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Impact of Production Strategy on Production Forecasting, Energy Demand and Carbon Emissions: Typical Case Study of the Brazilian Pre-Salt

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"This study aims to verify the impact of the selection of the integrated production strategy on the forecast of production, energy demand and carbon emissions, comparing the views of reservoirs and processing of the platform."

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Introduction

This text summarizes the paper published by Hohendorff Filho et al. (2025) which evaluated how the production strategy influences the main decision-making indicators in the development of the production of a Brazilian pre-salt field, considering reservoir and production system models integrated in a single simulation. The results showed the integrated modeling (reservoir, well and processing) was important to evaluate the impact of the selection of the design and management variables of the integrated production strategy, showing the interdependence between the simulated models. The study quantified the impact of production strategy variables in an integrated way, especially those related to the production system. This assessment is important for production forecasting and decision-making support on energy demand and greenhouse gas emissions from oil and gas production and processing.

Problem statement

The oil and gas industry is playing an important role in the energy transition, contributing to a future net zero balance in a number of ways. One way is to reduce greenhouse gas emissions (GHG) from your operations by increasing energy efficiency, reducing flaring, managing methane emissions, and powering your operations with low-carbon or renewable energy sources.

Recent literature presented studies on the minimization of greenhouse gas emissions (mainly CO_2) in production strategy projects, such as: the evaluation of the effect of the CO_2 rate on oil production; the development of tools for emission prediction; and the development of a production inventory model that considers interval uncertainty and carbon emission with time-dependent interval emission. None of these studies evaluated in an integrated manner issues related to the production unit integrated with reservoirs, with a focus on energy efficiency and carbon emissions, quantifying the impact of each project variable within the context of integration, with a methodology applicable to other case studies.

Methodology

The general methodology of the study is composed of the following steps: (1) obtaining the models for assembly and simulation of the integrated case; (2) selection of uncertain parameters and decision variables, and assembly of the set of samples (alternatives); (3) analysis of the statistical data of the reservoir and the production system; and (4) verifying of variables relevant to the objective functions.

The choice of alternative production strategies for the case study is initially based on traditional design variables for production development from the perspective of reservoirs for water injection compared to a base case (S1): number of producer wells (nwp – S3) and injectors (nwi – S4); platform capacity (Cap – S2); and reservoir maintenance pressure (pres – S6&S7). Other non-traditional variables are included in the choice of alternatives in the view of the production system with gas export and/or recycling: platform alternatives for gas recycling (S9); gas turbine-driven compressors (S10); operating pressure of the primary separator (psep – S5&S7); and production control of wells to limit CO2 production (S8).

Application and results

The applied benchmark was UNISIM-IV-2019, which served as the initial basis described in Botechia et al. (2022). The behavior of the reservoir is represented by a zero-dimensional "tank" model. The production line model is described by a simulation of permanent multiphase flow in pipelines based on a non-isothermal model with mass transfer between the liquid and gas phases. The process plant was built using the Peng-Robinson thermodynamic model within a PVT simulator with the possibility of process modeling to represent the behavior of the liquid and gas phases in separators and compressors. The platform's energy demand and CO_2 emission models were based on the work of Hohendorff Filho et al. (2024).

Fig. 1 and 2 present power consumption and CO_2 emission forecasts of the selected production strategies.

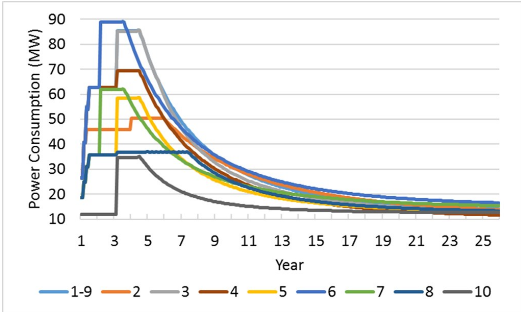

***Figure 1**: Power consumption forecast chart for selected strategies.*

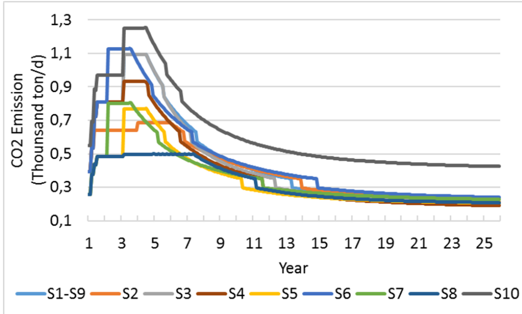

***Figure 2**: CO_2 emission forecast chart of selected strategies.*

Fig. 3 to 6 present tornado plots where combined variables of production strategy with coefficients less than 0.5% are not presented.

