MOTIVATING ENHANCED OIL RECOVERY (EOR) PROJECTS IN VIETNAM - A REGULATORY APPROACH

Phan Ngoc Trung[1], Pham Kieu Quang[2], Le Ngoc Anh[2]
[1]*Vietnam Oil and Gas Group*
[2]*Vietnam Petroleum Institute*
Email: trungpn@pvn.vn

Summary

While new oil fields are becoming difficult and expensive to explore, countries and companies have started to look at other unconventional sources to secure hydrocarbon reserves. One of such unconventional sources is oil itself left stranded in the reservoir, which can be recovered by enhanced oil recovery (EOR) methods. Vietnam is now in a similar position as it sees EOR the opportunity to increase the country's oil reserves apart from new projects abroad, where commercial potential might be limited amid a number of technical, economic and regulatory constraints. This paper therefore will look at EOR issues in Vietnam, starting with a discussion about EOR activities, followed by examining the features of an EOR project: which techniques can be used and which economic consequences might prevail. The paper will present the modelling results for a typical project in Vietnam to assess the impact of various policy factors on the project's profitability. Then three steps to improve the fiscal terms for EOR projects are proposed, including both the short-term quick fixes as well as the long-term changes in policies and regulations.

Key words: *Enhanced oil recovery, tertiary recovery, petroleum contracts, oil and gas policy.*

1. Introduction

A young and rising population and rapid economic growth in recent decades mean Vietnam needs enormous energy in general and oil in particular for development. The average GDP growth rate was 7.4% for the period 1990 - 2010, and though slowing down in recent years, is currently at more than 5.5% annually. Energy demand is therefore expected to hit 140 Mtoe in 2035, more than double that of 2010 [1]. Other forecast figures also show rapid increase in oil demand in Vietnam, reaching 64 Mtoe in 2030 [4], nearly four times that of 2012 [2]. The projection for oil production however does not show comparable growth figures. Currently, there are 22 oil fields under production by Vietnam and another 12 fields are being developed. As seen in Figure 1, oil production from discovered domestic fields starts to decline quickly after 2015. Adding output from other new domestic fields can not change the downtrend, only to delay the production peak for another one year to 2016. Then, total oil production in 2025 is around half of that in 2015 [6]. To keep up with the growing local demand, it is important that Vietnam needs to find more oil from other unconventional sources. And EOR is one of the options that Vietnam can consider.

Actually EOR has been high on the agenda for other countries as well as oil and gas majors. This comes from the fact that petroleum is still the dominating fuel - with oil expected to be at 27 - 30% of global energy mix in 2030 [3]. While access to new exploration acreage is difficult and expensive, largest producing fields (which started in the 1970s) are approaching the end of their life time. Oil and gas companies have, therefore, invested significantly in new technologies to get more oil out of current fields, given the recovery factor for petroleum remains just around 35% [5]. Others estimate that if oil recovery factor (Oil recovery factor - ORF or percent of the technically-recoverable out of in-place oil) improves by 1%, the world conventional oil reserves would increase by 88 billion barrels - or three times the current annual production [3]. EOR projects were highest at about 500 during the 1980s, but fell

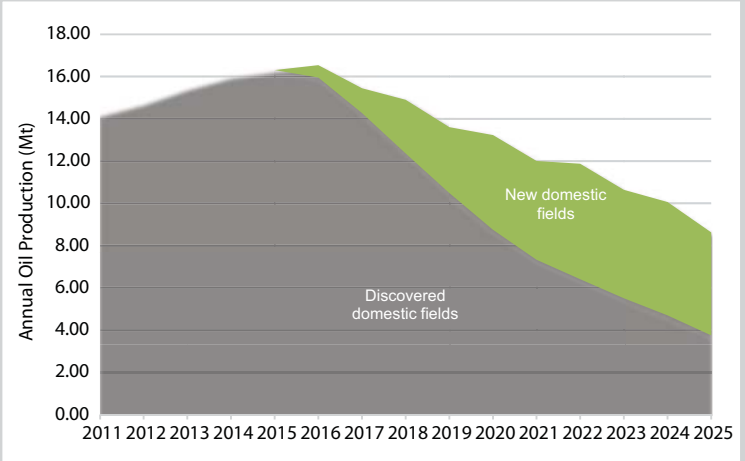

Figure1. *Vietnam annual oil production projections (2011 - 2025) [6]*

gradually to less than 200 in early 2000s, before picking up after 2005. Currently, EOR contributes around 3 million barrels per day (mmbpd) out of 85 mmbpd world daily production [5].

