UNISIM ON-LINE
Year 19, Number 1 155th edition February, 2024

"This work evaluates the impact of production system uncertainties in integrated simulations (reservoir-production system) for production, energy demand, and carbon emission forecasts through the application of a simple and efficient methodology."

Specials interests:

- UNISIM
- UNISIM Publications
- Reservoir Simulation and Management Portal
- Previous Issues

Links:

- UNICAMP
- Cepetro
- Petroleum Engineering Division
- School of Mechanical Engineering
- Petroleum Sciences and Engineering

Graduate:

Petroleum Sciences and Engineering: interested in Masters and PhD in the Simulation and Oil Reservoir Management area click here.

Effect of production system uncertainties on production forecast, energy demand, and carbon emissions

João Carlos von Hohendorff Filho

Introduction

This text summarizes the paper published by Hohendorff Filho et al. (2024) which evaluates the impact of production system uncertainties in integrated simulations (reservoir-production system) for production, energy demand, and carbon emission forecasts through the application of a methodology based on discretized Latin-hypercube method with geostatistical realizations (DLHG) and a proposed energy model for a surface facility. The results showed higher variation of all uncertainties in relation to the reservoir attributes only. The analysis indicated limited influence of technical and operational attributes on the net present value, production and injection, energy demand, and carbon emission indicators, and that the insertion of uncertain attributes of the production system is significant in the net present value, water production and injection, and CO_2 emissions results. The production system affected water production and injection, which directly affects the energy demand and carbon emissions, which was consistent with other work. The insertion of uncertain attributes of the production system can affect field development and management decision-making under uncertainties. These evaluations are important for production forecast and decision support over energy demand and greenhouse gas emissions from oil and gas production and processing.

Problem statement

Most works in the literature present risk analysis studies considering only geological uncertain attributes for reservoirs and, though good results are obtained for decision making, the process is still incomplete because it neglects the production system uncertainties. These studies often neglect other necessary parts of the production system: well, gathering system, and surface installations. Integrated energy system studies involve discrete, continuous, or mixed decision-making variables, multiple conflicting objective functions, non-linearity, non-convexity, and discontinuity affected by different techno-economic, environmental, and social parameters. Ignoring such uncertain parameters leads to less adaptable results to realistic conditions. Some works focused on uncertain attributes and risk analysis in reservoirs are found in the literature, and they show that this integration is a challenging process during studies' modeling, optimization, and decision-making processes. Calculation of energy demand and greenhouse gas (GHG) emissions from oil and gas production and processing is an emerging task for prognosis and decision support in energy companies. These evaluations aim to reduce GHG emissions and increase gains in operational efficiency while developing a low-carbon culture and avoiding climate changings. None of them has quantified the impacts of uncertain attributes of the integrated reservoir and production system and none explore risk analysis for energy demand and GHG emissions in this scenario.

Methodology

The main idea is evaluating the impact of uncertain attributes of the integrated production system with reservoir on the production forecasts efficiently. The specific steps of the methodology are:

1) Select uncertain attributes for reservoir (R), technical and operation (O) and production system (P);
2) Set number of simulations (N);
3) Use a statistical technique to generate N geostatistical realizations;
4) Evaluate levels for each attribute;
5) Combine attributes and geostatistical realizations using DLHG;
6) Update simulation datasets;
7) Run integrated simulations;
8) Evaluate energy and GHG emissions for each simulation using a proposed energy model for surface facility;
9) Compare risk curves;
10) Evaluate attributes.

Application and results

The applied benchmark was UNISIM-II-D, which served as the initial basis described in Correia et al. (2015) and Victorino et al. (2019). The uncertain attributes of the reservoir (R) were related by images generated through geostatistics. Technical and operational uncertain attributes (O) were related to system availability for platform, production or injection well groups, producer and injector wells. For the production system, the uncertain attributes (P) are fluid correlations, multiphase flow correlations, relative roughness, and pressure drop per unit length (dP/dL -multiplier adjustment factor) for the pipes. Fig. 1 shows the risk curves related to the economic performance. Figs. 2 to 4 show the risk curves related to the reservoir performance variables Np, Wp, and Wi, respectively. Figs. 5 to 6 are related to the total energy demand and CO_2 emission of the surface facility. The base case is related to the production strategy without uncertainty (initial case).

