General Information

1 Introduction

In planning a field development, there are many field design features to be decided upon. The company's development team has a responsibility to determine a configuration of those options which maximizes the value of the company's asset. Automated field development is a cutting-edge methodology to screen and search in an automated manner for the best combination of field design features under a given set of constraints. This work presents an automated field development methodology that is based on mathematical optimization.

The methodology is designed for a synthetic (fictitious) case called "Safari". Safari field is an offshore field located east of Johan Sverdrup and Grane fields, and west of Haugesund (North Sea). Water depth in the field location is approximately 120 m. The field is characterized by having multiple reservoir units (Løve, Nesehorn, and Sebra), where the reservoirs are non-communicating and have unique properties. All the reservoirs are undersaturated oil reservoirs.

In this work, the development concept for the field has been pre-defined, i.e., to use an FPSO. The FPSO is installed close to the Løve reservoir due to its central location. Production for each reservoir is tied to a constant-pressure separator at the FPSO. All the wells are subsea wells drilled from 4-slots subsea templates. All producers are completed with gas-lift as the artificial lift method. All three reservoirs are developed with subsea wells. The producers are drilled from 4-slot subsea templates and are completed with gas-lift. Production from all reservoirs is tied to a constant-pressure separator in the FPSO. The produced oil is stored in FPSO and offloaded by tanker periodically. Some amount of the produced gas is re-injected to the Løve reservoir for pressure maintenance, while the rest is exported through the Statpipe dry gas pipeline.

Development of the field is commenced from the 1st of January 2019. Facility construction and installation are planned to be completed in four years, and the field first oil is expected to be on the 1st of January 2023. The field is scheduled for abandonment on the 1st of January 2040, after 17 years of production.

2 Files Organization & Description

There are four optimization models available, i.e.:

1. CASE-1
   Location: \Default branch\master
   Description: an optimization model that maximizes the plateau duration by configuring the fluid flow rates, drilling schedule, and recovery mechanism.
   Comment: some brief explanations are available within the AMPL code

2. CASE-2
   Location: \Active branches\NPV-Opt
   Description: an optimization model that maximizes the NPV by configuring the fluid flow rates, drilling schedule, and recovery mechanism.
   Comment: some brief explanations are available within the AMPL code

3. REF-CASE-1
   Location: \Active branches\PlateauOpt-RateOnly
   Description: an optimization model that maximizes the plateau duration by configuring only the fluid flow rates.
   Comment: -

4. REF-CASE-2
   Location: \Active branches\NPVOpt-RateOnly
   Description: an optimization model that maximizes the NPV by configuring only the fluid flow rates.
   Comment: -

3 Requirements to Run the Optimization

3.1 Hardware Requirements

- 4 unused CPU cores with hyper-threads (8 threads)
- 4 GB RAM
- 1 TB available disk space

3.2 Software Requirements

- Operating system: Windows / Linux / macOS
- AMPL

The optimization models were implemented in AMPL (A Mathematical Programming Language), which is a programming language designed to solve a wide range of optimization problems. AMPL closely resembles the symbolic algebraic notation that many modelers use to describe mathematical programs. This makes it convenient to formulate and solve an optimization problem in AMPL. In addition, AMPL offers various powerful solvers, such as CPLEX, Gurobi, etc., to solve many classes of mathematical optimization.

If you do not have AMPL installed in your computer yet, I suggest you request a "full-featured 30-day trial version". This trial version allows you to run the optimization models since it has no problem-size limitations. There are two steps to set up the trial version:

1. Download an AMPL and solver package for your computer by following the instructions on https://ampl.com/try-ampl/download-a-free-demo/. You can complete the installation and solve optimization problems of a few hundred variables immediately, using the included demo license. **NB**: when installing AMPL, you should place the AMPL folder in a disk with a minimum 1 TB free space.

2. Request a trial license to convert your demo to a 30-day trial with no problem-size restrictions. It is done by filling out and submitting a short online form on https://ampl.com/try-ampl/request-a-full-trial/. As soon as your request is approved, they will email you a trial license file to replace the demo license that came with your download.

If you encounter any problems when installing AMPL or when setting up the trial version, please contact AMPL by filling out a form on https://ampl.com/about-us/contact-ampl/.

4 Steps to Run the Optimization

Once you have installed a full-featured package of AMPL, you can start running the optimization. For this purpose, AMPL offers two modelling environments, i.e.:

- AMPL IDE: an integrated command processor and editor that assists in model development
- AMPL Command Line: runs in a simple command window

It is your choice to use either of these modelling environments.

Procedures to run the optimization are provided as follows. These procedures are relevant for Windows, but I think they are almost similar for Linux or macOS (further details to run the optimization can be found in https://ampl.com/try-ampl/download-a-free-demo/).

Using AMPL IDE:

1. Move the files (".mod", ".dat", and ".run" files) associated with an optimization model to your AMPL folder (which initially named "amplide.mswin64").
2. Inside your AMPL folder, open the "amplide" folder.
3. Double-click the "amplide.exe" file to start the AMPL IDE application.
4. On the left side of the full IDE application window, change the current directory to the directory of your AMPL folder (e.g. D:\amplide.mswin64).
5. In the console section (in the middle of the IDE application window), you can type AMPL commands. To start running the optimization, you should give a command "include xxx;" with xxx replaced by the name of the run file of an optimization model (e.g. if you want to run the optimization for CASE-1, you should give a command "include CASE-1_Run.run;").
6. The optimization process continues until it reaches either the desired optimality gap or the defined time limit. The optimization results can be found in a ".out" file located in your AMPL folder.

Using AMPL Command Line:

1. Move the files (".mod", ".dat", and ".run" files) associated with an optimization model to your AMPL folder (which initially named "ampl.mswin64").
2. Inside your AMPL folder, double-click the "sw.exe" file.
3. Type "ampl" in the window that appears. Then you will see an "ampl:" prompt and can proceed to type AMPL commands.
4. To start running the optimization, you should give a command "include xxx;" with xxx replaced by the name of the run file of an optimization model (e.g. if you want to run the optimization for CASE-1, you should give a command "include CASE-1_Run.run;").
5. The optimization process continues until it reaches either the desired optimality gap or the defined time limit. The optimization results can be found in a ".out" file located in your AMPL folder.

5 Citing this Work

Type: Master Thesis Report
Title: Automated Decision Support Methodologies for Field Development - The Safari Field Case
Author: I Gusti Agung Gede Angga
Supervisor: Prof. Milan Stanko
Publishing Date: 09 July 2019
Publisher: Department of Geoscience and Petroleum, Faculty of Engineering, Norwegian University of Science and Technology (NTNU)
Access: will be available shortly in NTNUOpen (https://ntnuopen.ntnu.no/ntnu-xmlui/)

6 Contact

Please, feel free to send me a message if you have any inquiries regarding the optimization models and its application for your fields. Your thoughts or recommendations for this work are also very welcomed.

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