In Vietnam, EOR programmes are currently limited and mostly tested at lab scale. In 2013, there were only two pilot tests for Bach Ho and Rang Dong fields. How to motivate more EOR activities at commercial scale in Vietnam is the purpose of this paper, which will look at the issue from a regulatory perspective. The paper will start with the common definition of EOR to identify which particular exploration and production activities are entitled to the Government's support. Then a brief discussion of the various EOR technologies is mentioned, before the key economic features of an EOR project are analysed. The next section will look at various Government tools, specifically the Petroleum Contract terms, which are used to adjust the incentives for the Contractor(s). A model to calculate an EOR's profitability will be presented, with various cases to assess the impacts of different terms set by the Government. Based on these simulation results, we will identify the key policy levers to incentivise foreign Contractor(s) and propose a long-term pathway to adjust the fiscal regimes so that EOR programmes will become a needed and beneficial activity for both the Contractor(s) and the host Government.

2. EOR definitions and project characteristics

2.1. EOR definitions

To understand and agree on a definition for EOR, it is useful to divide the production process into three phases, based on the nature of energy used to produce oil (Figure 2). Each phase has a unique technical requirement: what and how energy is used to produce oil - from energy within the formation to external sources. This will be the key criteria to define different production phases and in particular EOR. Each phase also has unique economic and business implications - what costs and benefits are there for the Contractor(s), which will influence the decisions of various stakeholders in an EOR project. The timing of these phases are not fixed, with some project (extra heavy oil in Venezuela for example) can move straight into later parts from the beginning. So while this paper will describe each phase in sequence, it should be noted that the nature of extraction energy will decide when and whether EOR is carried out.

The first phase of production - primary recovery, crude oil can be produced by its natural flow or by artificial lift. Natural flow means elastic energy, dissolved gas drive, edge water drive, gas cap drive or potential gravity - all of which normally brings out 5 - 10% of oil in place. As output can drop quickly under natural flow, artificial lift such as gas lift, piston pumping, can be used to recover

