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Optimal planning of oil and gas development projects considering long-term production and transmission

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ABSTRACT

This paper proposes an integrated model for making a group of strategic decisions about oil and gas development projects simultaneously over a long-term planning horizon. These decisions involve: selection of field and pipeline development projects, scheduling of selected projects, production planning, and upstream transmission planning. The proposed model is formulated as a linear mixed-integer-programming model. It is implemented in a case study to demonstrate its usefulness and applicability in practice. Finally, a number of sensitivity analyses are carried out to analyze the impact of most influential uncertainties on the solutions and the corresponding results are discussed.

1. Introduction

Liquid fuels and natural gas are expected to remain the major source of energy in long-term horizon, having an estimated 50 percent consumption share (EIA, 2013) (Fig. 1).

As oil and gas resources have a limited availability, the importance of their planning activities rises. Optimal planning of oil and gas field development projects is an important issue because the corresponding investment decisions are irreversible and huge finance is committed over a long-term horizon (Huseby & Haavardsson, 2009).

Among the candidate development projects, some of them produce oil and/or gas, while others add some capacities for transmission of the products. Basic field development decisions are twofold: selection among the best candidate field development projects and sequencing/scheduling the selected projects. Moreover, production and transmission plans have considerable interactions with selection and scheduling decisions. For example, consider an existing production field, a demand node, and an existing pipeline which transmits the product(s) from the production field to the demand node. After selecting and executing a pipeline-development project, adding a new parallel pipeline, the transmission capacity will be increased. If the production amount from the field was previously restricted to the former transmission capacity, now it might be decided to increase the production amount if it is economically feasible. In that case, both of production and transmission plans will be changed according to the project selection decision. On the other hand, a higher level of production, as a production planning decision, may lead to selection and execution of a new pipeline-development project if the current pipeline is not able to transmit the increased amounts of products and also if the benefits of the extra production amounts are higher than pipeline development expenses.

These bidirectional interactions enforce to formulate an integrated decision model by incorporating long-term production and transmission decisions into a selection and scheduling optimization model. The main advantages of such integral planning are: (1) making the model more practical by accounting for some facts existing in the reality which is neglected in many oil-and-gas project selection models and (2) avoiding from sub-optimality arising from solving these interrelated problems separately. On the other hand, the main barrier for this integrated model is that it needs a more complex and time consuming data gathering process which is absolutely justifiable for such a long-term decision problem with huge financial consequences. Fig. 2 shows the components of our integrated model and their interactions. Because of the long-term horizon of the model and also its inherent complexity, the scope of upstream network is covered and the forecasted demand of midstream/downstream network is used as input data.

The rest of the paper is organized as follows. The relevant literature is reviewed in Section 2. The details of the tackled problem and

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