An Optimization Framework for the Assessment of Shale Gas Resources

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Abstract

Unconventional primary energy resources like Shale gas can play an important role in the world's energy production in the decades to come. It is estimated that 32% of the current total natural gas resources corresponds to Shale gas (EIA, 2013) and its importance in the global market is increasing as new technologies for exploration and exploitation are available. Shale gas could be a "game changer" with the potential of lowering prices and expanding supply. The availability of natural gas at low prices can bring new opportunities for chemical and electricity generation industries (Jenner and Lamadrid, 2013; Siirola, 2014). Nevertheless, the production of shale gas resources depends extensively on production costs and productivity where minor changes can make the difference between a resource that is economically viable and one that is unattractive at current market conditions. For instance, the extraction of shale gas is more aggressive in terms of environmental impact when compared to conventional gas. In particular, high water consumption and the potential for ground water contamination represent major concerns, which could hinder the development of Shale gas plays (Cafaro and Grossmann, 2014; Clark et al., 2013; Eaton, 2013; Vidic et al., 2013; Warner et al., 2013).Therefore, the assessment of Shale gas production is a challenging problem where economic and environmental aspects need to be considered at both the single field and supply chain decision levels.

In this work, an optimization framework for the assessment of shale gas resources is presented. The framework is based on a disaggregated approach that includes Shale gas production, water management and supply chain models. First, rigorous simulations for water and shale gas treatment facilities are carried out in order to provide detailed information about process performance under different configurations and operating conditions. Then, an optimization model is proposed to address the optimal development of a shale gas field. The decisions addressed in this level are: well-pad locations; capacities, technologies and location

of gas and water treatment facilities. The design of the gas and water transport network from well-pads to treatment facilities is also considered. Based on the results, surrogate models are developed to describe the performance of a shale gas field in terms of Capex, Opex, gas production and water use.

Finally, those models are integrated into a Mixed Integer Linear Programming (MILP) supply chain optimization model in order to deal with strategic decisions such as selection, capacity and location of process technologies on a regional and multi-time period basis. The capabilities of the developed optimization framework are demonstrated using a nationwide case study involving data from Colombia. This optimization framework is used to analyze the trade-off between economic and environmental aspects of Shale gas production and commercialization in the Colombian context.

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