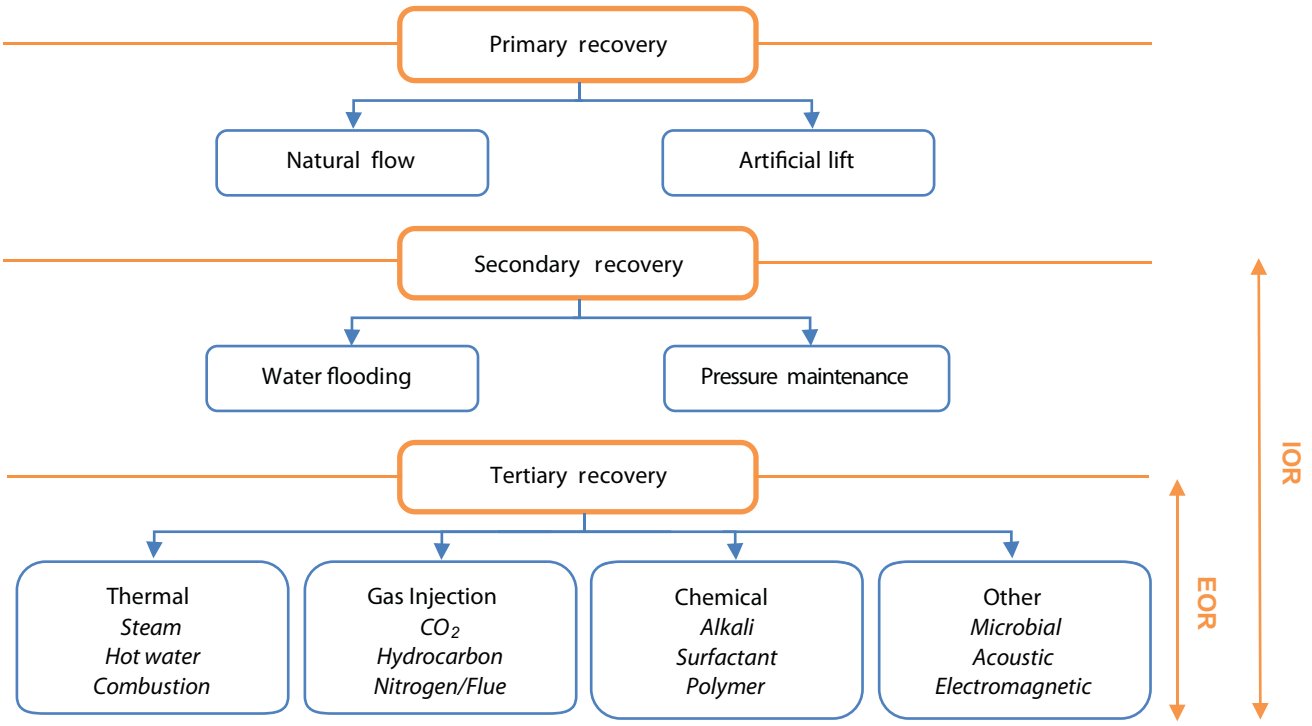

Figure 2. *Production phases and EOR [9]*

more surface oil, pushing the total oil recovery of the Primary Recovery phase up to 15%.

The second phase or secondary recovery involves reservoir pressure maintenance techniques to move oil to producing wellbores. In particular, water or gas (immiscible) flooding and hydrodynamic methods are applied to push oil recovery to 20 - 60%. These methods however can only affect the mobile oil within the reservoir, and there will be a limit to the recovery factor, which depends on the technical details of the field development plan. The field operator will, therefore, try to optimise this second phase to increase the production rate, improve the secondary recovery and consequently the economic efficiency. Both the first and the second phases however only use the energy of the reservoir or external sources without changing the chemical and physical nature of the oil and fluids. Such methods are called conventional oil recovery, and also lead to the third phase or the topic of this paper.

The third phase or tertiary recovery employs more advanced techniques, altering the oil and fluid's indicators such as surface tension, viscosity, and mobility ratio to get more immobile oil out of the reservoir. Techniques including thermal, gas (miscible) injection, chemical and other solutions like microbial or electromagnetic, are expected to push oil recovery rate to 50 - 80%. It should be noted that techniques for the second phase are also used in conjunction with more advanced methods in this tertiary recovery phase.

As shown in Figure 2, EOR are advanced techniques that must be employed in the tertiary recovery phase to produce the immobile oil by changing the chemical and physical characteristics of oil and fluids, which the primary and secondary recovery phases fail to bring out. Improved oil recovery (IOR), another frequently used term, means both methods used in the second and third phases, which involve energy from external sources rather than from the reservoir only. IOR therefore includes EOR, though only EOR methods are the subject of this paper.

Some EOR techniques have actually been deployed in early years, such as steam trials in 1930s or gas injection in 1940s; while on the other hand, latest methods are looking into low-salinity water flooding, unconventional heavy oil or offshore EOR [8]. In general, the oil and gas industry sees the following techniques as modern EOR:

- Gas methods: Carbon dioxide (CO_2), nitrogen (air) or gas injection;
- Thermal methods: Steam injection;
- Chemical and physicochemical methods: Alkali, surfactant, polymer;
- Others: Horizontal drilling with multi-stage hydro fracturing [3].

Thermal and gas are the two dominant methods, accounting for 50% and 45% of global EOR's hydrocarbon production respectively, while chemical techniques contribute the rest 5%. One important reason for this trend is the effects on incremental outputs, with thermal and gas methods can raise oil recovery factor by 15 - 20% and 5 - 10% respectively, while thermal techniques can only push the factor up by 3 - 8% [3]. In practice, choosing which particular EOR methods to use will require considering a number of technical and economic factors for a given field. For example, two major technical factors are the reservoir depth and oil viscosity and the applicability of various EOR methods is shown in Figure 3. High-viscosity oil in North America or the Middle East can be better recovered by the injection of steam to thin the oil, or polymer to thicken the water and improve sweep. Or in oilfields with low viscosity and increasing depth, carbon dioxide can be miscible with oil to reduce residual oil saturation, and therefore improve the recovery rate.

