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**An Approach to Value Flexibility
Considering Uncertainty and Future
Information: An Application to Smart Wells**

TESE DE DOUTORADO

Thesis presented to the Programa de Pós-Graduação em Engenharia Elétrica of the Departamento de Engenharia Elétrica, PUC-Rio as partial fulfillment of the requirements for the degree of Doutor em Engenharia Elétrica.

Advisor: Prof. Marco Aurélio Cavalcanti Pacheco
Co-Advisor: Prof. Richard James Stuart Booth

Rio de Janeiro
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Abstract

Abreu, Ana Carolina Alves; Pacheco, Marco Aurélio Cavalcanti (Advisor) Booth, Richard James Stuart (Co-advisor). **An Approach to Value Flexibility Considering Uncertainty and Future Information: An Application to Smart Wells**. Rio de Janeiro, 2016. 163p. Doctoral Thesis – Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro.

Smart well technology has the ability to acquire relevant information required for future decision-making, enabling the generation of a development strategy with future flexibility. However, to value its flexibility, if we do not account for uncertainty when performing an optimization, the resulting strategy will have two key shortcomings: it will assign too high value to the smart wells, and it will not take advantage of the ability of the smart wells to adapt and mitigate to uncertainty. We propose a strategy that allows to value flexibility under uncertainty, seeking the flow control strategy that maximizes the expected net present value, dynamically reacting to new information as it is acquired. We demonstrate the proposed approach using “toy problems” for which we can evaluate optimization solutions for a broad range of scenarios, including uncertainty and flexibility to accommodate future measurements, with a reduced time of evaluation. We then apply this proposed approach on a reservoir model that highlights its novel aspects: asset optimization under uncertainty, flexible control based on future information, and quantification of the value of flexibility and future measurements. In addition to valuing flexibility and future information, which contributes to the selection of appropriate smart-well technology and measurements, the proposed approach 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. This approach gives a qualitative value, indicating whether the field has the potential of significant improvement using smart wells, and a quantitative valuation of the benefits of smart completions resulting in a realizable strategy to guide the control of these completions in a real field management project.

Keyword

Smart well; value of flexibility; uncertainty.

Resumo

Abreu, Ana Carolina Alves; Pacheco, Marco Aurélio Cavalcanti; Booth, Richard James Stuart. **Uma abordagem para avaliação de flexibilidade considerando incerteza e informação futura: uma aplicação para poços inteligentes.** Rio de Janeiro, 2016. 163p. Tese de Doutorado – Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro.

Os poços inteligentes permitem a criação de uma estratégia de desenvolvimento flexíveis, dada, entre outras coisas, sua capacidade de adquirir informações relevantes necessárias para tomadas de decisão futuras. No entanto, se não considerarmos as incertezas quando pretendemos calcular o valor dessa flexibilidade, a estratégia de otimização resultante terá dois problemas fundamentais: pode-se atribuir um valor muito elevado para os poços inteligentes, e não se tira proveito da capacidade de adaptar e mitigar incertezas. Este trabalho propõe uma abordagem para avaliar flexibilidade sob incerteza, buscando a estratégia de controle de fluxo que maximize o valor presente líquido esperado, reagindo dinamicamente a novas informações. Demonstramos a abordagem proposta utilizando “*toy problems*”, nos quais podemos avaliar as soluções de otimização em uma ampla gama de cenários, incluindo incertezas e flexibilidade, com um reduzido tempo de avaliação. Em seguida, aplicamos esta abordagem em um modelo de reservatório que destaca aspectos como: otimização de ativos sob incerteza, controle flexível baseado em informações futuras, e quantificação do valor da flexibilidade e medições futuras. Além disso, contribuindo para seleção apropriadas da tecnologia de poços inteligentes e de medições, a abordagem proposta oferece uma árvore de decisão que descreve a estratégia flexível ideal, com os controles da válvula que adequadamente consideram medições futuras e seus impactos na redução de incertezas. Esta abordagem provê uma avaliação qualitativa, indicando se o campo tem potencial de melhoria significativa utilizando poços inteligentes, e avaliação quantitativa dos benefícios da tecnologia, resultando em uma estratégia realizável, que orienta o ajuste das válvulas um campo real.

Palavras-chave

Poços inteligentes; valor de flexibilidade; incerteza.

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