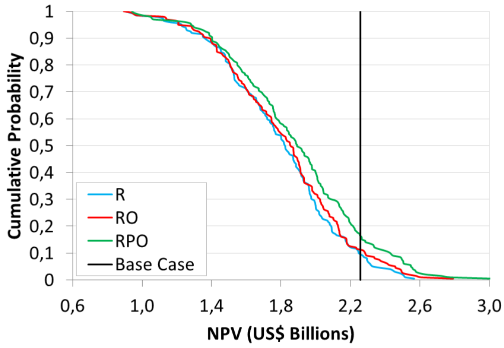

***Figure 1**: NPV results among all evaluated sets.*

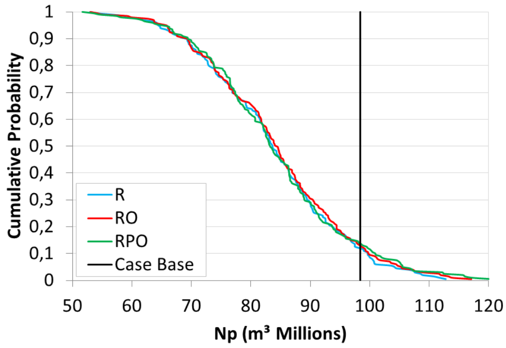

***Figure 2**: Np results among all evaluated sets.*

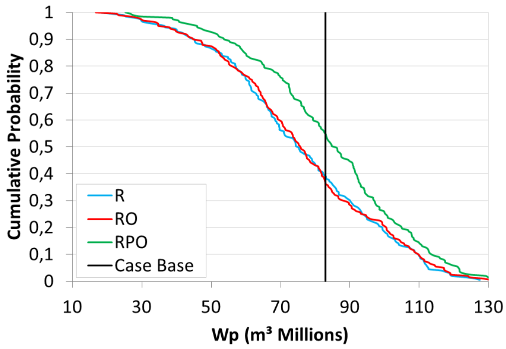

***Figure 3**: Wp results among all evaluated sets.*

"This work showed that multiphase flow correlations, production column roughness, and pressure drop multiplier factor, and the technical and operational attributes greatly impacted the financial return and CO2 emission."

