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Assessing Oil Vulnerability: Key Indicators and Policy Options

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

YOUNG PROFESSIONALS (YPs) TRAINING PROGRAMME

Assessing Oil Vulnerability: Key Indicators and Policy Options

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Research and Analysis

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Abstract

Petroleum products are a key source of commercial energy in Kenya. The economic impacts of first and second oil shocks of the 1970s and current volatile crude oil prices have pushed supply vulnerability to the top of energy policy agenda. Kenya ought to continuously review the energy policy contained in Sessional Paper No. 4 of 2004 as well as implement energy plans and investments to obviate her potential vulnerability to oil supply disruption and oil price volatility. The problem of sustained higher global oil prices may undermine Kenya's economic growth and weaken progress towards achievement of Vision 2030. Clearly then, it is imperative to understand Kenya's energy supply constraints, especially the level of oil supply vulnerability.

The study uses Shannon-Weiner index, Hirschmann–Herfindahl index and econometric modelling to assess Kenya's level of oil supply dependence, vulnerability and energy intensity, using secondary data sources. Two results emerged: First, Kenya is vulnerable to unanticipated supply interruption and international oil price volatility. Such supply vulnerability has knock-on effects for the Great Lakes region because the regional economy (consisting of Uganda, Northern Tanzania, Rwanda, Burundi, Eastern Democratic Republic of Congo and Southern Sudan) relies on petroleum infrastructure in Kenya for supply of refined products. Second, the econometric model shows that oil intensity rises positively and significantly with increases in per capita vehicle ownership and urbanization rate.

Several policy recommendations are drawn from this study such as the need to manage national demand for petroleum products by tapping into potentials for energy efficiency savings in various end-use sectors; the need to hedge external supply shocks by diversifying crude oil supply sources within Gulf producing countries by reducing the market share commanded by a single country; fast tracking implementation of essential stockpiling systems of strategic petroleum reserve; and exploiting alternative energy opportunities in Kenya.

Abbreviations and Acronyms

DRC	Democratic Republic of Congo
ESMAP	Energy Sector Management Assistance Programme
GDP	Gross Domestic Product
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agencies
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KPLC	Kenya Power and Lighting Company
KPRL	Kenya Petroleum Refineries Limited
LPG	Liquefied Petroleum Gas
MOE	Ministry of Energy
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
OPVI	Oil Price Vulnerability Index
SW	Shannon-Weiner
SWD	Shannon-Weiner Diversity
UNEP	United Nations Environment Programme
USA	United States of America
VIPER	Vulnerability Index for Petrol Expense Rises
WEC	World Energy Council

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1. Background

Oil is a key source of primary energy. It fuels most economic activities and is viewed as a strategic commodity with politics and conflicts on a local, national, regional and global basis (Stevens, 2006). Due to its inherent qualities and strategic function, oil demand in many oil consuming countries has been growing relative to other primary sources of energy. This implies that countries that are under-endowed in oil resources inevitably experience increase in oil import dependence and vulnerability.

In this study, import vulnerability[1] will be considered in a broader context in terms of risk and resilience. Many studies identify vulnerability with import dependency only. However, oil import dependence[2] alone does not translate into a serious threat since a country can be dependent without being vulnerable. Import vulnerability arises from several factors: degree and nature of import dependence, the potential harm to the economy, and social welfare loss from a severe disruption.

Historically, the oil shocks of the 1970s associated with the apparent supply disruption of the Arab oil embargo, the Iranian revolution and the Iraq-Iran war, forced oil vulnerability and security of supply to the top of the energy policy agenda. Oil shock and supply disruption lead to a rise in import bill and this has direct and indirect consequences on the GDP of most net oil importing countries.

Indeed, the policy trend in most oil importing countries has seen growing concerns about oil import vulnerability and current concerns stem from a number of related problems, but what appears to be the controlling factors are the huge imbalances of reserves and the economic control it generates (Shaw, 1998). Other reasons include unstable political climate in major supplier countries, substantial oil demand growth in the emerging economies, and uncertainty of market liberalization.

Although biomass constitute over 70 per cent of primary energy consumed in Kenya, petroleum products consumption predominates in commercial and industrial sectors, especially in manufacturing and transport sub-sectors. With the main sectors of transportation, industrial and commercial relying on imported petroleum products

[1] Vulnerability is defined as the degree to which energy system is unable to cope with selected adverse events.

[2] Percentage of domestic oil consumption that is met by foreign oil.

growing heavily, Kenya's economy will particularly be vulnerable to rising oil prices, feeding through into a rising cost of oil imports.

The market has undergone profound changes in the past decade because demand for a wide range of petroleum products[3] has grown rapidly. Total petroleum consumption in Kenya has grown from 42,000 barrels/day in 1980 to 67,000 barrels/day in 2006 (International Energy Agencies, 2007). With oil use being pervasive and deeply rooted in the Kenyan economy, the country's dependence on oil imports and the growing demand, coupled with lack of substitute for petroleum products is of concern.

Continued economic growth in Kenya is expected to give rise to further increases in the absolute levels of oil requirements. Therefore, oil vulnerability remains a potentially serious economic and strategic problem for Kenya, given the central economic role that oil will continue to play in future. It is important to note that assessing Kenya's vulnerability will constitute an integral part of sound and consistent energy policy.

1.1 Statement of the Problem

Oil import vulnerability has been a central energy policy agenda for most oil importing countries, especially after the first oil shock. However, this has not been central in Kenya's energy policy agenda. Kenya's petroleum market has undergone profound changes in the

Table 1.1: Consumption of petroleum products in Kenya, 2001 to 2006 (000' tonnes)

Product/Year	2001	2002	2003	2004	2005	2006
Liquefied petroleum gas	35.6	40.5	40.9	41.7	49.4	64.6
Gasoline (MSP and MSR)	374.3	365.8	327.9	326.4	337.7	363.4
Aviation spirit	2.4	1.8	1.5	1.8	2.0	2.0
Jet/Turbo fuel	417.3	470.2	487.3	521.1	559.1	594.7
Illumination kerosene	306.1	273.6	190.0	236.1	307.0	287.0
Light diesel oil	663.7	627.3	649.6	789.4	892.4	1030.6
Heavy diesel oil	27.7	28.0	24.4	25.2	25.5	41.1
Fuel oil	558.1	498.7	407.0	432.8	546.7	665.0
Total	2385	2306	2129	2374	2716	3048

Source: KIPPRA and KPC, 2007

[3] Petroleum products are defined as the range of commodities derived from the refining and secondary processing of crude oil into gases, liquids and solids.

last few years, with both import volume and demand for wide range of petroleum products rising. Table 1.1 shows the consumption trend of petroleum products in Kenya from 2001 to 2006.

The problem of increased oil import dependence makes Kenya vulnerable to fluctuations in international crude oil price. Sustained high oil prices will undermine economic growth and weaken the progress towards the achievement of Millennium Development Goals (MDGs) and Vision 2030. Higher oil prices lead to tighter financial constraints. Indeed, Kenya's import of petroleum products consumed about 31 per cent of the country's foreign exchange earnings from merchandise exports and accounted for an increase in import bill by 7.1 per cent from Ksh 113.7 billion in 2006 to Ksh 121.8 in 2007 (Economic Survey, 2008). This rising import bill has adverse effects on macroeconomic stability.

In addition, vulnerability issues have knock-on effects on the greater lake region, since Kenya supplies refined products to Uganda, Northern Tanzania, Rwanda, Burundi, Eastern DRC and Southern Sudan. The level of dependence on the gulf oil is very significant and is set to increase given that the indigenous production is still zero.

As the country enters a new phase in her development efforts, petroleum products demand will be expected to increase, and there is need to have policy measures that secure petroleum products supply, while minimizing economic vulnerability to oil price shocks. Therefore, the study attempts to develop a set of vulnerability indicators that could be utilized to evaluate the level of vulnerability.

1.2 Research Questions

(a) What is the extent of oil dependence of the Kenyan economy?

(b) What is the energy and petroleum intensity of Kenyan economy?

(c) How vulnerable is Kenya at present to sustain supply disruption?

(d) What are policy options for coping with oil vulnerability?

