TECHNICAL AND ECONOMIC VIABILITY OF PRODUCING MARGINAL OIL FIELDS IN THE NIGER DELTA USING WATER INJECTION

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Overview

Marginal oil fields which are produced conventionally by primary recovery methods are characterised by low reserves and sensitivity to economic changes. One way of economically increasing oil recovery from marginal oil fields is through water injection to maintain pressure and enhance productivity. However, there is a dearth of literature on the technical and economic evaluation of this production technique in the Nigerian marginal oil fields. This study, therefore, investigated the technical and economic feasibility of increased oil recovery from Nigeria's marginal oil fields in the Niger-Delta through water injection. Figure 1 shows the distribution of marginal fields in Nigeria both onshore and offshore.

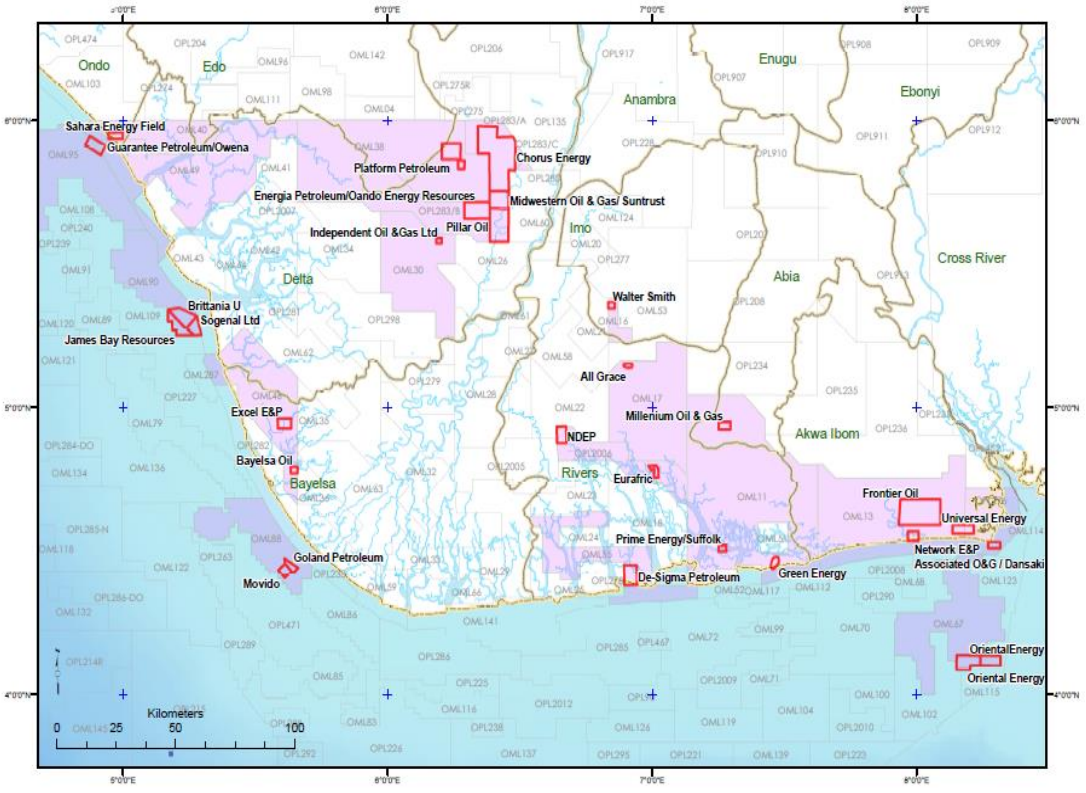

Figure 1: The Map of Marginal fields in Nigeria. Source: The Department of Petroleum Resources.

Methods

The study was anchored on the Least Square Method. Thirteen reservoir parameters: original oil-in-place, permeability, initial water saturation, reservoir pressure, oil viscosity, initial water saturation, reservoir thickness, porosity, API gravity, solution gas oil ratio, water viscosity and residual oil saturation were collected from 136 oil reservoirs producing under water drive and 129 reservoirs producing under solution gas drive. Preliminary screening was done to ascertain the impact of these parameters on oil Recovery Factor (RF). Existing models were used to develop new models adopted for Primary oil Recovery Factor under water drive, solution gas drive and Secondary

oil Recovery Factor under water injection. All the models were validated with data from producing marginal oil fields. Sensitivity Analysis showed Net Present Value (NPV), Internal Rate of Return (IRR) and Profit to Investment Ratio (PIR) were determined at different operating and economic conditions. Impact of RF, discount rate, oil price, development cost, annual operating expenditure and annual production rate on NPV were evaluated and analysed using Monte Carlos Simulation.

Results

Preliminary screening showed oil viscosity ranged between 2.6–7.0$\times 10^{-3}$ Pa-s (2.63-77centipoise, cp) and residual oil saturation of 33.0 – 56.0% had the highest impact on RF for water drive reservoirs, while API gravity of 14^{o} -26^{o}, pressure of 630 – 4837 Psia ($4.344 \times 10^{6} - 3.335 \times 10^{7} N/m^{2}$), solution gas-oil ratio of 82 – 250 scf/stb, oil viscosity and residual oil saturation had the highest impact on RF for solution gas drive reservoirs. Recovery factor values ranged between 58.0 – 68.0% and 14.0 – 64.0% for water and solution gas drive reservoirs respectively. With water injection, recovery factor ranged between 51.0 – 72.0%. The profitability of onshore marginal oil fields under water injection required RF above 20.0%, NPV ranged between $131.54 - $228.25 million, IRR between 36.2- 47.0%, PIR above 0.0 and a discount rate between 10.0-20.0% at oil price above $13/barrel. Profitability for offshore required crude oil prices above $21/barrel so that NPV and IRR would vary between $102 - $198 million and 26.2 -38.2% respectively. Sensitivity analysis showed that discount rate (5.0% - 20.0%), development cost ($198 – $258 million) and oil price ($25 – $55/barrel) had the most impact on NPV.

Conclusions

There is scope for reserves increment from marginal oil fields in the Niger Delta using water injection under the technical and economic conditions as indicated. Therefore, water injection technique should be used to improve recovery in marginal oil fields in the Niger-Delta.

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