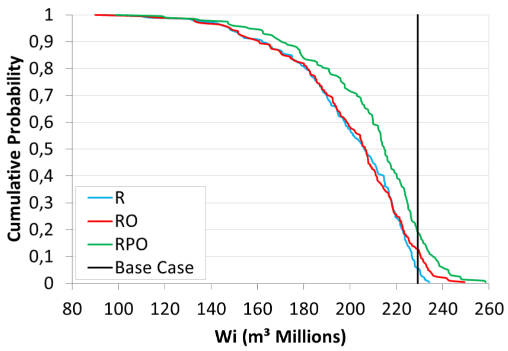

Figure 4*: Wi results among all evaluated sets.*

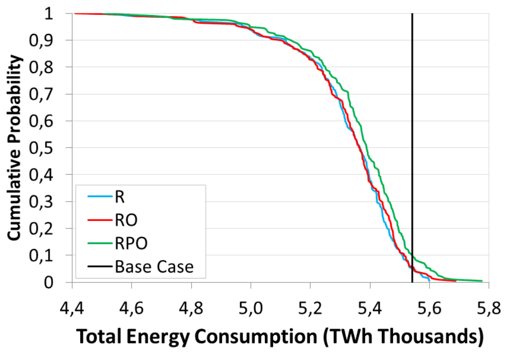

Figure 5*: Total energy consumption results among all evaluated sets.*

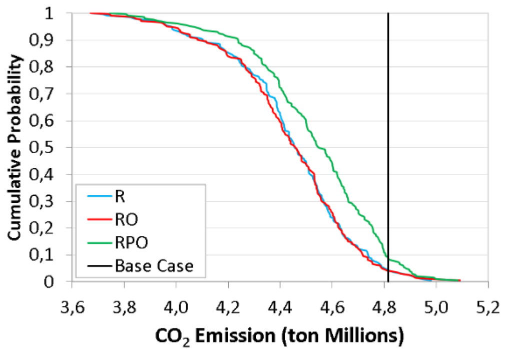

Figure 6*: CO_2 emissions results among all evaluated sets.*

Conclusions and final remarks

The methodology proposed is straightforward to implement and efficient, but it is simulation dependent and needs accurate information from the integrated model. The number of samples and the choice of uncertain attributes are key factors to guarantee accuracy from results. This work showed that multiphase flow correlations, production column roughness, and pressure drop multiplier factor, and the technical and operational attributes greatly impacted the financial return, and this depends on each case studied. From the results obtained in this work, the importance of including uncertain attributes of the production system, combined with the uncertain attributes of the reservoir, is clear because it shows that it promotes significant variations in the responses (net present value, cumulative water production and injection, and CO2 emission) of the risk analysis. Therefore, the choice of uncertain attributes of great impact must be considered to reduce errors in the project, adequately forecast production, reduce energy demand and GHG emissions, and avoid financial losses. Dynamic production data assimilation could reduce uncertainty in both reservoir (R) and production system (P) models to improve short- and medium-term production forecast (Maschio et al., 2021).

Acknowledgements

This work was conducted with the support of Energi Simulation and Petrobras within the ANP R&D tax as "commitment to research and development investments". The authors are grateful for the support of the Center for Energy and Petroleum Studies (CEPETRO-UNICAMP/Brazil), the Department of Energy (DE-FEM-UNICAMP/Brazil), and the Research Group in Reservoir Simulation and Management (UNISIM-UNICAMP/Brazil). In addition, a special thanks to CMG and Petrobras for software licenses.

References

Correia, M. G., Hohendorff Filho, J. C. V., Gaspar, A. T. F. S., Schiozer, D. J. (2015), UNISIM-II-D: Benchmark Case Proposal Based on a Carbonate Reservoir, SPE, SPE-177140-MS, SPE Latin American and Caribbean Petroleum Engineering Conference, Quito, Ecuador. https://doi.org/10.2118/177140-MS

Hohendorff Filho, J. C. V., Victorino, I. R. S., Bigdeli, A., Castro, M. S., Schiozer, D. J. Effect of Production System Uncertainties on Production Forecast, Energy Demand and Carbon Emissions, Journal of the Brazilian Society of Mechanical Sciences and Engineering, February, 2024. https://doi.org/10.1007/s40430-024-04688-2

Maschio, C., Hohendorff Filho, J. C. V., Schiozer, D. J. Methodology for Data Assimilation in Reservoir and Production System to Improve Short- and Medium-Term Forecast, Journal of Petroleum Science and Engineering, v. 207, pp. 1-21, December, 2021. https://doi.org/10.1016/j.petrol.2021.109083

Victorino, I. R. S., Hohendorff Filho, J. C. V., Castro, M. S., Schiozer, D. J. (2019), Analysis of the Production of a Pre-Salt Based Carbonate Reservoir Through Integrated Simulation of Reservoir and Production System, International Journal of Petroleum Engineering, Vol.3, No.3, pp.228–253. https://doi.org/10.1504/IJPE.2019.105645

About the author:

João Carlos von Hohendorff Filho holds a B.Sc. in Civil Engineering from UFSC, an M.Sc and PhD in Petroleum Sciences and Engineering from UNICAMP. He is a researcher at UNISIM/CEPETRO/ UNICAMP since 2013, researching and leading projects focused on simulation and integration between reservoir and production system.

UNISIM opportunities:

If you are interested in working or developing research in the UNISIM Group, please contact us.
For further information, click here.

Research in Reservoir Simulation and Management Group

Petroleum Engineering Division - Energy Department
School Of Mechanical Engineering
Center for Energy and Petroleum Studies
University of Campinas
Campinas - SP

Phone.: 55-19-3521-1220

unisim@cepetro.unicamp.br

For further information, please visit
http://www.unisim.cepetro.unicamp.br

The UNISIM Research Group is part of UNICAMP (Petroleum Engineering Division, Energy Department, School of Mechanical Engineering, Center for Energy and Petroleum Studies) that aims to develop Works and projects in the simulation and reservoir management area.