1.3 Research Objectives

The main objective of this study is to gauge Kenya's level of vulnerability

to international oil price volatility and to highlight some of the key policy options. The ultimate objective of the study is to understand exactly how vulnerable Kenya would be in a situation of continuing oil price rises and potential oil shortages in the medium to long term. Specific objectives of the study are:

(a) To assess oil dependence of the Kenyan economy

(b) To examine the energy and petroleum intensities of the Kenyan economy

(c) To assess Kenya's vulnerability to oil supply disruption

(d) Propose policy strategies to cope with oil vulnerability in Kenya

1.4 Justification of the Study

Although biomass constitutes a huge proportion of energy consumed in Kenya, petroleum products are an important commercial energy. Even with major advances in energy efficiency gains and renewable energy technology, petroleum products will remain key economic variables to determine the health of global economies (Stevens, 2006). However, the unexpected increase in demand has put considerable constrains on existing petroleum import handling and transportation infrastructure.

Understanding oil vulnerability level is critical because sustainable availability of petroleum products is requisite to maintain the momentum of the current economic recovery in Kenya, especially in light of Vision 2030 and MDGs, where Kenya hopes to attain the status of a middle level developed economy. Currently, Kenya's transportation, electricity and industrial sectors are totally reliant on oil and there is no flexible option of switching among fossil fuels from oil to gas to coal. This dependence gives oil both a unique and uncomfortable role in Kenya's national economic health and well-being.

Transformation of the Kenyan economy into a globally competitive nation with high quality of life, as envisaged in Vision 2030, requires among other interventions steady, predictable, quality and affordable supply of energy to all sectors ranging from manufacturing, services, mining, and agriculture. Despite laudable recognition of the problem of energy security in the sessional paper, little has been done to solve it. Therefore, a study is needed to establish current vulnerability level, oil intensity of the economy and identify policy options that will address any further consequences.

2. Literature Review

2.1 Theoretical Literature

According to economic production theory, the economic consequences of energy disruptions are expected to be related to the country's expenditure on oil relative to the gross domestic product (GDP), and this declines as the oil factor-share decreases. However, a study by Hamilton (1996) observed that the historical experience does not conform to the simple factor-share argument. In many oil dependent economies, the drop in GDP following the five most notable oil supply disruptions since 1950 far-exceeded the loss predicted by the oil factor share. This and other empirical tests led Hamilton (1996) and Huntington (2004) to conclude that the relationship between oil price shocks and output is more subtle and complex than originally thought, with shocks working their way through the economy in many sectors by indirect channels that can be surprisingly powerful. Therefore, for these reasons, we cannot be certain that the disruption component of the oil premium declines in direct proportion to oil share of an economy.

The other theory is the dynamic depletable resource theory, in which price paths are strongly driven by the estimated resource base size and backstop price. Indeed, the limits of depletable resource theory as a positive description of petroleum markets are well established (Watkins, 1992; 2006). Alternatively, viewing Organization of Petroleum Exporting Countries (OPEC) as a monopolist suggests that while elasticity of import supply may be ill-defined, the price charged will depend on national consumption via the effect of a country's consumption on OPEC's market share (Greene and Leiby, 1995). If the world could somehow reduce OPEC's market share enough, there would be pressure for prices to return towards competitive market levels. Depletability element leads to factors behind world oil prices volatility such as peak oil theory, which argues that world oil production is going to reach a peak in the near future and will not be able to increase anymore. This is illustrated by Hubbert's peak theory (1982), which demonstrated that oil production for an individual oil field, group of fields, or region (including the world) follows a generally bell shaped curve over time. Hubbert theory further states that when the field is first developed, there is a slow steady increase in productivity, followed by a sharp increase as the easy oil is extracted, then a plateau

("peak") and finally, a decline as recovery becomes more difficult. Peak oil production occurs when about half of the oil in a field (or region) has been exhausted. At some point, a peak output is reached and oil production begins declining until it approximates an exponential decline. A decrease in oil production often leads to an increase in oil prices, and vice versa.

Other applicable theory to energy supply security is portfolio diversification theory, which argues that reducing vulnerability to external shocks by diversifying fuel types and sources is akin to the portfolio diversification well known to investors. It is better to invest in a diverse set of companies than to invest in only one company, and this is the basic intuition that led to diversification among energy types and suppliers. Therefore, countries need to not only evaluate the security of individual supply chains, but also the risk of their energy supply portfolio against the vagaries of energy markets. For instance, the contribution of new and renewable resources is also increasingly seen from an energy security perspective. Most recent work extending modern portfolio theory to renewables shows that the reduction in risk through the introduction of a modest amount of renewables often outweighs the direct costs of even non-least-cost renewable sources. Significantly, these same analyses indicate that the optimal proportion of renewables is higher than current levels of deployment in many countries.

Another theoretical concept includes regional security complex (Polonkorpi, 2007), which was well explored in the light of security issues. This theory states that a group of security dilemmas concentrate in a small geographical area, where essential threats are so closely interlinked. In this case, the security of an individual state could not be easily separated from that of another. Built on this is the regional energy security complex, which is formed by energy related interaction between two or more states that include an energy dependency relationship. This theory takes into account the political aspect that can be argued as (energy) security threat.

This study adopted two strands of theories; portfolio theory because of the availability of the risk element associated with different suppliers that assist in capturing the supply-side vulnerability; and, theoretical concept of regional security complex theory because Kenya imports most of her crude and white products from one region, the Middle East, which is mostly perceived as having similar risk factors.

2.2 Empirical Literature

There are a number of other empirical studies that tried to analyse energy vulnerability. This review specifically looks at studies of energy system vulnerability in oil dependent countries and specifically oil importing countries. Studies by Dodson and Sipe (2005) estimated the potential exposure of households to adverse outcomes arising from increased fuel costs creating a locational measure of oil vulnerability termed 'vulnerability index for petrol expense rises' (VIPER). VIPER is a composite index constructed from three indicator variables to assess average household vulnerability. The variables used are:

- Area socio-economic index
- Household motor vehicle ownership
- Car dependence for work journeys

The study found that there is a highly uneven distribution of potential vulnerability to oil price pressures. They further used per capita energy consumption to analyse the relationship between energy consumption and GDP growth. This represents one of the economic indicators to assess the relationship of energy consumption and economic growth. The study concludes that a significant increase of energy to GDP ratio indicates increasing vulnerability, especially when the energy source is imported. In addition, Bacon and Mattar (2005) found that an economy characterized by high energy intensity experiences high levels of energy vulnerability especially for oil, if it represents high share in the total primary energy supply.

A study by Awerbuch and Berger (2003) adopted a probabilistic approach such as the modern portfolio theory approach to analyse fuel mix optimization in the power generation sector. However, this approach only gives desired results in a situation where there is sufficient information on risk regimes associated with different fuels and suppliers. Also, it only gives the power generation sub-sector overwhelming recognition.

A study by energy sector management assistance programme (ESMAP) of World Bank used data on sectoral consumption of fuels to determine oil vulnerability in 32 African countries. The study used two variables: the motor vehicle ownership and degree of urbanization. The oil intensity on motor vehicle per 1,000 population per US$ of GDP per capita was regressed on percentage of population urbanized.

The study adopted these variables on the premise that as the ratio of vehicle owned per capita to GDP per capita increases, the consumption of petroleum products would be expected to increase relative to GDP. Also, as the degree of urbanization increases, the use of oil related energy may increase.

The study by Sterling (1999) used a concept of diversity as hedging strategy to analyze market/supply diversity of energy. Using market concentration and diversity, he assessed how efficient a market is. This approach is highly appropriate in fossil fuel market where there is insufficient knowledge on the dynamics of the market. IEA (2004) analyses further incorporated political stability factor in the energy market concentration approach adopted by Sterling (1999) to reflect a reasonable measure of associated risks. The inclusion of this parameter scales up market concentration risks, if the country participating in the market is politically risky.

The World Energy Council (WEC) study (2008) established a wide range of indicators to assess Europe's vulnerability to energy crisis. Vulnerability indicators are broken down into three levels: the macroeconomic level (energy dependence/independence, energy intensity, net energy import bill, and carbon content of total primary energy supply); the micro and technological level (distribution and obsolete technology); and the social level (fuel poverty and access to grid). This analysis is included in the geopolitical level.

The WEC study goes on to conclude that the long-term energy supply is subjected to vulnerability due to predominant threats of growing import dependence on geopolitically unstable energy producing regions. In Europe, for instance, the growing dependence on imports and lack of investment in the energy sector are prime concerns perceived to have induced uncertainties and vulnerability to future supplies primarily of hydro-carbons. However, the study also concludes that a country may be dependent on imports without being vulnerable, especially if the imports portfolio is diverse and suppliers are reliable.