2.2. Project characteristics

Implementing an EOR project is a long and complex process given the advanced nature of the techniques as well as the uncertain nature of the tertiary production

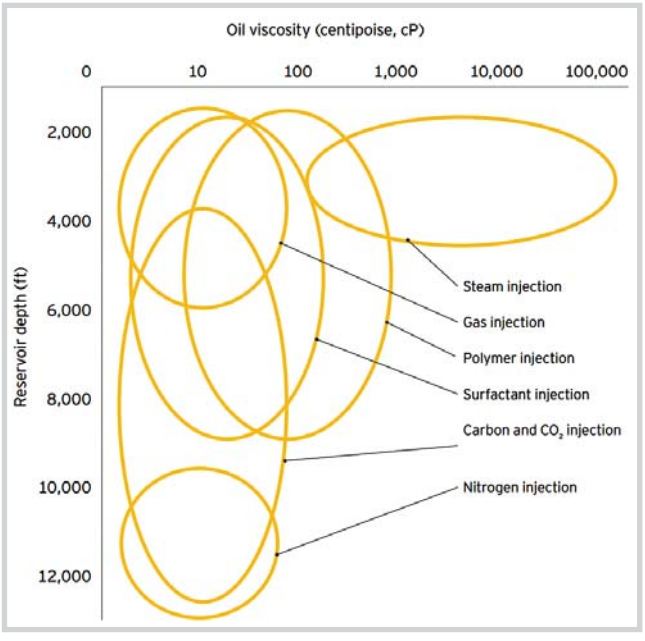

Figure 3. *EOR methods and related technical factors [3]*

phase. The preparation time of an EOR project can be as long as 6 - 10 years before field-scale production begins, with 3 major steps. Firstly, the laboratory testing and design step (1 - 2 years) will involve field screening study, EOR technique selection, reservoir modelling together with geological studies, and importantly the design parameters. Secondly, a pilot test (2 - 4 years) will apply the chosen techniques on a pilot well or field, where reservoir simulation is fine-tuned, while detailed economic models are analysed. Thirdly, a full scale deployment (3 - 5 years) is implemented on selected reservoirs, where the initial response is examined and used to decide later production potential (to be as long as 30 years) [7].

So an EOR project can have a very long lead time before production starts. This implies significant uncertainty and risk in testing and pilot, which might not lead to any large-scale production after a period as long as 6 years. Besides, this means the project's cash flow will concentrate at project-end, so the Contractor(s) might face some financial stress given the high investments needed. On the other hand, EOR project cost is driven by operating costs as shown in Figure 4. So the management and procurement of EOR agents or fluids will be the key in keeping

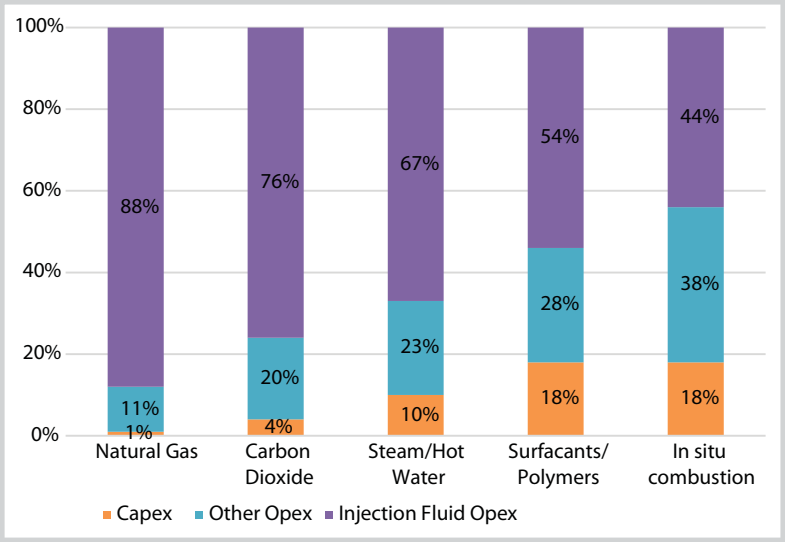

Figure 4. *EOR cost components [7]*

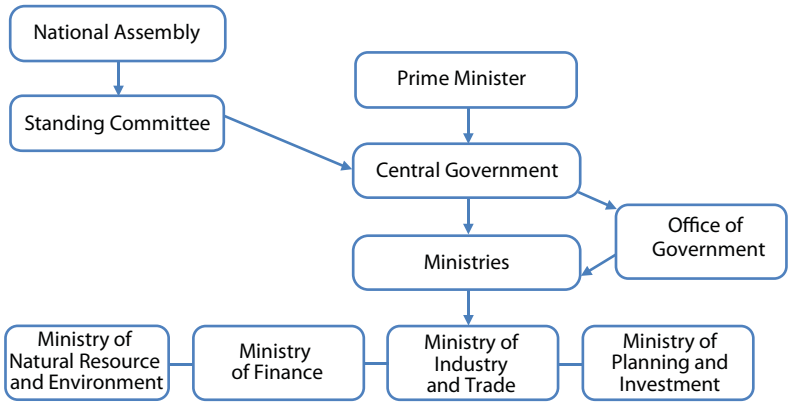

Figure 5. *The regulatory framework and related institutions for oil and gas industry in Vietnam*

