of demand. A cursory glance then at the income elasticity of demand for oil for Iran, Nigeria, Russia, and Mexico suggests that for these four countries, oil is a normal necessity (given that it ranges between 0 and +1). This is because demand for oil is increasing at a less-than-proportionate rate to the increase in income. This is in line with Engel's Law as previously argued by Bhar and Nikolova (2010). For Saudi Arabia, the income elasticity is greater than unity, suggesting that oil is more of a

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luxury good than a necessity since the rate of increase of demand for oil increases faster than the increase in income.

Using the algebraic expressions derived, and referring to the middle variant 2030 population projections by the UN (2004) and 2030 GDP forecasts by the World Bank, the paper proceed to forecast oil consumption for the countries of study. The results are shown in the table below.

Table 5

Oil Consumption Forecasts: 2030 Projected Oil Consumption (bbls/day)

Country	GDP vs oil consumption	Population vs oil consumption	Total
Russia *	2989078.613	4560309.059	7549387.67
Iran	2604705.451	2405113.308	5009818.76
Nigeria	300747.1711	393508.0764	694255.25
Saudi Arabia	4814244.99	3314151.612	8128396.61
Mexico	2348914.92	2097932.358	4446847.28
TOTAL	13057691.15	12771014.41	25828705.56

The study compare these figures to the 2009 figures, which form the base year for this study, see table 6. The data in table 6 can also be reduced into a column graph, a shown in figure 9

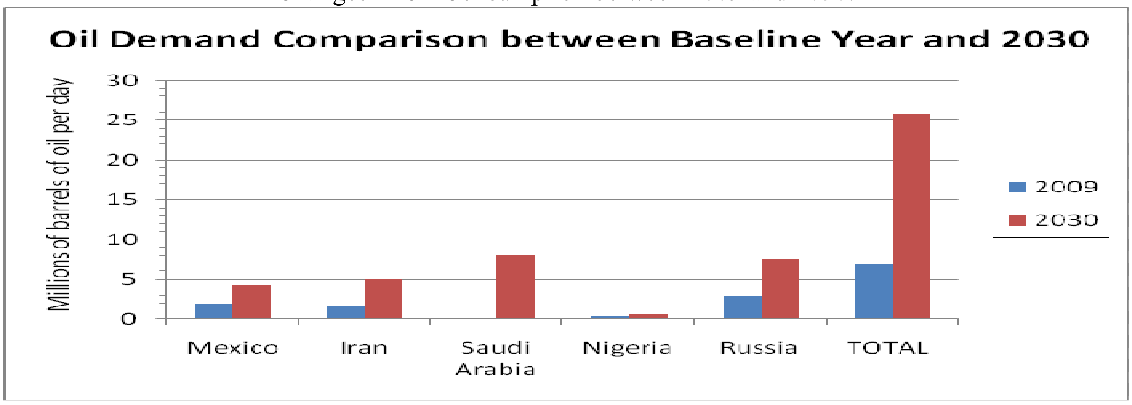
Table 6

Comparison between Baseline Year Consumption and 2030 Consumption:

Country	2009	2030	% Change	Year on Year % Change
Mexico	1,945,000	4446847.28	128.63%	6.13%
Iran	1,741,000	5009818.76	187.76%	8.941%
Saudi Arabia	2,614, 000	8128396.61	210.96%	10.046%
Nigeria	280,000	694,255.25	147.95%	7.045%
Russia	2,927,000	7,549,387.67	157.92%	7.520%
TOTAL	6,893,000	25,828,705.56	274.71%	13.081%

Figure 9

Changes in Oil Consumption between 2009 and 2030.



In summary, oil consumption/demand is expected to grow by between 3% and 10% every year for each of the five countries, and by 13% every year for the five countries as a bloc. For the entire forecasting period (21 years from 2009 to 2030), oil consumption/demand is expected to grow by between 67% and 187%, and by 274% for the five countries as a bloc.

b *Oil Intensity*

Energy intensity is used to measure the efficiency with which energy is used. High energy intensity rates signify inefficient use of energy, that is, more energy is used to generate the same amount of GDP. In contrast, low energy intensity rates signify high energy efficiency. By definition, energy intensity = energy consumption ÷ GDP.

Using the projected consumption levels of oil for 2030, and the GDP estimates provided by World Bank, the oil intensity for the five countries under study can be depicted as shown in the table 7.