2.2.1 Policies to reduce oil vulnerability

With such harmful effects on the economy, there is serious need to reduce the level of vulnerability. Different policies have been adopted across developed and transition economies in Europe, USA, Latin America, Asia and Africa. The European energy strategy traditionally explores

four key areas of energy security to alleviate Europe's vulnerability to energy crisis namely: management of demand, diversifying supply sources, greater efficiency in the domestic market and management of external supplies through mutual dialogue with production countries.

Organization for Economic Cooperation and Development (OECD) net oil importers reduced their vulnerability through induced sectoral demand shift and consequent large reduction in energy intensity as well as improvements in energy use efficiency (Bacon and Mattar, 2005). For instance, advancement in ethanol technology is diversifying fuel mix in Brazil, with improved contribution to the country's economy through ethanol exports and reduced vulnerability by fuel substitution. Precisely, Brazil reduced its oil import dependency by 50 per cent between 1990 and 2003.

The Chinese experience offers some replicable lessons for Kenya; firstly, investing through national oil companies in overseas oil and gas projects, with the activity covering more than 30 countries today (Dirks, 2006); and secondly, seeking strategic oil partners throughout the world. Although this approach may hardly offer a complete solution to China owing to her scale and geographical consideration, it is worth emulating for Kenya.

The sub-Saharan African net oil importing countries adopted a prudent policy in improving energy mix by encouraging hydropower which is independent of oil price and can form a direct substitute for the use of more hydrocarbons for power generation.

2.2.1.1 The strategic petroleum reserves

The sharp increases in crude oil prices that occurred between 1973 and 1974 has shifted the policy focus towards a strategic petroleum reserve (SPR). This cushions the economy from the effects of a sudden loss of oil supply (Hogan, 1983). The overarching purpose of SPR would be to reduce the adverse macroeconomic impacts that can result from oil price shocks.

Against this backdrop, strategic petroleum reserve has been uniformly embraced as one of the tools to protect the country against supply shocks. The primary purpose of the SPR is to diminish economic vulnerability to the harmful effects of petroleum supply disruptions, and as a political tool. Furthermore, in an erratic oil market, SPR is widely viewed as a useful asset for improving the national energy and

economic security, mainly because it provides a potentially valuable buffer against short-term oil supply disruptions. The key purposes of SPR are:

- It acts as a first line of defense against interruption in critical petroleum supplies
- Deterrent to hostile cutoff of oil imports
- Provides economic security
- Increases worldwide stability

A handful of oil importing countries have adopted SPR policy successfully. This is mainly motivated by the oil shock of 1973 and the fact that the International Energy Agency's (IEA) imposed requirements that member countries, especially the net importers, should maintain emergency oil reserves of 90 days of net imports. This led several countries such as France, UK, USA, Japan, Sweden, Germany and South Korea to put strategic petroleum reserves in place. According to Bamberger (2006), USA provisions for the SPR were included in the Energy Policy and Conservation Act (EPCA) of 1975 with the intent of protecting the nation against supply disruptions and, today, in the United States, SPR holds roughly 660 million barrels of oil (with the capacity to hold 700 million barrels) and is the largest emergency stockpile of oil in the world.

China also followed other nations in establishing strategic oil reserves with a long-run goal to store 90 days of net imports, about 400 million barrels at projected future import rates. This would also bring them into compliance with the IEA's recommendation for strategic reserves.

However, according to Komor and Blumstein (1996), the SPR has some serious constraints: costly, insufficient funding to meet mandated fill levels, encouragement of import dependence by hidden subsidy and lack of adjustment mechanism for oil levels.

2.3 Energy Vulnerability and Petroleum Products Demand in Kenya

There are three main sources of energy in Kenya: wood fuel, petroleum and electricity, accounting for 70 per cent, 21 per cent, and 9 per cent of total energy use, respectively (Mwakubo *et al.*, 2007). Kenya is highly

dependent on oil imports mainly from the Middle East region, which is perceived as presenting higher political risks. Imports of petroleum accounted for 16 per cent of the total import bill in 2002 and consumed 31 per cent of the country's foreign exchange earnings from merchandise exports. Between 1997 and 2003, an average import of crude petroleum and petroleum products accounted for 10.5 per cent and 9.1 per cent, respectively. The imports of petroleum products recorded the highest growth during the period, at an average of 21.2 per cent. Kenya's petroleum consumption has increased significantly over the years due to rapid economic growth, and is expected to grow in future.

2.3.1 Assessment of the literature review

Most of the empirical literature has focused on the demand side factors that affect oil vulnerability. Diversity and per capita consumption are common approaches for estimating oil vulnerability. These approaches are attractive because they capture demand vulnerability as well as the supply. However, the approaches suffer from the criticism of factoring in greatly demand side measures. Vulnerability Index for Petrol Expense Rises (VIPER) and portfolio theory approaches use socio-economic variables and risk, respectively. The disadvantage of these approaches is that they result only in locational impacts of oil vulnerability and can be used when all risk factors of a given supplier are available. However, hybrid approaches of supply and demand side were chosen for this study because they permit the estimation of vulnerability from both sides and they also yield better results under inadequate data set.

From the literature review, a wealth of knowledge has been generated particularly in developed economies of Western Europe and the USA. However, no energy policy study has explicitly addressed the question of Kenya's oil vulnerability status. This study aims to fill this vacuum.

2.4 Conceptual Background

Oil is arguably a quintessential commodity in the modern economy. Energy (especially oil) is a vital input in many productive processes and, therefore, a causal factor for economic growth which stimulates the consumption of oil. In the situation of internationally determined oil prices, the vulnerability assessment of an oil-importing country can be broken down into various dimensions (Nkomo, 2006): oil resource

dependence, oil import dependence and the energy intensity of the economy.

Energy vulnerability is usually defined in terms of susceptibility to threats and inability of the energy system to cope with adverse effects. There are at least two important dimensions of energy vulnerability assessment. The first is the supply side, which is measured by assessing diversity and concentration of supply. The second aspect is demand. Three cases may be identified: oil resource dependence, import dependence, and fuel used in major sectors of the economy. The supply side also considers factors of crude oil market, which comprise of output from OPEC and non–OPEC producing countries whose production decisions hinge on geological, economic and political factors. Nationally, an oil price rise will have reverberations through a number of channels and on macroeconomic variables.

The vulnerability context of an economy is also influenced by time trends in variables such as urban population growth, motor vehicle ownership, oil intensity of the economy, GDP per capita, and shocks resulting from factors such as bad weather, terrorism, conflict among others. Proper understanding of energy policy behaviour in response to such external effects is crucial in analysing oil vulnerability. A number of economic sectors have varying degrees of oil intensity and the relationship between sectoral consumption and oil vulnerability is extremely important for policy work. If oil use is limited by local endowments then, as the economy develops and becomes urbanized and the level of motorization increases, use of oil is expected to increase, such that some level of substitution is required. However, information on aspects of sectoral use is limited in Kenya.

This study uses qualitative and quantitative techniques depending on data availability to assess a number of key indicators. The vulnerability assessment includes an evaluation of the level of vulnerability and analysis of options for enhancing the robustness of an energy supply system. The task of conducting an assessment can create an awareness of risk and vulnerability management and increase the motivation to work on these issues.

The level of supply diversity and degree of market concentration is critical in analysing oil vulnerability. To assess diversity, Stirling (1994) adopted Shannon Weiner index. The index is calculated as follows:

$SW = -\sum_i X_i lnX_i$, where X_i = market share of supply country

However, to get realistic SW value, there is need to factor in political stability index of the supplier country and the final equation takes the following form:

$SW=-\sum_i X_i lnX_i b_i$, where b_i=political stability index of exporting countries

The value of Shannon index is naturally higher with a greater number of suppliers. SW index assumes a value in a range (low diversity) $0 \leq SW \geq 2$ (high diversity). The zero indices correspond to an extreme case where there is no diversification and where there are full diversifications.

3. Methodology

3.1 Nature and Sources of Data

Secondary data was used for this study to determine the level of vulnerability. The key datasets of interest are: total primary energy consumption, oil imports volume, oil/energy intensity, and political stability factor as well as import sources among others. Data sources include: IEA and World Bank central database, Petroleum Institute of East Africa, Kenya Petroleum Refinery Limited (KPRL), Ministry of Energy, and Kenya National Bureau of Statistics.

3.2 Techniques of Data Collection and Analysis

This study follows a two-stage methodological approach from data collection, analysis, to final presentation of the research findings. The major vulnerability indicators are assessed both at demand and supply levels.