the project running smoothly and its costs under control, given possibilities of demand-supply mismatch, constraints from local content requirements, and environmental regulations [7]. As seen on Figure 4, natural gas and carbon dioxide themselves can take up to 88% and 76% respectively of the total cost in related EOR projects. For in situ combustion for example, injection fluids are only 44%, but adding other items, total operation costs still take about 82% of the total costs.

Summing up, the unit production cost for EOR sees a wide range from 20 to 80USD/barrel. EOR projects therefore can be quite costly compared to conventional oil projects whose cost ranges from less than 20USD/barrel to highest at more than 40USD/barrel. EOR can be even more expensive than offshore deepwater, which has maximum production cost around 70USD/barrel. Looking at the higher range for production cost, EOR only ranks after heavy oil bitumen, oil shales and Artic oil [3].

3. Motivating EOR projects

Given the economic and financial challenges, the Government's support is vital to bring EOR projects forward, for the benefits of both the host country and the Contractor(s). Such support can be in a variety of forms under the petroleum regime, which might require considerable time and effort to implement by different institutions. An overview of the regulatory framework for petroleum projects in Vietnam is presented in Figure 5.

Apart from the Constitution which is the highest-level legal document, the key document is the Petroleum Law, which is detailed in a number of related Decrees, and ultimately influences other measures of the host country. Then, there will be various regulations, either by the Ministries or the National Oil Company (NOC), affecting both the technical and economic sides of the projects. Finally, there is the contract between the host government

and the Contractor(s) - the Petroleum Contracts (PC), including terms, conditions, and all the details that are key to the operation and profitability of standard project and subsequent EOR schemes. Therefore, the PC and related tools are important and short-term measures for the Government to motivate EOR projects.

Under the PC, and after royalty, the Contractor(s) will recover project costs from petroleum revenue, with the remaining income to be shared between two parties. However, there will be in fact much more factors, or tools that the Government can use to fine-tune a project's attractiveness (Figure 6).

To assess the current incentives for oil and gas projects in Vietnam, and possible effects on an EOR schemes, this paper will present the simulation results using a financial model of a specific project in Vietnam. The model is constructed in Excel, with inputs including operation and financial assumptions for the projects such as production profile, CAPEX and OPEX, decomissioning cost, ownership structure, oil and gas price (subject to various scenarios of medium and long-term price movements), as well as PC terms; and outputs including Net Present Value (NPV) and Internal Rate of Return (IRR). Basically, the model will show the effects of varying inputs, especially the PC terms, on the project's profitability.

The modelled project (Project A refers to the original project, and Project A(EOR) refers to the EOR scheme) replicates the technical profile of a producing and EOR-potential field in Vietnam. Project A is assumed to start exploration in 1993 and production activities in 1999. The Contractor(s) agrees to move into EOR in 2012 and first incremental output begins in 2015. Detailed assumptions for Project A are presented in Table 1.

The purpose is to measure the attractiveness of current Vietnam's PC: how it is compared to other EOR incentives in neighbouring countries in terms of NPV for the Contractor(s) (using the same project's technical datasets), and how it changes when other factors change. We will then use the findings to propose several policy options and steps to motivate EOR projects in Vietnam.

We start with looking at Vietnam's Petroleum Laws and comparing these with the Malaysian and Indonesian terms for the original project without EOR (Project A). The results show that without investment incentive conditions, the Vietnam's PC under the Petroleum Laws (1993, 2000 and 2008) - though better than that of Malaysia, generates lower NPV for the Contractor(s) compared with the Indonesian. But when investment incentive terms are applied, Project A's NPV is the highest under the case of Vietnam's Petroleum Law 2000 at USD 6,225 million, compared with USD 4,663 million for Malaysia (above-1,000-m-depth incentives) and USD 4,972 million for Indonesia (GR79/2010 regulations).