Table 7

Oil Intensities for Russia, Mexico, Iran, Saudi Arabia and Nigeria

COUNTRY	2009 ANNUAL CONSUMPTION	2009 GDP	2030 ANNUAL CONSUMPTION	2030 GDP	2009 OIL INTENSITY	2030 OIL INTENSITY
Mexico	709,925,000	878,730,000,000	1623099257	1485844557000	0.00080789889954821200	0.001092375
Iran	635,465,000	70,320,000,000	1828583847.40	120233136000	0.00903676052332196000	0.015208651
Saudi Arabia	954110000.00	346,710,000,000	2966864762.65	629937399000	0.00275189639756569000	0.004709777
Nigeria	102,200,000	143,930,000,000	253403166.25	312889427000	0.00071006739387202100	0.000809881
Russia	983,675,000	870,120,000,000	2755526499.55	1484076672000	0.00113050498781777000	0.001856728
TOTAL	3,385,375,000	2,309,810,000,000	9427477533.05	4032981191000.00	0.00146565085439928000	0.002337595

The percentage change in oil intensity for the five countries (separately and as a bloc), using the figures in the table above, can be presented as shown in the table 8:

Table 8

Change in Oil Intensity between the Baseline Year and 2030

COUNTRY	2009 OIL INTENSITY	2030 OIL INTENSITY	% CHANGE (2009-2030)	% CHANGE (ANNUALIZED)
Mexico	0.00080789889954821200	0.001092375	35.21184403%	1.676754478
Iran	0.00903676052332196000	0.015208651	68.29759913%	3.252266625
Saudi Arabia	0.00275189639756569000	0.004709777	71.14659564%	3.387933126
Nigeria	0.00071006739387202100	0.000809881	14.05692009%	0.669377147
Russia	0.00113050498781777000	0.001856728	64.2388154%	3.058991209
TOTAL	0.00146565085439928000	0.002337595	59.49194128%	2.832949585

On the basis of the figures in the table above, the energy intensity of oil is expected to increase during the forecast period, suggesting that as oil consumption is likely to become more and more inefficient. This increase will be driven by increases across four countries (Mexico, Iran, Saudi Arabia, and Nigeria), with the only decrease in oil intensity being in Russia. At present, of the five countries, Mexico and Nigeria have the lowest energy intensity rates for oil, while Iran and Saudi Arabia have the highest oil intensity rates.

c) Per Capita Consumption:

By definition, per capita consumption of oil = oil consumption ÷ population size. Using figures already presented in the preceding sections, the paper compares the likely trends between changes in per capita consumption for our base year (2009) and for the year 2030. This comparison is presented in the table 9.

Table 9

Per Capita Consumption: Baseline Year and 2030

COUNTRY	2009 ANNUAL CONSUMPTION	2009 POPULATION	2030 ANNUAL CONSUMPTION	2030 POPULATION	2009 PER CAPITA CONSUMPTION	2030 PER CAPITA
Mexico	709,925,000	111,211,800	1623099257	123430254.00	6.38354023583828000000	13.14993046
Iran	635,465,000	66,429,280	1828583847.40	78516000.00	9.56603774721027000000	23.28931488
Saudi Arabia	954110000.00	28,686,630	2966864762.65	36500000.00	33.25974504499130000000	81.2839661
Nigeria	102,200,000	149,229,100	253403166.25	288000000.00	0.68485302129410400000	0.879872105
Russia	983,675,000	140,041,200	2755526499.55	128000000.00	7.02418288332291000000	21.52755078
TOTAL	3,385,375,000	495,598,010	9427477532.85	654446254.00	6.83088901022827000000	14.40527389

On the basis of the figures adduced in the table above, the percentage change in the per capita consumption rates for the five countries can be presented as shown in the table below.

Table 11

Per Capita Consumption Changes

Country	2009 Per Capita Consumption	2030 Per Capita	% Change (2009-2030)	% Change (Annualized)
Mexico	6.38354023583828000000	13.14993046	105.9975%	5.047497883%
Iran	9.56603774721027000000	23.28931488	143.4583%	6.831348616%
Saudi Arabia	33.25974504499130000000	81.2839661	144.3914%	6.875782319%
Nigeria	0.68485302129410400000	0.879872105	28.47605%	1.356002346%
Russia	7.02418288332291000000	21.52755078	206.4777%	9.832269148%
TOTAL	6.83088901022827000000	14.40527389	110.8843%	5.28020575%

In line with the increase in the absolute demand for oil over the forecast period, per capita consumption of oil for the five countries is likely to increase over the forecast period, from 6.83 barrels per person per year to 14.4 barrels per person per year. At present, Nigeria has the lowest per capita consumption of oil, at just 0.68 barrels per person per year, while Saudi Arabia has the highest per capita consumption at 33.3 barrels per person per year. By country, per capita consumption is likely to increase across the board.