3.2.1 Demand side measurement

The demand side measures were identified at micro level as follows:

- Compute oil dependence, the share of total primary energy that is supplied by oil and oil products in total primary energy mix over time
- Compute per capita oil consumption
- Review the trends in total final energy consumption by sectors, for example transportation, industrial, residential and commercial sectors among other key energy intensive sectors. This assesses the trend in sector oil intensiveness
- Assess the fuel diversity of Kenyan economy
- Compute energy and oil intensity of the gross domestic product
- The oil intensity model and determinants

Consistent with energy intensity modeling principles and considering practical availability of data, some partial evidence was sought from three variables for this study to assess oil intensity. The study regressed

oil intensity on vehicle ownership, degree of urbanization and GDP per capita. On the basis of literature on energy models, the final model for the variables took the following form:

$$Oil\ int = \alpha_o + \alpha_1 VEH_t + \alpha_2 URB_t + \alpha_3 GDP_{pc} + \varepsilon_t$$

Where:

$Oil\ int_t$ = oil intensity

VEH_t = motor vehicle ownership

URB_t = urbanization

GDP_{pc} = GDP per capita

ε_t = Error term

3.2.2 Supply diversity measurement

To assess supply side vulnerability, the study relies on two methods for quantifying diversity of supply:

(a) The Hirschmann-Herfindahl index (HHI), which assesses import concentration; and

(b) Shannon-Wiener index (SW), which assesses oil supply diversity

4. Analysis, Results and Discussions

4.1 The Kenyan Energy System

There are many ways to present the Kenyan energy system. However, this study's main concern is identifying points of vulnerability resulting from rapid supply disruption and price changes, while focusing attention on the ability of the system to accommodate these changes. Reliance on imported oil may be prima facie evidence of Kenya's vulnerability, although it may not obviously translate into vulnerability. Kenya's domestic production is zero. In addition, Kenya has distribution challenges. The transport and distribution modes such as pipeline is capital intensive and forms a unique aspect of the physical vulnerability of national energy system.

The oil system is primarily susceptible to an import or production disruption or a severe relative price change. Although the inventories held in SPR could provide the primary public remedy, this option is not available in Kenya. The next soft spot could be in oil, using electrical generation facilities. However, substitution is possible in the form of electricity from hydro power and other energy sources such as geothermal. Finally, at end use points, vulnerability can be generated by breakdowns. The ability to adjust to breakdowns is conditioned by both physical rigidities such as ability to use more than one kind of fuel, increase in refining volumes, and existence of pipelines with excess capacity. For Kenya, the sheer lack of substitution fuel, constrained refinery capacity, lack of pipeline with excess capacity and lack of SPR inventory is an ultimate limitation.

4.2 Sources of Petroleum and Resource Potential

Petroleum products are the most important sources of commercial energy in Kenya. They are a dominant element in Kenya's energy mix (measured as a percentage of total primary energy consumption in thousand tonnes of oil equivalent-Ktoe). They are mainly used in transportation, industrial, agricultural and commercial sectors. Kenya has no indigenous sources of oil and all her oil requirements are met through imports. So far, Kenya's exploration success rate has been relatively low. Kenya will continue to rely on imports to meet all the country's requirements for the foreseeable future. However, there

are high expectations for the development of offshore and onshore oil industry, especially from 2000 to date. Therefore, as a result of under-endowment of hydrocarbon resources, Kenya will continue to depend on foreign oil suppliers.

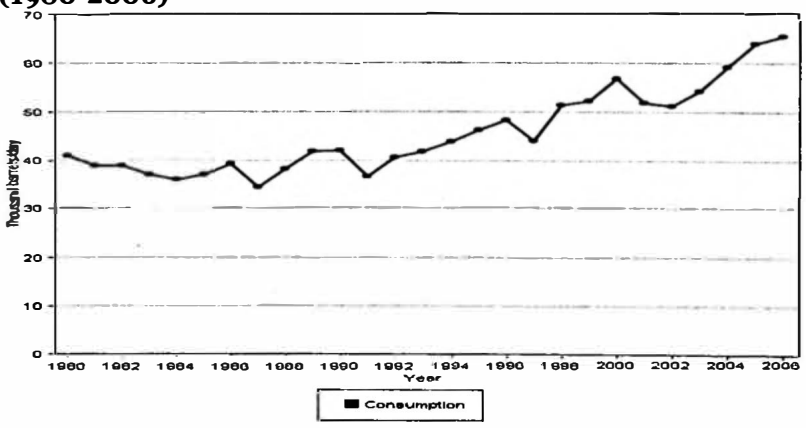
4.3 Oil Consumption Trend in Kenya

Kenya's oil consumption has increased significantly as a result of recent rapid economic growth. Kenya consumed 3,172 thousand tonnes of oil in 2006, approximately 67 thousand barrels of oil per day compared to 42 thousand barrels a day in 1980 (Figure 4.1).

High dependence on oil is inevitable given the energy intensity situation and the nature of economic activities. However, the high dependence is a matter of choice as Kenya has adopted patterns of transportation and production that are oil intensive.

Currently, Kenya consumes nearly 5,000 tonnes of oil per annum, an amount that has increased by 65 per cent since 1995. Like most developing countries, Kenya has relied on oil to fuel her economy and, given that Kenya is in the early stages of economic development, the expected industrialization and urbanization tend to lead to extensive infrastructure and housing development (energy intensive activities). Therefore, petroleum consumption is likely to increase over time.

Figure 4.1: Kenya's oil consumption in thousand barrel/day (1980-2006)



Source: International Energy Agencies (2006)

Table 4.1: Oil consumption per capita in barrels, 1994-2004

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0.68	0.67	0.69	0.66	0.69	0.72	0.68	0.65	0.64	0.64	0.64

Source: World Oil and Gas Review (2006)

The per capita oil consumption is illustrated in Table 4.1 and statistics show that per capita consumption has remained constant over the period. However, with prospective economic growth and heavy reliance on oil for transport system, the per capita consumption is likely to grow in future.

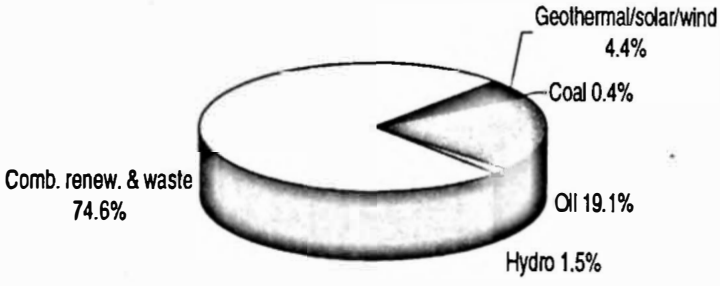
A critical analysis of Kenya's oil demand increase in absolute terms over the years shows that consumption growth has been influenced by car ownership and usage. Indeed, the transport sector has been the key demand component of Kenya's growing need for oil.

4.4 Oil Self-sufficiency and Oil Import Dependence

The level of oil dependence, being the share of oil and petroleum products in the total primary energy, shows that oil dominates other sources of primary energy (except biomass) in Kenya. Figure 4.2 illustrates that oil commands the highest share in total modern primary energy. The shares are net of biomass. However, when biomass is considered, it is still an important source of primary energy, with Kenya deriving 74.6 per cent of total energy supply from the source (IEA, 2005).

Presently, the combined primary energy source does not influence greatly the choice of energy, leaving Kenya to totally rely on oil and oil

Figure 4.2: Share of total primary energy supply in 2005



Source: International Energy Agencies (2005)

Table 4.2: Oil energy dependence in Kenya, 1995-2006

Year	Oil energy dependence[3]
1995	0.70
1996	0.84
1997	0.84
1998	0.84
1999	0.86
2000	0.91
2001	0.84
2002	0.85
2003	0.83
2004	0.83
2005	0.86
2006	0.87

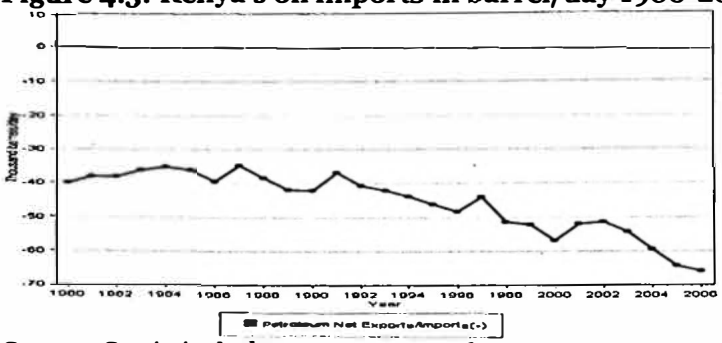
products. Overall, Table 4.2 shows that Kenya is effectively dependent on oil with other primary source of energy being utilized fully. This particular aspect contributes to high oil vulnerability with worrying trend of low substitution.

