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Energy Planning Policies With Environmental Considerations In Nigeria

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Abstract

The last decade has witnessed a fundamental change in the planning process for development in Nigeria. It is now recognized that the dimension of environment protection is of vital importance for sustainable development. From the comparative survey of available energy planning models, it was found that the environmental considerations are limited only to estimating the pollution load, thus sending false price signals to the technology market and leading to environmentally distorted policy decisions. The main focus of this research is a methodology for integrated energy sector planning, policy impact assessment, and policy mix analysis, incorporating the impact of environmental externality cost of energy supply and use into the planning process. The model aims at determining the least cost energy planning policy path for Nigeria with the least environmental damage.

Keywords: ***Energy Policy, Externality, Nigeria***

Introduction

The policy for planning the use of energy has been of great concern to Nigeria. In this research, we provide a useful comprehensive and time saving methodology for integrated energy sector planning and policy mix impact assessments. The technical, economic and environmental aspects of the energy system planning are integrated to formulate a model, based on linear programming approach (LP) taking into account the environmental concerns. The model's validity as an efficient policy analysis tool to find out the optimal energy path for the country over the next 25 years was proved by applying it on Nigeria's energy sector. The model with its complexity and size is solved in less than five minutes on a 486 personal computer.

Methodology and Model Description

The proposed model is economy driven and is an optimization model using the LP approach to formulate the energy system planning task. Many models of this type have been developed, among them the well known multi-period models such as EFOM (Finon, 1976), TESOM (Marcuse and Boden, 1976), MARKAL (Fishbone, 1979) and MESNA (Stocks and Musgrove, 1984).

The proposed model belongs to the multi-period LP family of models, however, it differs from the above models in many aspects, namely: the purpose, the scope, the structure and the size. EFOM was designed specially to serve the French national energy planning and was later adapted to the needs of the European Economic Community. It includes a detailed description of the demand subsystem. TESOM could be used on regional or inter-regional energy analysis. It has been applied to study the optimal implementation mode of new energy technologies, break-even cost of new technologies.

A general view of the energy flow diagram for the suggested energy planning optimization model (termed here by EPOM) is demonstrated in Figure 1. There are two types of decision variables in EPOM: the structural and the operational.

