6 Conclusions

In this thesis, we have proposed an optimization strategy to value flexibility, seeking the optimum valve settings to maximize the expected net present value, considering geological and technical uncertainties, and dynamically reacting to the acquisition of future information. We proposed a methodology that dynamically defines the control of smart completions to improve the NPV in oil field asset, incorporating future information to optimally control the reservoir system in the presence of significant reservoir uncertainties.

Our methodology designed the optimal usage of smart wells and assigns a quantitative value to the benefits that they provide, both in terms of the flow control valves (flexibility) and measurement gauges (information). Notably, it provides a qualitative valuation that indicates whether a field benefits from smart completions or not. This versatile methodology also provides a practical and realizable strategy for actual operations of these valves that is adaptable to future information over time, thereby delivering a decision tree that describes a flexible strategy of optimum valve settings that properly accounts for future measurements and how their impact on uncertainty reduction can be readily quantified.

The proposed methodology is able to devise a strategy that is both proactive (i.e., optimized with respect to expected forecast reservoir behavior) and reactive (i.e., can accommodate future measurement data and react appropriately). The methodology is therefore superior to either of the two separate approaches. The approach seeks a balance between static and flexible optimization policies in order to produce robust results in a practical time frame.

Due to the high computational cost involved in the optimization and simulation process, this methodology makes use of parallel programming to distribute computationally expensive tasks and simulation dictionary to save the simulation results done. The approach also is flexible enough to allow us to define the frequency of timing for optimal control and assimilation of measurements. We considered approaches for improving the computational efficiency of a rolling-flexible optimization: 1) a rolling-flexible-k strategy that reduces the number of optimization control variables, 2) only optimizing time steps where the new information reduces reservoir uncertainty, 3) adjusting the number of time steps in the problem, and 4) optimizing only using representative models. These approaches can be applied singly or in combination. The rolling-flexible-k strategy has shown promising results in our numerical experiments even for small values of k, yielding greater value that the rolling static policy and similar value to the rolling-flexible policy with a reduced number of reservoir simulations. Even the rolling-flexible-1 strategy provided higher expected NPV values than the flexible proactive strategy (no information). In the second approach, we showed that our approximation of optimizing only when new information reduces reservoir uncertainty yields values that are nearly equal to those achieved when optimization is performed at each time step, while significantly reducing the required number of reservoir simulations. The use of representative models for optimization allow us to reduce the number of evaluation functions without to lose the prior and the future information available.

We prove the concepts of the proposed approach applying it on a “toy” model, represented by a single tank model, and we also check the approach reliability with a “toy model”, but that was refined to allow fast optimization and generation of several uncertainty scenarios, represented by multiple tank model. The “toy” models provided a useful case for the development and testing of our flexible optimization code. Furthermore, they allowed us to quickly compare optimization strategies and to test the quality of approximation in the rolling-flexible strategy. Another advantage of these “toy” models is that the optimal solutions are readily available by inspection, allowing us to test the quality of our optimization solutions.

So we prove the concepts of our optimization strategy on the single tank model whose highlights its novel aspects: asset optimization under uncertainty, flexible control based on future information, quantifying the value of flexibility and future measurements, and considering potential financial loss due to the failure of a smart completion. In short, in addition to valuing flexibility and future information, which contributes to the selection of appropriate smart-well technology and measurements, our methodology delivers a decision tree that describes a flexible strategy of optimum valve settings that properly accounts for future measurements and their impact on uncertainty reduction. The multiple tank model allows us to check how reliable our optimization results are. We obtained promising results when we apply the optimized flow control strategy for new scenarios, in order to follow the play-book based on the current scenarios behavior, without to require for extra optimizations.

Considering the reservoir model, the tests results shows that the proposed optimization strategy provides a qualitative valuation that indicates whether a field benefits from smart completions and also provides a realizable strategy for the control of the valves that adjusts to future information over time. Our results also demonstrate the economic benefits of using smart well technology for a specific field case, showing that this methodology can efficiently optimize the flow control strategy, increasing NPV compared with other methods. Again these results also demonstrate that the use of information on the optimization strategy definition can increase the expected value through uncertainty reduction. Our results also show that increasing the number of time steps at which the valve settings may be adjusted in reaction to future information leads to an increase in value. While this still leads to an increase in the number of simulations required, the increase is relatively modest provided that we only consider altering valve settings when simulated measurement data suggests that relevant and specific information might be obtained. This is a better use of spare computational capacity than detailed optimization of the proactive strategy.