5 Conclusion

Oil consumption over the forecasting period is expected to increase by between 67% and 187% for each of the five countries studied individually, and by 274% for the five countries as a bloc. This increase in consumption is expected to be driven by accelerated economic growth across the board, and by rapid increases in the size of the population for four of the countries (Mexico, Nigeria, Iran, and Saudi Arabia). The larger portion of this increase is however expected to come from the high rates of economic growth expected over the forecasting period. Evaluating the trends in energy intensity over the forecasting period, it can also be demonstrated that energy intensity rates are expected to increase over the forecasting period for four of the five countries. It is only Russia which is expected to witness declining energy intensity rates. Since energy intensity is used as an indicator of the efficiency with which energy is used, this suggests that over the forecasting period the use of oil is increasingly expected to become more inefficient. In line with the increase in the absolute demand for oil over the forecast period, per capita consumption of oil for the five countries is likely to increase over the forecast period, from 6.83 barrels per year to 14.4 barrels per year. Increases in per capita oil consumption are also expected for each of the five countries.

The rapid increase in oil consumption against a backdrop of peaking production has the potential to transform a number of leading oil exporters into net oil importers over the forecasting period, leading to pronounced global shortages. Additionally, the expected increases in oil intensity suggest that more units of energy to produce the same amount of GDP will characterize these countries going forward, suggesting increasing inefficiency in the use of oil. Higher consumption per person over the forecasting period is likely to further exacerbate demand conditions. Given the carbon footprint associated with oil production and consumption, this is also expected to worsen GHG emissions and lead to worsening outcomes for the environment. This calls for a number of measures to be adopted, including:

- Diversification of energy needs to other fuels away from oil, and preferably away from fossil fuels.
- Adoption of technological interventions such as: the use of fuel cell vehicles, the shift to renewable sources of energy, enhancement of fuel efficiency, electrification, use of carbon capture and storage technology in power generation and in industry, the shift to nuclear technology, and fuel switching. These technologies will not only reduce GHG emissions, they also possess strong substitutive threats to oil (given their sustainable and non-environmental degrading appeal)or are likely to increase energy efficiency, and are thus likely to dampen the need of oil from both the supply and demand side.
- In the transport sector, alternative fuels such as biofuels, hydrogen fuels, and vehicle electrification should be adopted.
- Within the building sector, a number of measures should be taken to enhance energy efficiency, including: the use of energy efficient appliances (e.g. heat pumps, condensers, solar water heaters, and insulation of hot water cylinders), better building envelop, and the improvement of the thermal performance of windows.
- Energy efficiency at the industry level should be enhanced through such measures as the adoption of industrial CHP systems, cogeneration and through a deliberate shift to alternative energies for power generation purposes.

References:

1. Alquist, Ron and Kilian, Lutz 2010. What Do We Learn From the Price of Crude Oil Futures? *Journal of Applied Econometrics*, Volume 25, issue 4, pages 539 – 573.
2. Bhar, Ramaprasad and Nikolova, Bijana 2010. Global Oil Prices, Oil Industry and Equity Returns: Russian Experience. *Scottish Journal of Political Economy*, Volume 57, Issue 2.
3. Blomgren, H, Jonsson, P, and Lagergren, F. 2011. *Getting back to Scenario Planning: Strategic action in the Future of Energy Europe*.
4. BP Statistical Review. 2011. *BP Energy Outlook 2030*. Retrieved on 2nd November 2011 from http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2011/STAGING/local_assets/pdf/2030_energy_outlook_booklet.pdf
5. Dickel, R., Kunai M., and Konoplyanik A. 2007. *Explaining Oil and Gas Pricing Mechanism: Theoretical and Historical Aspect in Putting a Price of Energy, International Pricing Mechanisms for Oil and Gas*. Published by Energy Secretariat.
6. Ellis, J. 2010. *The Effects of Fossil-Fuel Subsidy Reform: A Review of Modeling and Empirical Studies*. GSI.
7. Ghosh D, Shukla PR, Garg A, Ramana PV. 2002. "Renewable Energy Technologies for the Indian Power Sector: Mitigation Potential and Operational Strategies. *Renew. Sustain. Energy Rev. 6(6):481–512.*
8. Goldthau, Andreas 2012. From the State to the Market and Back: Policy implications for changing Energy Paradigms. *Global Policy Journal* Volume 3, Issue 2. Pages 198 – 210.
9. Gorelick, Steven G. 2009. *Oil Panic and the Global Crisis: Predictions and Myths*. Published by

