

**SYSTEMS APPROACH TO
PETROLEUM PROCESS ENGINEERING
AND
ENVIRONMENT
IN NIGERIA**

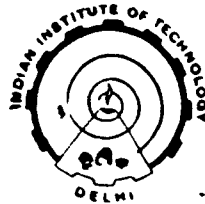
**A POST-DOCTORAL RESEARCH
DOCTOR OF SCIENCE ENGINEERING
in
ELECTRICAL ENGINEERING**

By

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C E R T I F I C A T E

This is to certify that Dr.PAUL CHUKWUNYERE NJOKU, has been holding a POST-DOCTORAL FELLOWSHIP of the Indian Council of Social Science Research in the DEPARTMENT OF ELECTRICAL ENGINEERING at this Institute under my supervision in the area of:

SYSTEMS APPROACH TO PETROLEUM/ENERGY PROCESS ENGINEERING
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since 10th June 1992.

I recommend Dr.PAUL CHUKWUNYERE NJOKU very strongly for suitable placement in an appropriate organisation on the basis of my long and close association with him for the last 9 years during the course of his DOCTORAL and POST-DOCTORAL RESEARCH under my supervision.

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DR. P. S. SATSANGI



D E D I C A T I O N

The Lord is good, His love is eternal for ever. And His faithfulness lasts for ever. We are people He cares for. The flock for which He provides.

To the members of my beloved family. Mr. EVEREST NJOKU, MRS. FIDELIA NJOKU and the family of Col. A.V. MANUEL, Mrs. ASHA MANUEL who have constantly given me love and affection, and have been continuously encouraging and helping me tangibly during my student career.

To my sweet parents, I must express my deep sense of gratitude for their endless love and sacrifice in bringing me up and offering me an excellent opportunity to be educated.

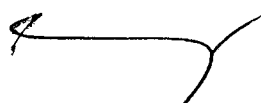
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A B S T R A C T

The research investigations presented in this thesis pertain to the Systems Approach to Petroleum Process Engineering and Environment in Nigeria. The economic development of Nigeria, as of today, is dependent on its oil. Nigeria is a member of the Organization of Petroleum Exporting Countries, its abundant oil resources should be utilised in such a way that the people of Nigeria would benefit most. In this context, the petroleum system of Nigeria would play a significant role in its development.

There have been few studies in which the socioeconomic implications of the petroleum industry have been analysed. The first chapter deals with nature of the petroleum process engineering and environment of Nigeria and relevant literature reviews of petroleum/energy sector models/studies. Dynamics of petroleum/Oil production model, alternative energy sources and energy efficiency technologies have been treated. The relevant systems concepts and techniques and purpose of study have been highlighted.

Chapter 2, reveals the essence of petroleum and environmental engineering impact assessment of Nigeria. Research and development on petroleum refining processes and environment, automotive fuel emission, air quality standard, technology development for alternative automotive fuels have been highlighted. Environmental engineering planning strategies, and policy implications of petroleum regulations have been analysed.

Attempt has been made in chapter 3 to identify the indigenous demand and supply of oil products in Nigeria, the potential for export, the contributions of domestic refineries

and the import of specialised heavy crude on the basis of observed data. In this connection, the interzonal petroleum product flows over the transport network have been modelled through a suitably calibrated and validated gravity model with predictive capability for future target years. The estimate of interzonal flows for future years are on the basis of projections of the demand in future as well as the identified export-import models for assessing domestic supply availabilities.

The current energy scene in Nigeria and its future needs have been analysed in chapter 4. The five major demand sectors considered are : Industry, Agriculture, Transport, Commercial/Services/Government and Residential certain major determinants of demand are identified before making demand projections, In this respect, an attempt is made to build three scenarios. Scenario I is for major sectoral growth remaining unchanged from the trends observed in the past. Scenario II is for the situation where the total energy demand mix may change as the economy adopts higher energy intensity growth path, and Scenario III is for the case where the total energy demand mix may change further as demand management measures are adopted. The petroleum policy alternatives are dealt with in chapter 5. The rationale behind analysing petroleum supply options for three demand scenarios is only to illustrate the importance of energy demand management as an energy policy tool. The methodology of evaluation of the Net Present Value (NPV) is applied to the Nigerian situation, to analyse the implications of the international oil market developments on the Nigerian Petroleum Industry in

particular and on the Nigerian economy in general. Different simulation runs suggest a range of policy options for utilisation of Nigeria's oil reserves. The issues related to potential growth of the Natural Gas utilisation are also highlighted.

The thesis ends with a concluding chapter highlighting the research contributions and delineating future scope of pertinent research work.

NOMENCLATURES (ABBREVIATIONS) USED IN THE THESIS

- C_{ij}^m : unit cost of carrying petroleum product
m from origin i to destination j
- t_{ij}^m : Total flow of commodity m from region i to
region j measured in metric tonnes
- K, A_i, B_j, f : Normalising factors
- t_{ij}^m (i=1,2,...5, j=1,2,...19) Matrix, row sums, column sums
- E_t, E_o, I_t, I_o Quantity of crude oil exported and
imported in t^{th} years and base years
- $E_t/C_t/F_t$: Total electricity/non-coking coal/fuel oil consumption in year t
- K_{it} : Electricity consumption intensity in sub sector i in year t
- $F1t(F2t)$: Freight traffic by rail(road) modes in year t in bnkm
- $P1t(P2t)$: Passenger traffic by rail (road) modes in bpkm
- $E2t$: Energy demand for water transport
- $E4t$: Energy demand for air transport
- ATF : Aviation turbine fuel
- API : American Petroleum Institute
- Gwh : in Giga watt hours
- Ha : in Hectare
- hp : Horse power
- kcal : Kilo Calories
- Kwh : Kilowatt hour
- Mtoe : Million tonnes of oil equivalent
- MMT : Million metric tonnes
- Mtcr : Million tonnes coal equivalent
- Mtpa : Million tonne per annum
- Mw : Mega watt
- Mbd : Million barrels-daily

N : Naira (Nigerian currency)
Tce : Tonnes of coal equivalent
Toe : Tonnes of oil equivalent
CDU : Crude distillation unit
FCC : Fluidized catalytic crackers
FYP : Five Year Plan
GDP : Gross domestic product
HC : Hydro craker Unit
HSD : High speed diesel
IEA : International Energy Agency
IPWH : Industrial Process Water Heating
LDO : Light diesel oil
LPG : Liquefied petroleum gas
NNPC : Nigerian National Petroleum Corporation
OPEC : Organization Of Petroleum Exporting Countries
OECD : Organization for Economic Cooperation & Development
PV : Photo-voltaic
RES : Reference energy systems
RETs : Renewable energy technologies
VDU : Vacuum distillation unit
BGTKM : Billion gross tonne-kilometre
BNTKM : Billion net tonne-kilometre
BPKM : Billion passenger-kilometre
Kgcr : Kilogram of coal replacement
SWHs : Solar water heaters
CFM6 : Total Present Value of costs incurred for New
: Refineries of FCC type coming in stream

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