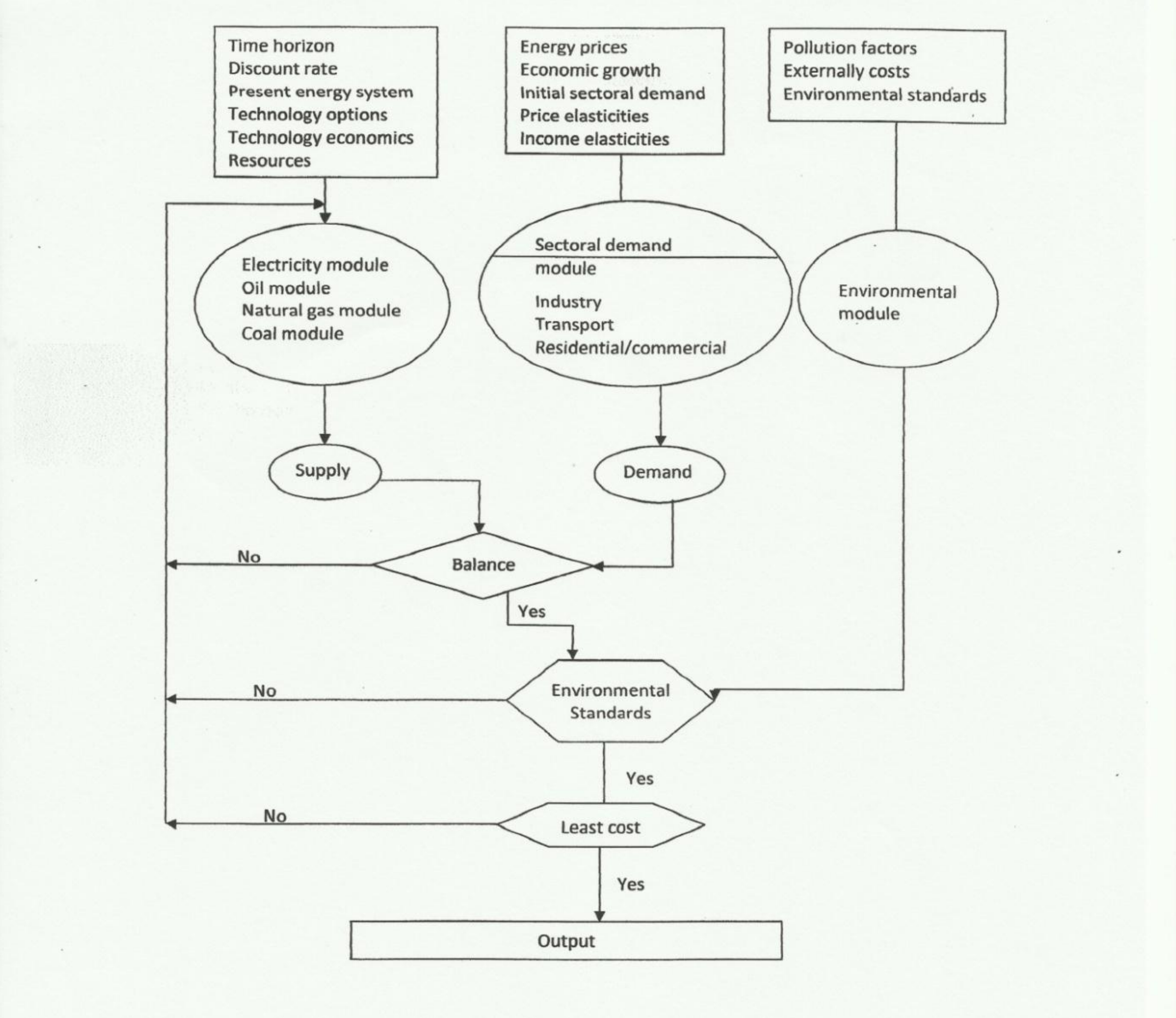

Figure 1: Flow Diagram of EPOM Model

The structural variables represent new capacity expansion of the existing energy system and are associated with investment costs. The operational variables represent the level of activity, or how the capacity of various energy systems is utilized. Thus, these variables represent the energy flows in the energy network. The planning horizon of the model is divided into multi-periods. Each period is represented by a mid-year; and the model variables are expressed in period averages of annual quantities. The model consists of six modules as follows:

1) The electricity Module
2) The Oil Module
3) The Natural Gas Module
4) The Coal Module
5) The Demand Module
6) The Environmental Module

Table 1: Process and Capacity Mix

Power Expansion Capacity Mix	Electricity Generation Mix
Refining Expansion Configuration	Crude Oil Production Policy
NG Transmission Capacity	Refining Output
NG Processing Capacity	Energy Imports/Exports
Coal Mining Capacity	NG Production Capacity
Coal Processing Capacity	Coal Production Policy
Oil Shale Liquidations Capacity	Oil Shale Production Policy
Coal Transportation Capacity	Pollution Level
Coal Port Facilities	Capacity Requirement

The first four modules describe the planning and operation of the energy supply subsystem; each subsystem is characterized by the final energy form it produces. The energy demand module expresses the energy demand of the four sectors of the economy, which should be met by the output of the supply modules. Thus, in each period, the energy demand module links all four modules together. The environmental module deals with the major air pollutants: SO_x, NO_x, particulates and CO_2 resulting from the energy combustion systems. In addition, the impacts of the standard pollution levels are addressed in this module. The models also include the objective function which represents the present worth of total lifecycle costs of the energy system to be minimized over the time horizon. EPOM includes 1268 constraints and 1381 basic variables, integrates all the components impacting the energy system planning and incorporates specifically environmental adders in the objective function to capture the damage to environment.

The main characteristics of EPOM are as follows: the electricity generation options include new technologies i.e. the integrated gasification combined cycle (IGCC), fluidized bed combustion (FBC), solar, thermal, photovoltaic, wind and oil shale combustion. The oil module includes the detailed refining configuration, such as thermal cracking and secondary conversion processes. New technologies such as coal, liquefaction and gasification, oil shale processing are introduced into the model. The four economy sectors considered are; the industrial, residential/commercial/government, transport, and agricultural sectors. Thus EPOM has the following advantages:

1. Suitability to any country;
2. Inclusion of energy-economy interactions;
3. Incorporation of energy-environmental interactions;
4. Consideration of new power generation technologies;
5. Consideration of renewable technologies;
6. Inclusion of downstream refining processes;
7. Accounting for energy import-export;
8. Adopting an integrated energy planning approach;
9. Carrying out policy impact assessment;
10. Carrying out policy mix analysis;
11. Cost and time saving; and
12. Easy to run on 486 personal computers.

