OPTIMIZATION MODEL FOR CRUDE OIL ALLOCATION IN NIGERIA UNDER GLOBAL ENERGY TRANSITION DYNAMICS

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Overview

This paper proposes a framework within which the Nigeria's produced oil can be optimally deployed to meet the objective of maximizing the total producer and consumer surplus. The imperative of this research is derived against the backdrop that while the oil industry contributes more than 90% of the foreign exchange revenues to the country, it is not clear that the consistent allocation of more oil to export than domestic utilization is an optimal pathway. This comes especially under the pressure imposed by the global energy transition which reckons that Nigeria's oil production will need to decline by 3% per annum to 2050 as its own contribution to meeting the global target of keeping temperature increases under 1.5°C. The profile of Nigeria's refinery capacity build up versus oil exports ratio indicates that the most aggressive refining capacity ramp up occurred between 1979 and 1989. In that decade Nigeria increased her refining capacity by 178% from 160kbpd (1979) to 445kbpd (1989), even as the Country's percentage of oil production dedicated to exports increased rapidly from 76% to 89%. By 2009, 99% of Nigeria's production was dedicated for export with the consequence that domestic refining capacity utilization fell to 7%. To meet domestic demand for refined product, >80% of domestically consumed refined products has been imported in the last decade.With declining upstream oil production, increasing domestic demand for petroleum products, volatile energy prices, and an global energy transition underway, this paper seeks an optimal allocation of Nigeria's oil production under these dynamics.

Methods

We developed the Reference Energy System for crude oil utilization through a network of possible end-uses. This forms the basis for the development of a mathematical programme for the optimal allocation of crude oil. The objective function is developed which is to maximize net benefits which is the difference between "Inflows" and "Outflows". Our "Inflows" are the sum of receipts from export crude oil sales, refined products and domestic sales of refined products. The "Outflows" are constituted of upstream costs, refining costs, distribution costs and "loss" costs. Constraints are identified as the total domestic refining capacity, offshore refining capacity, upstream oil production, and refined petroleum product demand. Within this framework, we generate an optimal future pathway for optimum oil allocation using metrics such as Oil Export/Production ratio, and Import/Demand Ratio.

Results

The mathematical programme which we developed has twenty-four (24) decision variables in the objective function and forty-four (44) constraints. The decision variables are the $\boldsymbol{Q^{O}_{EXP}}$ (quantity of oil for export), $\boldsymbol{Q^{O}_{OFF}}$ (quantity of oil for offshore refining), $\boldsymbol{Q^{O}_{DOM}}$ (quantity of oil for domestic refining), $\boldsymbol{Q^{O}_{IMP}}$ (quantity of oil imported), as well as quantity of products as follows: $\boldsymbol{q^{P}_{EXP}}$ (list of product quantities for export), $\boldsymbol{q^{P}_{IMP}}$ (list of product quantities imported), $\boldsymbol{q^{P}_{DOM}}$ (list of product quantities supplied to domestic from local refineries), and $\boldsymbol{q^{P}_{SWP}}$ (list of product quantities swapped from offshore refineries).

Conclusions

A mathematical programme which forms a framework for the optimal allocation of crude oil to different utilization options to meet petroleum product demand has been formulated. This framework is then applied to optimally allocate produced crude oil to meet increasing domestic demand under the constraints of declining oil production, increasing domestic demand of refined products and refining capacity.

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