4.5 Kenya's Regional Import Dependence

Oil imports fill the gap between domestic production and national demand. Kenya is under-endowed in oil resources, hence imports all her demand. Figure 4.3 illustrates the import pattern over the period 1980-2006. Import of crude oil and petroleum products predominates. Under the current oil supply patterns, there is clear regional dependence on imported crude and refined products (Annex Table 1). In addition, Kenya has shown clear dependence on few suppliers and has done little to diversify its sources of import. The major oil suppliers are: Saudi Arabia, UAE, Iran and Kuwait. Current imports from OPEC made up 100 per cent of total net imports. With projected growth in oil demand and consumption pattern, Kenya will continue to procure most of her incremental oil imports from the Middle East. This rising oil import dependence on such a volatile region will pose potential threats to Kenya's oil supply security and, based on these characteristics of the Middle East region, it can be argued that Kenya will be exposed to greater future vulnerability.

[3] Ratio of petroleum consumption to total primary energy consumption (excluding biomass)

Figure 4.3: Kenya's oil imports in barrel/day 1980-2006



Source: Statistical Abstract, 1995-2006

4.6 Petroleum Product Consumption

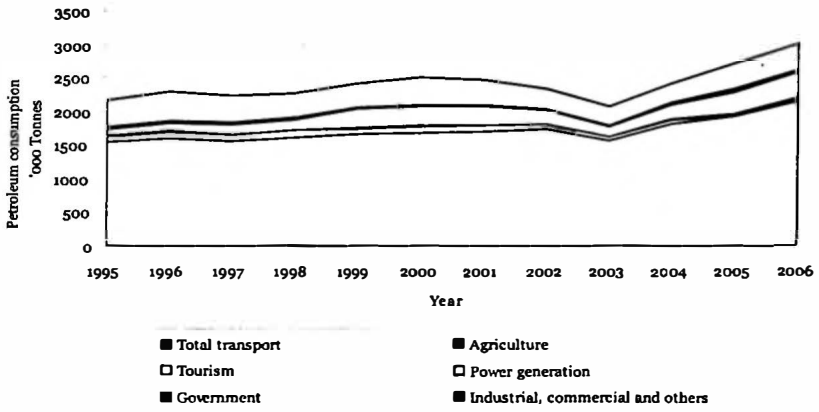
Detailed analysis of the share of individual petroleum products in total product consumptions from 2001 to 2006 (Appendix Table 2) shows that Kenya's petroleum consumption has increased significantly over the years as a result of rapid economic growth witnessed. Gasoline is a light fuel used almost exclusively to power automobiles and light trucks. At present, it has no widely available commercial substitute. In 2006, gasoline constituted 11 per cent of total petroleum product used and it does not show drastic increase over the period. Domestic refineries supply most gasoline needs. The distillates fuel oils are used for diesel transportation, small commercial and industrial properties and power generation. Distillates account for high percentage of total consumption. The heavy oil left after the lighter products have been distilled in the refinery is used as boiler fuel to power ships and for other marine use.

Jet fuel consumption was about 19 per cent of 2006 total consumption. Over the years, and jet fuel has increased slightly probably owing to the improved economic conditions and airline competition. LPG is used as fuel in residential and commercial sectors and sometimes as feedstock in the industrial sector. Over the years, LPG intake has been growing slightly. The data suggests that the primary use of petroleum products in Kenya is for transportation and any policy aimed at reducing consumption of petroleum products must focus on the transport sector.

4.6.1 Oil consumption by sectors

Demand for petroleum products in each of the major end use sectors (transportation, commercial, residential, industrial and electric power) varies, and generally, all sectors have a different sensitivity to crude oil

Figure 4.4: Kenya's oil consumption by sector, 1995-2006



Source: Author's computation

price changes. Patterns of oil consumption and relative shares of demand for the major sectors in Kenya in the period 1995-2006 are shown in Figure 4.4. The largest oil users are the transportation and industrial sectors. Kenya's transport sector relies totally on petroleum products and currently, there are no commercially available substitutes for petroleum-derived motor vehicle fuels. The primary petroleum products used are diesel (distillate) fuel, motor gasoline, jet fuels and kerosene.

As the economy develops and becomes urbanized or sets to move towards attaining economic targets such as Vision 2030, the use of oil is likely to increase. Therefore, ways to substitute or economize oil need to be found.

Industrial and commercial sectors

The industrial sector encompasses manufacturing, forestry, construction and other commercial activities. Industrial sector activities consumed about 11 per cent of total oil demand in 2006. Industrial and commercial sectors' demand has ranged between about 11 per cent and 13 per cent of total petroleum consumption over the past ten years. Industrial oil demand is sensitive to general economic trends. Fuel use in industrial and commercial sector increased to a record high of 405.9 thousand tonnes in 2006, which is a 12 per cent rise. This was mainly attributed to increased performance in the manufacturing sector.

Agriculture and government

Consumption of petroleum products in agricultural sector dropped

from a record high of 110 thousand tonnes in 1998 to as low as 35 thousands tonnes in 2006. The decline is partially attributed to shifting of large scale farmers from sourcing petroleum fuel supplies directly from oil marketers to retail and pump outlets. The government's consumption declined by over 40 per cent from 58 thousand tonnes in 2005 to 31 thousand tonnes in 2006. The decline is highly attributed to cost containment measures through reduction of high capacity vehicles.

Power generation

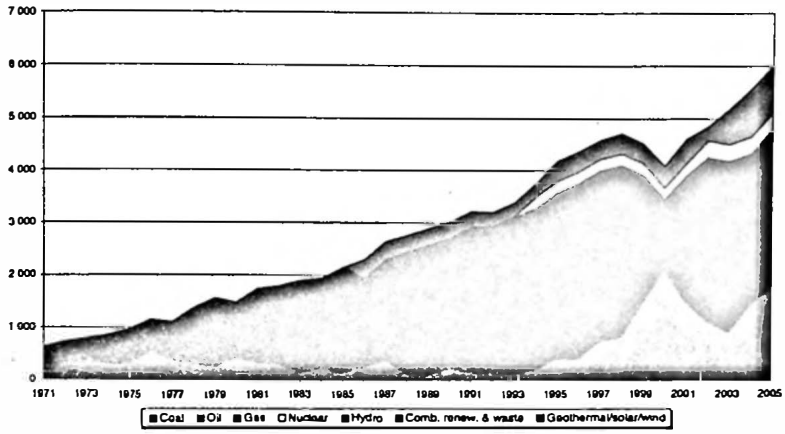
The power sector accounted for about 11 per cent of Kenya's petroleum demand in 2006. Oil demand for power generation has been increasing since 1995 and is at 387 thousand tonnes in 2006 (IEA). The increase can be attributed to the increasing economic activities and electrification level. The demand for oil use in power generation is tied to: relative price of oil and other competing fuels, capacity needs, availability and weather conditions. A steep growth in electricity demand could spur an increase in utility oil use.

In rural electrification programmes, KPLC figures state that 150,000 new connections are made every year. An increasingly prosperous middle class, an electricity penetration of only 15 per cent (2005) and plans to industrialize the economy, all signal an even greater demand for electricity in the country. However, decreased rainfall has led to low water levels in the mainstays of power generation systems. The hydroelectric dams that Kenya increasingly depends on are petroleum dependent and use oil-price sensitive thermal generators to meet the shortfall. As of 2005, 23 per cent of Kenya's energy needs were met through such diesel-powered generators. Ministry of Energy projections then showed that these generators provided 34.5 per cent of the energy requirements in 2007. Figure 4.5 shows evolution of electricity generation by fuel mix, between 1971 and 2005, with hydro power dominating in the mix.