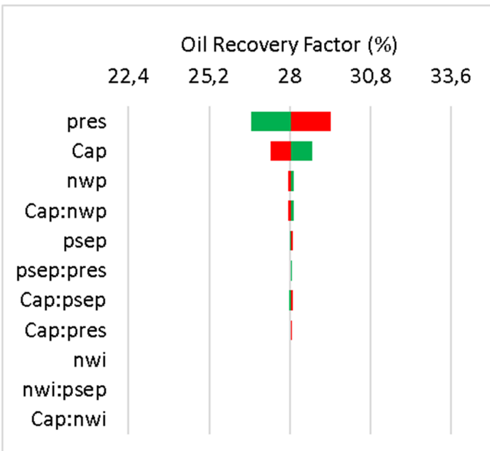

***Figure 3**: Tornado plot of oil recovery factor.*

For the case study analyzed, there is an indication of (1) operating with higher pressure at the inlet of the platform, favoring gas compression (S1xS5), (2) operating with lower reservoir maintenance pressure, allowing depletion (S1xS6), and (3) evaluating the optimization of the processing plant, as it is relevant in the field development project.

In general, the results showed that the choice of production strategy related to design variables (especially platform

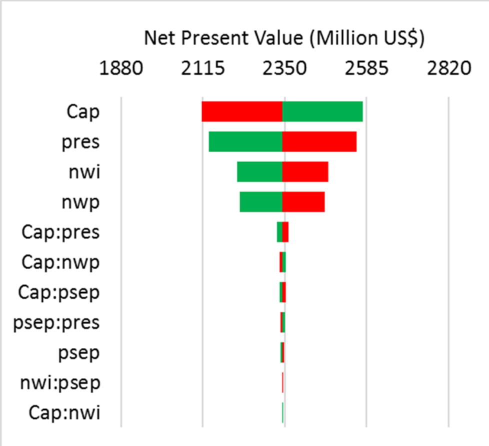

***Figure 4**: Tornado plot of financial return.*

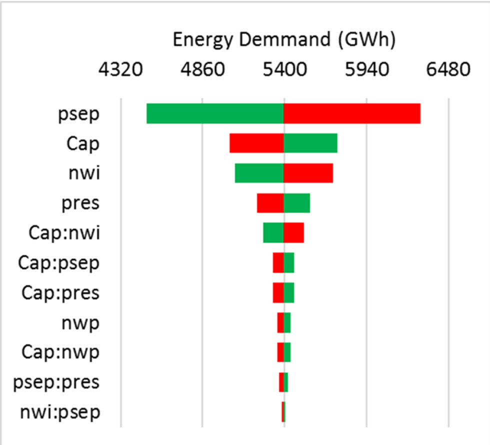

***Figure 5**: Tornado plot of energy demand.*

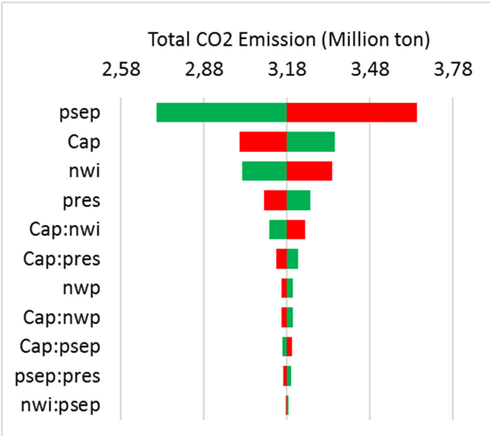

***Figure 6**: Tornado plot of total CO_2 emission.*

capacity) had a greater impact in economic terms. The management variables of the production unit (pres and psep) had a greater impact on the indicators of oil production forecast, financial return, energy demand and carbon emissions, also affecting the oil produced per CO_2 emitted ratio. The number of wells was significant across all indicators. The iteration between the independent variables was low. This can be explained by the prevalence of platform capacity and pressure maintenance in the reservoir, imposing maximum production and injection values that are not influenced by other design and management variables.

Conclusions and final remarks

Integrated modeling was important to highlight the interdependence between the simulated models and the significant impact of uncertain reservoir parameters and between design and field management variables. The results showed that the reservoir parameters may not act as the main component in the energy demand, total CO_2 emission and the oil produced per CO_2 emitted ratio. The production strategy variables had a greater impact on these indicators.

Considering the production strategy variables related to the production system adequately representing the behavior of platform and reservoir in terms of pressures and flows, as well as optimizing the capacity of the processing plant in the field development project, are important decisions that directly affect energy demand and greenhouse gas emissions.

Acknowledgments

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“The results showed that it is possible for the oil and gas industry to reduce greenhouse gas emissions from future operations by increasing energy efficiency, maintaining oil recovery and financial return.”

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