We then examine how these petroleum contract terms affect the NPV for an EOR project - Project A(EOR) as in our calculation. The results show that Vietnam Petroleum Law 2000 again gives the highest NPV at USD 119.7 million, which is the profit for the foreign Contractor(s) on the EOR programme only. This is slightly higher than the outcome for the Petroleum Law 1993 and that of Indonesia's EOR policies.

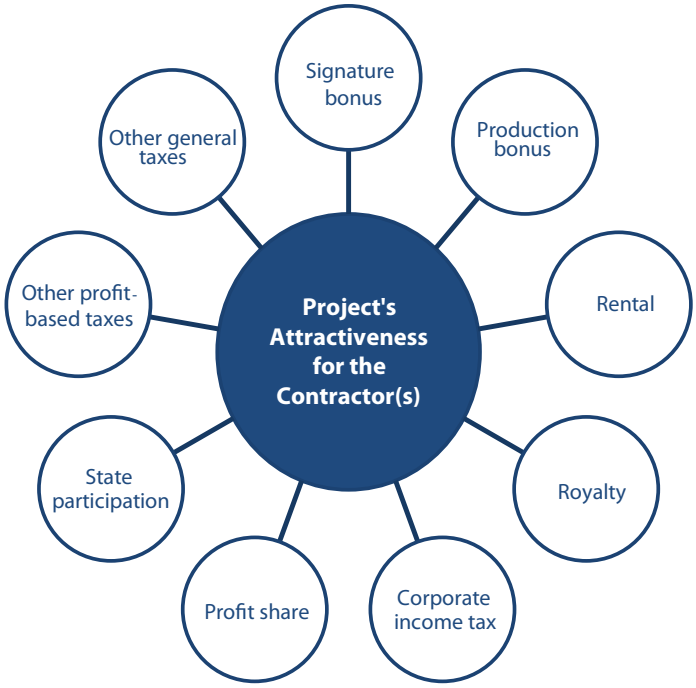

Figure 6. *Factors influencing the project's attractiveness for the Contractor(s)*

Table 1. *Model inputs for Project A*

Items	Project A	Project A (EOR)
Petroleum production (MMboe)	249.74	7.59
- Oil	*239.20*	*7.59*
- Gas	*10.54*	*0.00*
Total costs (USD million)	4,070.95	141.13
- Sunk costs	*674.45*	*0.00*
- CAPEX	*1,232.59*	*125.53*
- OPEX	*2,011.88*	*8.10*
- Decommissioning costs	*152.03*	*7.5*

Therefore, this paper will use the Vietnam Petroleum Law 2000 as the baseline regulation to first construct an EOR incentive schemes for Vietnam and then to assess the impact of various factors on the incentive's attractiveness. Specifically, we refer to the Vietnam Petroleum Law 2000 when constructing the base case for EOR incentive scheme, with key terms as followed:

- Natural resource tax: 4%;
- Export tax: 4%;
- Corporate income tax: 32%;
- Cost recovery rate: 70%;
- Profit share for the Contractor(s): 70%.

We alter several terms to access the impact on project's profitability, in order to come up with a proposed PC structure that is robust to attract an EOR project. The results are presented on Figure 7. It should be noted that the figure is to assess the impact on the project's NPV when altering specific terms in the PC, and the figure will not reflect the relative importance of each term. First, raising the natural resource tax rate will lower the project's profitability but by a small amount. In particular, the project NPV falls 3.6% and 5.4% as natural resource tax rate is up from 4% to 6% and 7% respectively. Similarly, crude oil export tax rate has a negative effect on the project's NPV: pushing NPV down by 12.6% as the tax rate hits 10%. Raising tax rates for EOR activities is not a recommended option but these results can help to calculate the impact of such option, especially when it can be employed with other supporting measures.

The simulation also looks at cost recovery rate, which allows the Contractor(s) to quickly get back money for the amount spent on CAPEX and OPEX. However, the results show that project's NPV only improves slightly, by 0.9% and 1.5%, when cost recovery is lifted from 70% to 80% and 90% respectively. For corporate income tax, we consider two other cases: 32% but with 100% tax waiver for the first profitable year and 50% waiver for the second year; and 28%. The results show that NPV is up by only 1.9% if tax waiver policy is used, but jumps to 7.7% at 28% corporate income tax. The final measure being examined is the profit oil and gas rate for the foreign Contractor(s), which obviously is the direct share among the parties and will considerably influence the project's profitability. The simulation shows that NPV jumps by 9.6% when the Contractor's share is raised from 70% to 75%, and NPV reaches 19.2% when the Contractor(s) receives 80% of profit oil/gas. So apart from policy adjustments, changing profit oil rate is still the direct and powerful measure to determine the profitability of a project from a Contractor's perspective.