Transport sector

The transport sector encompasses highway, air, rail, marine and military transportation. This sector is the largest oil user, accounting for almost 50 per cent of the nation's total oil consumption in 2005. The factors influencing transport demands are: total number of vehicles, fleet mix, fleet fuel efficiency, miles travelled by total vehicles and replacement rate of old vehicles with new ones. However, other factors do affect the demand for petroleum products consumption in transportation

Figure 4.5: Evolution of electricity generation by fuel, 1971-2005



Source: International Energy Agencies Energy Statistics, 2006

sectors such as personal income, changes in GDP, driving culture and demographic patterns. Over 70 per cent of transport sector's oil demand is consumed by motor vehicle (tracks, cars and buses), 25 per cent by aircraft and the remainder is split between rail and marine transport (KNBS, 2006). Clearly, a factor that is primary to consumption growth is car ownership changes and usage. Achieving reduction in transportation sector demand is like hitting a moving target because of continuing growth in transportation demand. In addition, figures from the Registrar of Motor Vehicles in 2006 indicate there were 12,000 new cars registered every month. With expected relative growth in the size of the transport sector in future, the economy would be expected to become more oil-dependent.

As the economy develops and becomes urbanized, the use of oil will likely increase. Therefore, some partial evidence of sectoral oil intensity[4] can be sought by establishing the correlation between vehicle ownership, degree of urbanization and GDP per capita. Theoretically, as the ratio of vehicles owned per capita to GDP per capita increases, the use of petroleum products would be expected to increase relative to GDP, so as to generate some positive relationship between oil intensity and vehicle ownership relative to GDP. In addition, as the proportion of population living in towns increases, the use of oil-related energy is expected to increase, so that a positive relation will be expected. Table

[4] Oil intensity measured as barrels of oil consumed per unit of Gross Domestic Product, is one measure of the economy's vulnerability to oil disruptions.

Table 4.3: Regression of oil intensity on vehicle per 1,000 population, GDP per capita and on percentage of population urbanized (1975-2005)

Dependent Variable: LOINT				
Method: Least Squares				
Date: 05/30/08 Time: 15:37				
Sample: 1975 2005				
Included observations: 31				
Variable	Coefficient	Std. error	t-statistic	Prob.
C	11.64383	0.650315	17.90490	0.0000
LPURB	-1.221636	0.399751	-3.055993	0.0050
LRGDP	-0.049264	0.096248	-0.511849	0.6129
LMV	0.549024	0.126471	4.341119	0.0002
R-squared	0.871595	Mean dependent var		8.940342
Adjusted R-squared	0.857328	S.D. dependent var		0.141781
S.E. of regression	0.053553	Akaike info criterion		-2.896360
Sum squared resid	0.077435	Schwarz criterion		-2.711330
Log likelihood	48.89358	F-statistic		61.09068
Durbin-Watson stat	1.304818	Prob(F-statistic)		0.000000

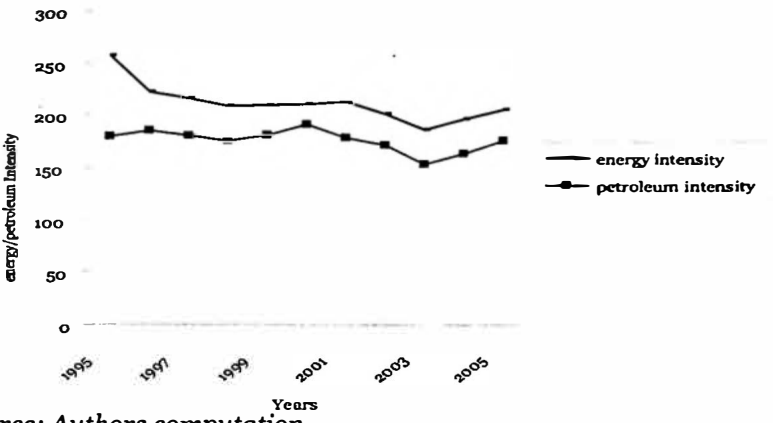
4.3 shows a regression result of oil intensity (which is indicative of oil vulnerability) on the vehicle ownership per thousand population, degree of urbanization and GDP per capita for the period 1975-2006.

The regression result shows a very strong relationship with squared correlation at 85 per cent, indicating a strong relationship in which both vehicle ownership and urbanization rate are positively and significantly related to oil intensity. However, GDP per capita made no much significant difference to the equation. These results have important implications for future vulnerability. Between 1975 and 2005, the urbanization rate has been increasing steadily and is likely to continue increasing; this will increase oil intensity and vulnerability. Similarly, over the period, the increase in vehicle ownership has been on an upward trend and will continue to increase, hence increasing further oil intensity and vulnerability.

4.7 Energy and Petroleum Intensities of Kenyan Economy

Energy intensity is an overall measure of how much energy is used to produce a unit of economic output in a country or a sector. Energy literature posits that a key factor that relates to oil vulnerability is energy

Figure 4.6: Energy and petroleum intensity 1995-2005



Source: Authors computation

intensity. The theory states that for a given level of oil fuel dependence, the higher the energy intensity, the greater the oil vulnerability (Figure 4.6).

The total energy and petroleum intensities indicate that the share of total petroleum products, measured as total petroleum consumption to GDP, fell between 1995 and 2003, but rose steadily between 2003 and 2005. This is insignificant. However, continued economic growth in Kenya is expected to give rise to further increases in the absolute levels of oil requirements. Even as the relative importance of oil to output continues to show steady decline in the periods and as the oil intensity of economic output continues to decline in Kenya, the reality remains that oil intensity will never reach 'zero'. This implies that further economic growth will over the foreseeable future lead to some modest increase in oil consumption and intensity.

4.8 Fuel Diversification

Diversification among fuels is a major strategy for reducing vulnerability and the risks of overall dependency. Kenya's energy supply is dominated by five types of energy generation: that is, petroleum products, coal, hydro, renewable energy and biomass. If Kenya is to use all five of these sources equally (assuming they are ultimately interchangeable in use), then the diversification index would simply be:

$Hfuel=5(1/5)2 = 0.20$

Table 4.4: Energy concentration by fuel

	X^2_i (square of the fractions)					$\sum X^2_i$
	Oil & PP	Coal	Hydro	Geothermal and solar	Biomass and waste	Total
2003	0.02631	0.000013	0.0003143	0.001837122	0.598455785	0.62693
2005	0.041743	0.000014	0.0002198	0.001887988	0.538240645	0.58211

Source: Author's computation

However, these sources of energy are not used in equal proportion, and the analysis shows that despite efforts to diversify, Kenya is still overly dependent on petroleum products (in modern primary energy). Table 4.4 shows the measurement of the relative level of diversification among fuel types. The larger the diversification index, the less diversified is the energy mix.

The above fuel diversification index shows that, in modern energy, Kenya uses significantly more petroleum products than other energy sources. Therefore, the net result is that the diversification index significantly worsens. To reduce the fuel diversification index to 0.29– the world's average–Kenya would have to make capacity addition in hydro, geothermal and other renewable energy without increasing oil consumption. However, at the current level of increased fossil fuel consumption and slow pace of exploitation of hydro and geothermal potentials, it seems unlikely that Kenya can substitute perfectly for oil in the future.

4.9 Indicators of Crude Import Diversity and Supply Concentrations

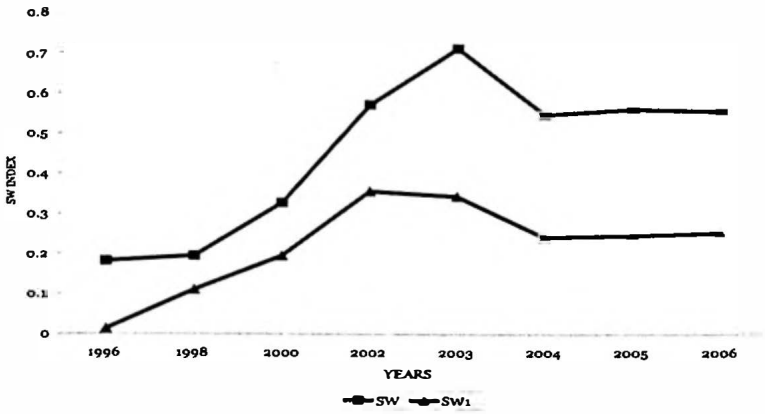
The study adopted two sets of indicators to analyse vulnerability situations. These are Shannon-Weiner index and Hirschmann-Herfindahl index.

Shannon-Weiner Index (SW)

Shannon-Weiner index was considered for two stages; that is, the traditional SW index where political stability factors are not considered, and SW1 where political stability[5] associated with producer countries are duly accounted for. From the data computed, it emerges that between

[5] The used index of political stability and violence absence is provided in the context of the 'worldwide governance indicators' by the World Bank. This index ranges from 0 denoting low political risk to 1 denoting high political risk.