Model Implementation and Energy Planning Policies

The complicated energy system expansion planning task being formulated as a linear programming problem is successfully solved by the most efficient software, namely GAM386 (general algebraic modeling system). This package was developed by GAMS Development Corporation in Washington under the direction of Alexander Meeraus (Brooke et al, 1988) and was funded by the World Bank.

The major policy issues and their impact assessments are investigated through 35 policy scenarios. The policy scenario of medium economy rate of 4.5% pa with constant real energy prices is considered as a reference case for comparison. The addressed energy planning policies are:

1) High economy growth (GDP growth 5.5% pa);
2) Medium economy growth (4.5% pa);
3) Low energy growth (3.5% pa);
4) Annual 5% price increase of oil products;
5) Annual 5% price increase of natural gas (NG);
6) Annual 5% price increase of electricity;
7) Annual 5% price increase of coal;
8) Increased crude oil prices (US $28/bbl);
9) Differential price increase of energy forms are 2% pa for crude oil, petroleum products and electricity; 1% pa for nuclear, coal and oil shale;
10) Non-nuclear expansion;
11) Non-coal expansion;
12) Non-renewable expansion;
13) Increased renewable expansion;
14) Reduced transmission/distribution losses to 12%;
15) Efficient power generation (5% improvement);
16) Promotion of hydro skimming expansion;
17) Encouraging the thermal processing;
18) Encouraging the secondary conversion processing;
19) Reduced crude oil production policy by 10%;
20) Non-export of crude oil;
21) Trebling crude oil reserves;
22) Doubling NG reserve;
23) Increasing nuclear reserve by 50%;
24) Encouraging compressed natural gas (CNG) vehicle technology;
25) Non-environmental considerations or controls;
26) Constant externality cost regulation;
27) Applying carbon tax regulation over 5 years;
28) Applying carbon tax regulation over 10 years;
29) Tightening pollution standards by 5%;
30) Promoting energy efficiency in industry;
31) Promoting energy efficiency in the residential/commercial/government sector;
32) Promoting energy efficiency in transport;
33) Promoting energy efficiency in agriculture;
34) Promoting energy efficiency in all economic sectors; and
35) Efficient lighting in the residential sector.

Energy Policy Mix Analysis and Results

EPOM was used to carry out comparative policy impact assessments, with the objective of identifying and ranking the best energy planning policies for Nigeria. The highly recommended energy planning policies which have environmental and economic benefits are combined together in a policy mix to analyze their combined impact. Three policy mix scenarios are investigated and compared with the objective of recommending the best energy planning mix suitable for Egypt. The considered policy mix scenarios are:

Socially Oriented Energy Policy Mix:

This scenario is mainly based on constant real energy prices to relieve the burden on consumers beside the following policies:

a) Promoting energy efficiency in all economic sector;
b) Doubling NG reserve;
c) Tightening pollutions standards by 5%;
d) Efficient lighting in the residential sector;
e) Reduced transmission/distribution losses to 12%;
f) Efficient power generation (5% improvement);
g) Encouraging CNG vehicle technology; and
h) Encouraging the secondary conversion processing;

Price Oriented Energy Policy Mix

This scenario is basically the same as the previous mix, but it applies a moderate price increase of 2% pa to the main energy forms (electricity, oil products and natural gas) to send a reasonable price signal to the consumers to conserve energy.

Self-Oriented Energy Policy Mix

Finally, this scenario is the same as the second policy mix. In addition, it includes the following policies:

a) Increased dependence on domestic energy resources;
b) Reduced dependence on gas oil imports;
c) Encouraged NG exports; and
d) Delayed nuclear and coal expansion programmes.