Willey Online Library
10. Greene, DL. 2001. *Long-Term Energy Scenario Models: A Review of the Literature and Recommendations*. National Transportation Research Center.
11. Huntington HG and Weyant JP. 2002. "Modeling Energy Markets and Climate Change Policy." In *Encyclopedia of Energy*. Academic Press/Elsevier Sci.
12. Huss W., R., Honton EJ. 1987. "Scenario Planning – What Style Should You Use?" *Long Range Planning*, 20, 21 – 29, 1987.
13. IEA. 2011. *World Energy Outlook 2011 Factsheet: How Will Global Energy Markets Evolve To 2035?*
14. Jeffer A and Schwienfort W. 2011. "Building Scenarios with Fuzzy Cognitive Maps: An Exploratory Study of Solar Energy." *Futures*, 43, 52 – 66, 2011.
15. Jensen, J., (2011), Natural Gas Pricing: Complicated Past, Uncertain Future, *Geopolitics of Energy*, Volume 33, Issue 4, April 2011, Pages 2-14**.**
16. Makarov, A.A., (2009). Scenarios of Russian energy future, *Geopolitics of Energy*, Volume 31, Issue 2, February 2009.
17. Martinot, E, Dienst, C, Weiliang, L and Qimin, C. 2007. "Renewable Energy Futures: Targets, Scenarios, and Pathways." *Annual Review of Environment and Resources 2007.*
18. McDowall W, Eames M. 2006. "Forecasts, scenarios, visions, backcasts and roadmaps to the hydrogen economy: A review of the hydrogen futures literature." *Energy Policy* 34(11):1236–1250.
19. Nakata T. 2004. "Energy-Economic Models and the Environment." *Progress in Energy and Combustion Science* 30(4):417–75.
20. Nielsen, KS, and Karlsson, K. 2007. "Energy Scenarios: A Review of Methods, Uses and Suggestions for Improvement." *International Journal of Global Energy Issues*, 27 (3), pp. 302-322.
21. Organization of the Petroleum Exporting Countries (OPEC). 2010. *World Oil Outlook*.
22. Parikh, J. K. 1998."The Emperor Needs New Clothes: Long-Range Energy-Use Scenarios By IIASA-WEC and IIPCC." *Energy, 23*(1), 69-70, 1998.
23. Pierce, Janathon J. 2012. Oil and the House of Saud: Analysis of Saudi Arabian Oil Policy. *Digest of Middle East Studies.* Volume 21, issue 1 pages 89-107.
24. Ramachandra T.V., Loerincik, Y and Shruthi B.V.2006. "Intra and Inter Country Energy Intensity Trend." *The Journal of Energy and Development*, Vol. 31(1): pp. 43-84.
25. Robert J and Lennert M. 2010. "Two Scenarios for Europe: "Europe Confronted With High Energy Prices" Or "Europe after Oil Peaking."" *Futures*, 42, pp. 817 – 824.
26. Rogner, HH and Popescu, A. 2008. "An Introduction to Energy." In, *World Energy Assessment: Energy and the Challenge of Sustainability*.
27. Shell International BV. 2011. *Shell Energy Scenarios to 2050: An Era of Volatile Transitions*.
28. UN. 2004. *World Population to 2300*. Department of Economic and Social Affairs, Population Division, ST/ESA/SER.A/236.
29. Van Vuuren, D, Fengqi, Z, de Vries, B, Kejun, J, Graveland, C, and Yun, L. 2003. "Energy and Emission Scenarios for China in the 21st Century - Exploration of Baseline Development and Mitigation Options." *Energy Policy*, 31(4), pp. 369-38.
30. Von Moltke, A, McKee, C, and Morgan, T. 2004. *Energy Subsidies: Lessons Learned in Assessing their Impact and Designing Policy Reforms*. Greenleaf Publishing.