Figure 4.7: Shannon-Weiner Index under two scenarios



Source: Authors calculations based on import data

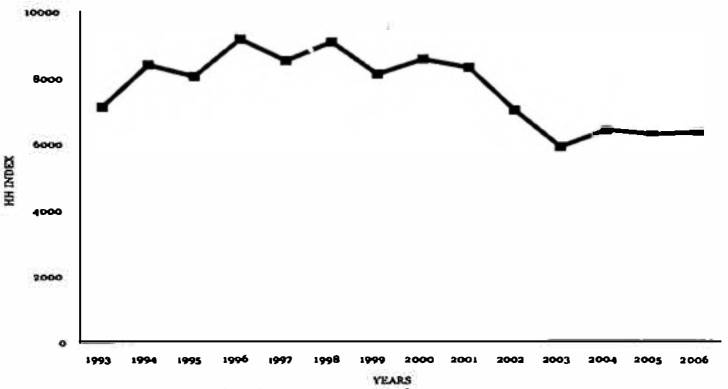
1996 and 2006, the degree of diversification achieved by Kenya is not impressive, especially between 2002 and 2006 (Figure 4.7). Kenya made little attempt to diversify producer countries; the index settles at very low value (below one).

When political stability is not factored, the supply diversity seems better albeit marginal. However, calculating results on sole consideration of import source diversity while excluding international political situation of the export country may be insufficient to reveal the true vulnerability of supply and, against this, the analysis factored political stability of Kenya's supply and the results showed that the index became lower, indicating a deteriorating security of supply. Introducing risk measurements of exporting countries reduces the original index most significantly. The implication of this fall in diversity is an increase in insecurity, as the supply becomes more confined to few supply sources, which have similar political risk factors.

Other factors that have considerably affected the index is the number of supply countries. Kenya has been depending on few suppliers and moreso countries that share a similar level of political risk.

From Figure 4.7, it is apparent that Kenya's index lies below 1, indicating a system that is not diversified (highly concentrated) and dependent on few sources of supplier, to an extensive degree that would clearly threaten supply security in an event of any sustained interruption. Therefore, the index provides indications that can have significant policy implications, and guides the identification of new measures for mitigating supply vulnerability.

Figure 4.8: The Herfindahl-Hirschman Index



Source: Authors calculations based on imports

Hirschmann-Herfindahl index

From Figure 4.8 analysis, the evolution of diversity can be broken down to examine the suppliers' countries and concentration. Oil supply in Kenya is increasingly dominated by fewer suppliers who are highly concentrated in the gulf region. The supplier countries were reduced literally to two, that is Saudi Arabia and UAE from 2004 to 2007. This is demonstrated by stable but high HH index from 2004 to 2006. With HH index ranging from 5,862 to 9,166 between 1993 and 2006; it is clear that Kenya has a high concentration of supply. The results obtained using the HHI are consistent with those obtained using Shannon-Weiner index. The results presented by both indices generate increased confidence about the quantitative conclusions drawn by the analysis.

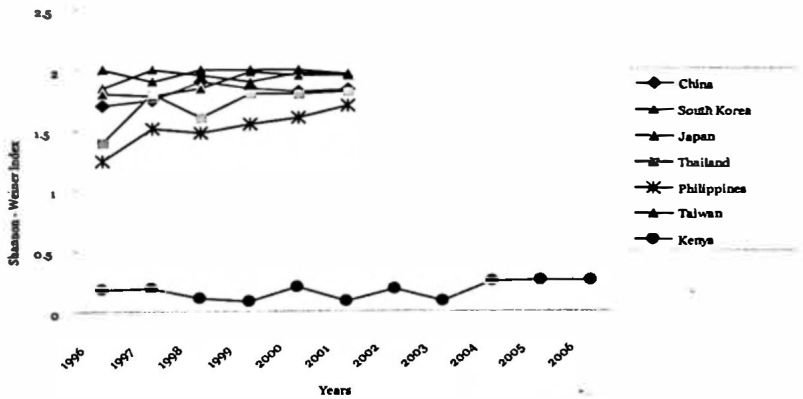
4.9.1 Oil supply security and diversification

The degree of crude supply security and import diversification for Kenya is relatively weak. A close comparison can be made between Kenya and Philippines, whose SW index was lower than 1.50 in 1992 but has since, through crude supply diversity, achieved almost near total diversification by 2001 (Figure 4.9). The import diversity for all the countries being compared shows substantial changes. However, Kenya's diversity index still registered a low index of 0.56 by 2006, a mark which most comparator countries had achieved far above by 1990. Such low level index indicates a system that is highly concentrated and

dependent on few sources of the supplier, to an extensive degree that would clearly threaten supply security in an event of any sustained interruption.

Oil supply in Kenya is increasingly dominated by few suppliers who are concentrated in the gulf region. More so, the worrisome aspect is that the supply pattern is characterized by single supplier commanding huge market share of supply. Between 2004 and 2007, the supplier countries were reduced to only two (Saudi Arabia and UAE) with UAE commanding over 75 per cent of total supply. Contrastingly, the comparator countries have diversified their supply over the years, with a good number of them sourcing their supply from African countries such as Nigeria, Angola, Equatorial Guinea, Asian Pacific as well as Middle East countries. Their diversification capability was boosted by modern technology refineries that facilitate refining of high sulphur crude from some African producers. However, Kenya's ability to refine high sulphur crude is constrained by lack of desulphurization facility at Kenya petroleum refinery plant in Mombasa.

Figure 4.9: Indicators of crude import diversity for Kenya and six Asian countries: A Shannon-Weiner index approach



Source: Ssu–Li Chang and Yen–Yin Chen (2002)

5. Conclusions and Policy Recommendations

5.1 Conclusions

The vulnerability of the oil market and supply to Kenya is linked to a large number of risk factors and uncertainty related to physical disruption and price volatility. Therefore, Kenya must reply with strong policies.

This study analyses Kenya's oil vulnerability levels and assesses policies that are in place to address these concerns. Critical analysis of all indicators shows that Kenya is highly vulnerable and does not have concrete proactive policy measures to address vulnerability issues. The first factor explaining Kenya's high oil vulnerability is her total dependence on imported oil, since her import dependency is constrained by domestic resource endowment of hydrocarbons. It appears Kenya will continue to depend on oil imports in the foreseeable future.

The second factor explaining high oil vulnerability in Kenya is its high dependence on oil as a source of primary energy, while the third factor is high regional import dependence and import concentration. Combining these factors gives an overall view of the situation in Kenya. The analysis shows that:

- Oil fuel dependence and diversity has not changed substantially over the years and substantial changes are unlikely in the medium term
- There are few strategies in place to minimize vulnerability problem

Two features characterize Kenya's oil supply: lack of diversity and high dependence on oil as key primary energy. In addition, the import is extremely concentrated and the main oil suppliers are from the politically volatile Gulf region and countries with comparable political stability index. Therefore, from the analysis, Kenya is vulnerable to the consequences of peak oil induced shock to the global economy.

From the study, the level of vulnerability is unlikely to reduce in the foreseeable future, given the likely increase in absolute level of oil requirements. However, this extreme value of vulnerability is partially

offset by its lower total oil intensity; although this may actually increase as Kenya experiences further development. In future, there is little prospect that Kenya can reduce her import dependence on oil.

Conclusively, there is a serious problem of adjusting to the present and potential future oil shocks and supply disruptions in Kenya. There would appear to be no specific policies that could substantially reduce Kenya's vulnerability.

5.2 Policy Recommendations

The concept of vulnerability, which highlights the potential to sustain future shocks described by key indicators in Kenya, can serve to highlight the main areas for pragmatic energy policy recommendations. There are a wide range of tools required to increase resilience to short, medium and long term shocks at national level.

Kenya's energy policies need to explore key strategies in order to alleviate national vulnerability to oil crisis. There is need to manage the national demand for petroleum products by tapping into the potential energy savings that exist in the major energy intensive sectors (transport, commercial, industrial and domestic). A policy strategy to reduce intensity and develop the potential for greater efficiency needs to be in place. This will aim at weakening the link between GDP growth and the growth in oil demand. Therefore, strategies of making energy conservation a priority with the ultimate objective of reducing consumption need to be incorporated at most national level activities. This includes improving efficiency of fossil fuel power plants, biofuels, and adoption of micro-generation technologies.