Conclusion

Nigeria has limited energy resources. It depends mainly on crude oil, natural gas and hydro resources to fulfill the energy demand of all economic sectors. Both the limited nuclear and coal resources are not exploited. There are major uncertainties associated with supply of energy resources, and it is expected that Nigeria may become in the near future an energy importing nation if no new discoveries are added.

At present, petroleum provides the cornerstone of energy supply and meets the bulk of the demand. In the same time, there is increased dependence on natural gas to relieve the pressure on oil reserves.

The management of the energy sector in Nigeria is still polarized; petroleum, natural gas, electricity and nuclear aspects are each managed separately, thereby making it difficult to speak of an overall energy sector in the country. The domestic prices of all energy forms are still below the economic level, except the price of gasoline. In the past, energy in Nigeria was very cheap and becoming even cheaper in real terms. This was reflected in increased energy consumption behavior leading to encouraging the bleeding of valuable limited energy resources.

The investigation of the major energy policy issues through 35 policy scenarios and their comparative policy impact assessments indicate that the present worth of total life cycle costs, investment requirements and pollution load of the energy sector are very sensitive to the economy growth policies. A drop of 1% in the growth rate of the gross domestic product (from 5.5% to 4.5%) corresponds to about 21% reduction in these key factors. The combined cycle (CC) utilizing natural gas and the integrated gasification combined cycle (IGCC) utilizing bituminous coal are found to be the most attractive expansion candidates for power generation, having the largest expansion shares. The CC expansion share ranges between 31% and 62%, while that of IGCC lie between 12% and 37% under all the investigated energy planning policies.

The policy of adopting the secondary conversion processing of heavy atmospheric residue is highly recommended, compared with the thermal processing, preferring the hydro generation. This would allow more export potential of light and middle distillates. On the other hand, the policy of keeping the export of crude oil at a level of 10Mtpy cannot be maintained beyond the next 15 years in most of the energy planning policies. Afterwards, Nigeria is expected to become a crude oil importer if no new discoveries are added.

Natural gas use is highly recommended under all the energy planning policies. The two policies of high economy growth and doubling natural gas reserves have the highest impact on the additional NG transport capacity, demanding about 44% to 58% more expansion capacity than the level of medium economy growth policy. Natural gas exporting is only feasible in the case of doubling the reserve.

The energy policy mix analysis based on the highly recommended policies, indicate that a self-oriented energy policy mix is the best energy path for Nigeria due to its environmental and economic benefits. This policy mix realized the following benefits compared to the reference case:

a) Less demand of energy forms by 6% to 20%;
b) Less power expansion capacity by 30%;
c) Less power transmission capacity by 33%;
d) Less reforming and hydro-treating capacity by 14% to 22%;
e) Less vacuum units and hydrogenating capacity by 10%;
f) Less atmospheric distillation capacity by 17%;
g) More gasoline and kerosene exports by 4%;
h) Less LPG and gas imports by 41% to 68%;
i) Less coal exports by 59% to 64%;
j) Less pollution load by 22% ; and
k) Less life cycle cost by 15%.

The optimal energy path recommended for Nigeria over the next 25 years is the total power system expansion capacity to meet the demand growth of electricity amounts to 15,450MW, with expansion shares of 89% for combined natural gas, 4% for fluidized bed combustion utilizing oil shale, 2% for gas turbine and 5% for renewable. The total additional electricity transmission capacity required for peak load growth amounts to 9220 MVA. The electric sector requirements for NG and oil shale over the next 25 years amount to 292 to 60MT respectively.

It should be noted that researchers are in disagreement over what are the appropriate discount rates to be used in the analysis, especially for valuing the environmental externalities. Utility planners assert that resource selection decisions should be made on the same financial basis, thus applying the discount rate for capital as environmental externality cost for consistence. Environmentalists defend the zero discount rate for externality cost, particularly with respect to human life and health risks, arguing that life in the future is as valuable as present life. But this would place more economic burden on the present generation than the future one. Since the public has lesser willingness to pay for damages far into the future, the discount rate of time preference which reflects the rates at which society is willing to remedy environmental hazards over time.

As far as the mode is concerned, the analysis does not include an investment constraint although capital may be scare in Nigeria. Adding such constraints would make the problem infeasible. Therefore, the right-hand side of available funds has to be relaxed.

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