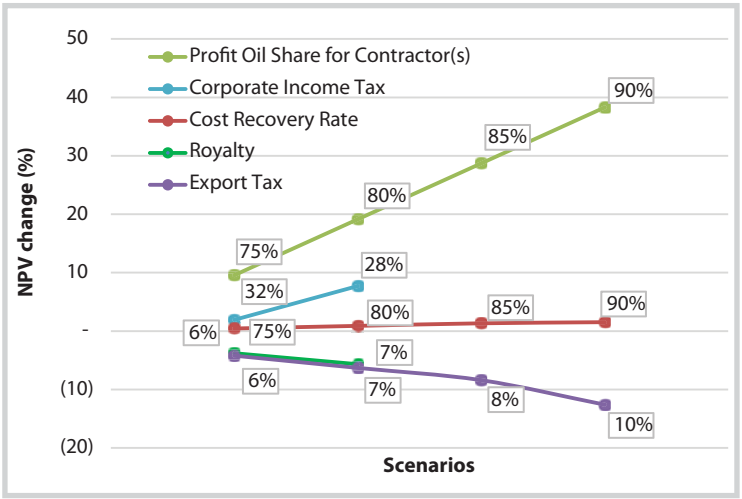

Figure 7. *Sensitivity analysis for Project A (EOR)'s NPV*

4. Conclusion and policy recommendations

The above sections on project economics and fiscal regime simulation show that effective Government policies to motivate EOR activities must address two important issues: long-term commitment of the Contractor(s), and the specific risks for individual projects. First, the Government should design its policies and related petroleum regulations so that the foreign Contractor(s) will focus on the ultimate recovery rate of the field, rather than on the immediate targets or short-term profits. This will help to achieve optimal exploitation of hydrocarbon resources and bring long-term financial rewards to the host Government and foreign Contractor(s). The solutions can include direct measures, such as compulsory life-cycle planning which requires the foreign Contractor(s) to consider and propose EOR programmes. Early planning leads to early assessment and R&D studies, which is not only cost-effective but also provide more and better results for the Contractor(s) when implementing the EOR programmes later in the project. Encouraging long-term commitment in EOR also relates to other indirect measures by the Government. For example, promoting energy security will direct more attention to the indigenous oil and gas resources, where EOR can help to fully recover. Also, emphasising environmental issues

requires sustainable treatment of CO_2, where EOR again can be helpful by capturing CO_2 for the long-term storage. Besides these high-level policies, the Government also needs to employ flexible tools at lower levels to adjust the incentives for various projects due to their respective technical and economic risks.

The paper therefore proposes a 3-step strategy to motivate EOR projects in Vietnam, starting from the short-term measures and ready tools that the Government can use to quickly encourage EOR programmes, to longer-term measures that require lengthy political process but will also be the key to the attractiveness and viability of EOR projects in Vietnam.

Step 1: The Government first adjusts the profit oil and gas rate for EOR projects, to the range of 70 - 90% for the foreign Contractor(s). Besides, Petrovietnam will propose the Government (subject to the Prime Minister's approval) to extend the PC duration as an incentive for the Contractor(s) to continue to strive for more production from the existing fields.

Step 2: The Government then amends the cost recovery and windfall tax for projects signed after 1 Jan 2010. In particular, cost recovery rate is advised to be raised to 75 - 90% while windfall tax will be the same as for investment incentive projects regulated under Decree 100/2009/ND-CP dated 3 November 2009.

Step 3: The Government will seek approval from the National Assembly to amend related tax policies. Specifically, natural resource tax for the incremental production will be at 4 - 7%. Export duty will be at 4 - 10%, again for the incremental production by the EOR project. And finally, the corporate income tax should be adjusted down to 28% for the profit attached to EOR production, and this tax rate will be lifted to 32% once the EOR project has recovered the CAPEX costs.

These adjustments can be made to the current PC Model, or applied to a newly-created EOR PC which is based on but separated from the original PC. The EOR PC then can be designed to fit with the unique technical and economic characteristics of EOR practice. This will have the flexibility advantage for the Government and the Contractor(s) to strike a deal that brings a win-win outcome in a type of programme that is usually costly, risky, and time consuming.

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