It is essential to manage external supplies by initiating dialogue with neighbouring and distant producing countries within Africa as well as diversifying crude oil supply source within Gulf producing countries by reducing the market share commanded by a single country. As a lesson from China and South Korea, Kenya needs policy measures that secure oil imports by deepening political and economic ties with producer states and strengthening bilateral relations through reciprocal investments in downstream oil sectors.

The policy focus for the key oil intensive sectors should be in place in the transport sector (which is 100% dependent on the oil market). There is need to have tax laws favouring fuel efficiency, improved traffic management, more funding for research and development in the field of

alternative fuels, vehicle tolls in the cities and lastly, promotion of public transport. Also, improving vehicular and system operation efficiencies in the short-run are effective strategies against the economic costs of oil dependence.

Effective partnership between public and private enterprises should be fast tracked by building more LPG storage facilities, making cooking gas more readily available in the domestic markets and reducing the cost of LPG. This will also induce conservation of environment by weaning most households from unsustainable use of wood fuel/biomass.

Measures to strengthen preparedness in emergency situation are required in Kenya. From this standpoint, what is essential is stockpiling systems that provide an effective option to cope with availability and higher oil prices. Against this, strategic petroleum reserve should be adopted as an effective measure against temporary supply interruption. The actions of China and other countries highlight their willingness to take pro-active measures to address vulnerability concerns and their recognition of the urgency surrounding this action. Kenya needs to consider similar measures.

Hydropower and geothermal power should be encouraged as a valuable policy option to reduce oil dependence. Hydro and geothermal are independent of the price of oil and can act as direct substitutes for the use of more hydrocarbons for power generation. Policies aimed at promoting small and large hydro schemes should be actively encouraged as part of fuel diversification in any future power sector expansion plan.

Natural gas has not yet penetrated into Kenya, but it is worth positioning for the exploitation of Tanzania's and Mozambique's discoveries. This seems like an attractive option that can boost Kenya's primary energy mix. Kenya's oil requirements are comparatively small in an international context. However, in the event of a global shortage, Kenya should consider contracting National Oil Companies (NOCs) in oil producing countries that continue to have a surplus of production relative to their domestic requirements. A number of bilateral agreements of this nature could be put in place as options to be managed by NOCK, and established as binding treaties between Kenya and the supplying countries.

Additionally, support for the production of biofuel should be encouraged as a modest measure to provide alternative fuel supplies. The current initiative of promoting production of Jatropha as a source

of biofuel is encouraging, and Kenya needs to fast track the initiative and also pursue bioethanol production.

There is need for policies that recognize the strategic importance of energy research and development (R&D) and security and use it as an instrument for the expansion of the energy supply portfolio and for the reduction of security and environmental risks associated with fossil fuel dominance of the nation's primary energy. The R&D portfolio should use incentive-based mechanisms and emphasize several key technology areas, including renewable energy, energy efficiency, carbon capture and sequestration.

Finally, regional cooperation in the provision of energy services should be increased to improve Kenya's energy mix. Cost effective regional energy supply options exist for Kenya, such as joining East African power pool.

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Appendix

Table 1: Oil intensity, 1975 to 2005

Years	Oil intensity
1975	9,725
1976	10,845
1977	10,237
1978	9,786
1979	9,222
1980	9,356
1981	8,550
1982	7,917
1983	7,205
1984	7,644
1985	7,403
1986	7,303
1987	7,611
1988	7,095
1989	7,075
1990	6,879
1991	6,504
1992	6,871
1993	6,798
1994	7,286
1995	7,180
1996	7,438
1997	7,220
1998	7,067
1999	7,264
2000	7,646
2001	7,176
2002	6,898
2003	6,183
2004	6,582
2005	7,111

Oil intensity is shown as BTU per US$ in 2000 values

Source: International Energy Agencies (IEA)

Table 2: Vehicle ownership and urbanization, 1975-2005

Years	% Urbanized	Motor vehicle/ 1000 pop.	GDP per-capita
1975	12.6	14.8	1,533
1976	13.1	14.5	1,846
1977	13.7	14.7	2,281
1978	14.2	14.9	2,441
1979	14.8	14.8	2,577
1980	15.2	15.0	2,810
1981	15.4	14.7	3,145
1982	15.6	14.3	3,414
1983	15.7	13.9	3,683
1984	15.9	14.2	3,955
1985	16.2	14.4	4,389
1986	16.5	13.9	4,902
1987	16.7	14.2	5,192
1988	17.0	14.6	5,792
1989	17.2	14.9	6,892
1990	17.3	14.4	7,562
1991	17.4	14.6	8,334
1992	17.5	15.7	9,284
1993	17.6	15.8	11,054
1994	17.7	15.3	12,754
1995	17.8	15.0	14,308
1996	17.9	17.0	17,096
1997	18.1	17.3	19,788
1998	18.2	19.1	21,267
1999	18.4	19.5	22,208
2000	18.9	19.4	22,943
2001	19.4	19.5	24,902
2002	20.0	19.8	31,828
2003	20.5	20.2	31,825
2004	20.8	20.8	32,457
2005	21.0	21.3	33,476

Source: Kenya National Bureau of Statistics (KNBS)

Table 3: Shares of various petroleum products in total consumption 2001-2006

Product/Year	2001	2002	2003	2004	2005	2006
Liquefied petroleum gas	35.6	40.5	40.9	41.7	49.4	64.6
Gasoline (MSP and MSR)	374.3	365.8	327.9	326.4	337.7	363.4
Aviation spirit	2.4	1.8	1.5	1.8	2	2
Jet/Turbo fuel	417.3	470.2	487.3	521.1	559.1	594.7
Illumination kerosene	306.1	273.6	190	236.1	307	287
Light diesel oil	663.7	627.3	649.6	789.4	892.4	1030.6
Heavy diesel oil	27.7	28	24.4	25.2	25.5	41.1
Fuel oil	558.1	498.7	407	432.8	546.7	665
Total	2385	2306	2129	2374	2716	3048

Source: Statistical Abstract (Kenya)

Table 4: Energy concentration by fuel (2003 and 2005)

		2005		2003		
Fuel		Fraction of total	Square of fraction		Fraction of total	Square of fraction
Coal	66	0.003763472	1.41637E-05	57	0.003608737	1.3023E-05
Oil and PP	3583	0.204310886	0.041742938	2562	0.162203229	0.026309887
Hydro	260	0.014825797	0.000219804	280	0.017727129	0.000314251
Geothermal, solar etc						
762	0.043450989	0.001887988	677	0.042861665	0.001837122	
Biomass and waste	12866	0.733648857	0.538240645	12219	0.77359924	0.598455785
	17537		0.582105539	15795		0.626930068

Source: Author's computation

Table 5: Imports of crude oil by country of origin (tonnes)

Source	1993	1994	1995	1996	1997	1998	1999	2000
Saudi Arabia	161791		29332		52553		54,180	73,065
UAE	1640009	1833050	1428696	1515710	1541134	1596151	1,605,897	1,800,662
Kuwait			59654	68019			49,850	0
Iran	160947	176873	79751	1037	79789	82202	79,889	79,721
Oman							0	0 .
Total	1962747	2009923	1597433	1584766	1673476	1678353	1,789,816	1,953,448

	2001	2002	2003	2004	2005	2006	2007
Saudi Arabia	160,514	82,702	324,718	411,190	408,958	425,717	248,530
UAE	1,514,378	1,271,955	1,128,917	1,304,079	1,211,649	1,294,428	1,353,536
Kuwait	0	0	0	0	0	0	0
Iran	0	0	84,630	0	0	0	0
Oman	0	188,823	0	0	0	0	0
Total	1,674,892	1,543,480	1,538,265	1,715,269	1,620,607	1,720,145	1,602,066

Source: International Energy Agencies (IEA)

Table 6: Political stability index of exporting countries

Countries	1996	1998	2000	2002	2003	2004	2005	2006
Iran	-0.69	-0.39	-0.35	-0.82	-1.06	-1.08	-0.15	-1.25
Saudi Arabia	-0.52	-0.08	0.05	-0.47	-0.42	-1.08	-0.71	-0.65
Abu Dhabi	0.74	0.72	0.8	0.8	0.81	0.61	0.58	0.68
Kuwait	0	0.35	0.61	-0.01	-0.01	0.06	0.06	0.28
Qatar	0.33	0.96	1.03	0.67	1	0.91	0.74	0.23
UAE	0.74	0.72	0.8	0.8	0.81	0.61	0.58	0.68

Source: Governance matters III: Governance indicators (1996-2006) and freedom house