Estimating Reserves When Production Curve Forecasts Are Obtained using Probabilistic Approach

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Production Forecasts obtained by Probabilistic Approaches

Obtaining production curves by probabilistic methods can be relevant to:

- Clarification of the main uncertainties;
- Portfolio management;
- Planning.

However, for disclosure purposes, it is necessary that reserve estimates are obtained in accordance with the definitions and rules issued by international bodies and regulators.
Rules for reporting oil and gas reserves

- TARGETS:
  - Standardization;
  - Transparency;
  - Confidence;
  - SEC rules: proper comparison between different companies by investors.

It is necessary that the Reserve’s estimation, for disclosure purposes, considers all requirements established by these rules.

Probabilistic approach

- Petrobras allows both approaches (deterministic and probabilistic);
- In the case of probabilistic approach, the criteria define certain minimum levels needed:
  - 1P (proven): 90%
  - 2P (proven + probable): 50%
  - 3P (proven + probable + possible): 10%
- When probabilistic methods are used, one should be alert to the fact that other requirements must be properly incorporated. Treatment of these items is easier when the deterministic approach is used.
The area of the reservoir considered as Proved includes (1) the area delineated by drilling and defined by fluid contacts, if any, and (2) adjacent undrilled portions of the reservoir that can reasonably be judged as continuous with it and commercially productive on the basis of available geoscience and engineering data.

In the absence of data on fluid contacts, Proved quantities in a reservoir are limited by the lowest known hydrocarbon (LKH) as seen in a well penetration unless otherwise indicated by definitive geoscience, engineering, or performance data. Such definitive information may include pressure gradient analysis and seismic indicators. Seismic data alone may not be sufficient to define fluid contacts for Proved reserves.

Reserves in undeveloped locations may be classified as Proved provided that:
• The locations are in undrilled areas of the reservoir that can be judged with reasonable certainty to be commercially productive.
• Interpretations of available geoscience and engineering data indicate with reasonable certainty that the objective formation is laterally continuous with drilled Proved locations.

For Proved Reserves, the recovery efficiency applied to these reservoirs should be defined based on a range of possibilities supported by analogs and sound engineering judgment considering the characteristics of the Proved area and the applied development program.
**PRMS – Probable and Possible Reserves**

Probable Reserves may be assigned to areas of a reservoir adjacent to Proved where data control or interpretations of available data are less certain. The interpreted reservoir continuity may not meet the reasonable certainty criteria.

Possible Reserves may be assigned to areas of a reservoir adjacent to Probable where data control and interpretations of available data are progressively less certain. Frequently, this may be in areas where geoscience and engineering data are unable to clearly define the area and vertical reservoir limits of commercial production from the reservoir by a defined project.

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**Development Plan – Uncertainty Analysis**

1. Development Plan: Uncertainty Analysis according to Company criteria;

2. Seismic data indicates two separate blocks;

3. Block 1:
   - WOC by drilled well;

4. Block 2:
   - Undrilled;
   - WOC presumed as the same of block 1 by Seismic.

5. Water injection hasn’t yet been tested (pilot). Pilot is scheduled.
**Uncertainty Analysis Production Forecasting**

Production Forecasting from uncertainty analysis:

- Both areas drained (blocks 1 and 2);
- Effectiveness of water injection considered.

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- P10 = 252,33 MMm³
- P50 = 198,61 MMm³
- P90 = 106,84 MMm³

Without any kind of restriction according to PRMS's criteria.

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**Suggested Methodology**

Identifying deterministic runs (approaches Np from uncertainty analysis):

- Geologic Model P50 of base case;
- Geologic Model P50 of lower case.

- Geologic Model P90 of upper case;
- Geologic Model P50 of base case.

Chosen geologic models:

- Geologic Model P10 of base case;
- Geologic Model P50 of upper case.
Suggested Methodology

- Block 2 not considered for Proved, only for 2P and 3P.
- WOC from drilled wells on block 1 and seismic data for block 2;
- Clipped net pay for 1P area;
- For 3P scenario, upper case properties.

Final runs - Reserves

1P 37,6 MMm³  2P 193,13 MMm³  3P 224,6 MMm³
Conclusions

1. The target of the probabilistic production forecasts for project evaluation don’t need to fulfill all the reserves estimate rules;

2. The direct use of P90, P50 and P10 forecasts curves such as 1P, 2P and 3P reserves, can result in reserves incorporation that are not aligned with the rules of the standards (PRMS and others...);

3. The recovery factor of each scenario is important to be checked.
References

- Society of Petroleum Engineers (SPE); World Petroleum Council (WPC); American Association of Petroleum Geologists (AAPG); Society of Petroleum Evaluation Engineers (SPEE). Petroleum Resources Management System (PRMS), 2007;

- Society of Petroleum Engineers (SPE); World Petroleum Council (WPC); American Association of Petroleum Geologists (AAPG); Society of Petroleum Evaluation Engineers (SPEE), Society of Exploration Geophysicists (SEG). Guidelines for Application of the Petroleum Resources Management System, 2011. A;
