Optimizing the Development Strategy for the Block Faulted Oil field with Merak Capital Planning

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Abstract. The block X is an integrated upstream and downstream development, comprising the development of oil fields and the construction and operation of pipelines and a refinery [1]. The upstream development consists of 73 fault blocks scattered in nine oil fields, in which four blocks are already in development, and the others will be under full development in the near future. The development strategies need to meet the strategic goal of maximizing the length of the stable production plateau for three production scenarios (low, base, and high) while fulfilling the objectives of maximizing the integrated economic value (NPV), fast recovery of the investment, and minimizing risks. To model the development strategy [2, 3], first, a single well economic case for each development block is created, and total production volume at economic limit is generated. It is then followed by the screening process to filter out the uneconomical blocks which do not meet the hurdle rate for the single well economic limit production volume. The economics results for each block passing the screening process are then brought into Merak Capital planning as the base for the optimization. The optimization is set up to generate three strategies which determine the onstream time options for each of the block development to meet the three strategic production plateau goals and fulfill the objectives. The business rules modeled in Merak Capital Planning [4–6] represent the dependency between the onstream time and the commissioning date of the export pipelines, the completion time of the surface facilities, the size

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and quality of the blocks, and the distance of the block to CPF, as well as the processing capacity of the refinery. The optimization is done by using both the Lindo and Genetic Algorithm methods. For each strategy, multiple options are generated from the optimization. Based on the optimization outcomes, full life cycle economic evaluation is performed to assess integrated upstream–downstream economic value [7] of the multiple development options for each strategy. Finally, the optimal development option for each strategy to meet the company's strategic goals is determined based on the integrated economic results of the optimized development options [8−10].

Keywords: Investment portfolio optimization · Upstream and downstream integration · Block faulted oil field · Genetic algorithm · Development strategy

1 Introduction

The block X fields are located on the Bongor basin. The block falls under a single concession license, as we know, which also includes acreage in the north and south of the country.

Five oil fields have been discovered on the Bongor West Block: Baobab, Mimosa, Ronier, Prosopis, and Cassia N. Wood Mackenzie has indicated that there are at least 800 million barrels of oil in place across the five fields.

Production from the block X development started in May 2011. A 311-kilometer pipeline links the facilities with a new 20,000-b/d refinery built by CNPC and the Chad Ministry of Petroleum at N'Djamena, close to its capital city N'Djamena.

Production from the three block X fields is limited by demand for refined products and the efficiency of the refinery. It has been proposed that the refinery will be expanded to 60,000 b/d at some point in the future. However, the economic viability of this will depend on whether demand can be found. We have therefore modeled that from 2017, a further 300 mmbbls will be exported. The potential pipeline from CNPC's Agadem development in Niger to the Chad-Cameroon pipeline lies 75 km to the west of the block H fields, providing the possibility of a tie-in.

The paper is aimed to identify the optimal development strategy options for the block faulted oil field block X to meet the strategic goal of maximizing the length of the stable production plateau while fulfilling the objectives of maximizing the integrated economic value, fast recovery of the investment, and minimizing risk (Fig. 1).

2 Project Challenges

Development strategies for block X were optimizing while taking into account the following:

(1) Complex reservoir characteristics (large number of buried hills) lead to high uncertainty in reserves estimation.
(2) The completion time of the surface facilities (CPF and FPF) and the distance between them and the fault blocks determine development investment level and start-up pace (Fig. 2)

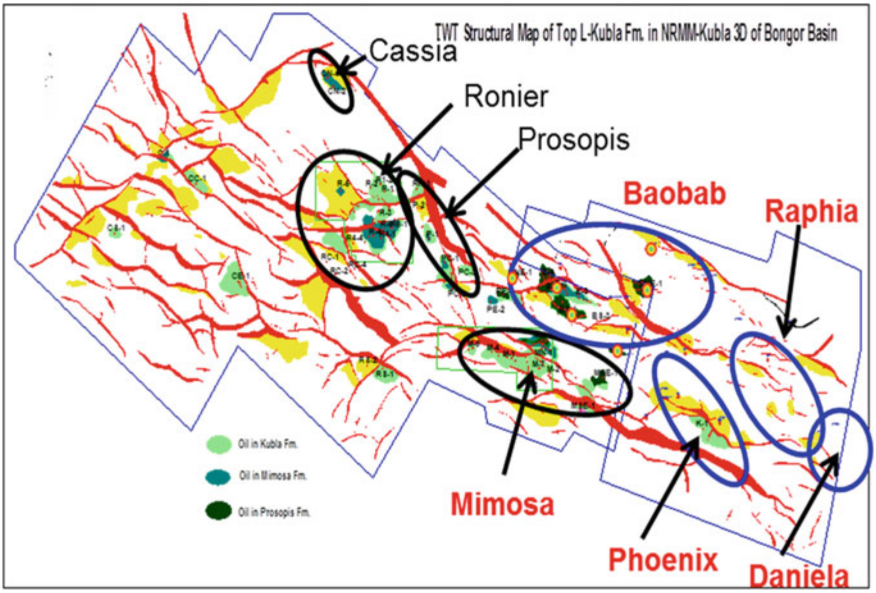


Fig. 1. TWT structural map of top L-Kubla Fm.in NRMM-Kubla 3D of Bongor Basin

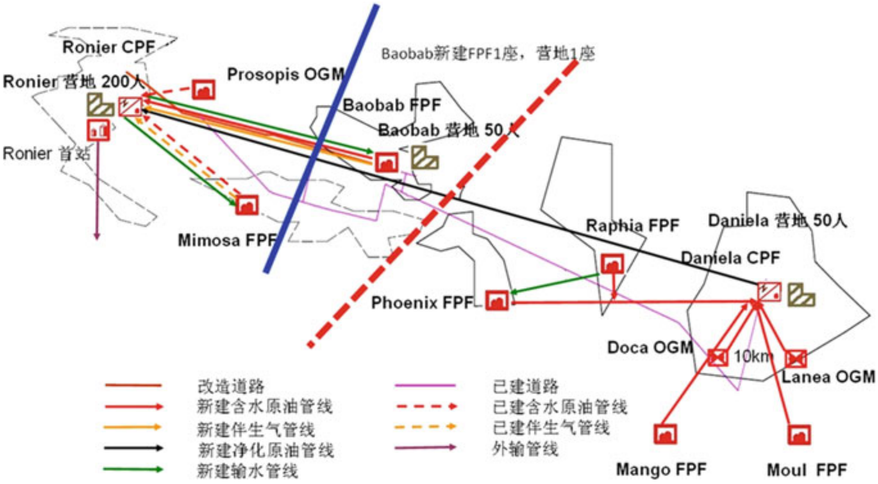


Fig. 2. Surface facilities distribution for block X

(3) The length and capacity of the export pipeline impact the investment and economic return of the upstream and pipeline.

(4) Oil field refinery processing capacity determines its own economic results and the proportion of for crude oil export (Fig. 3)

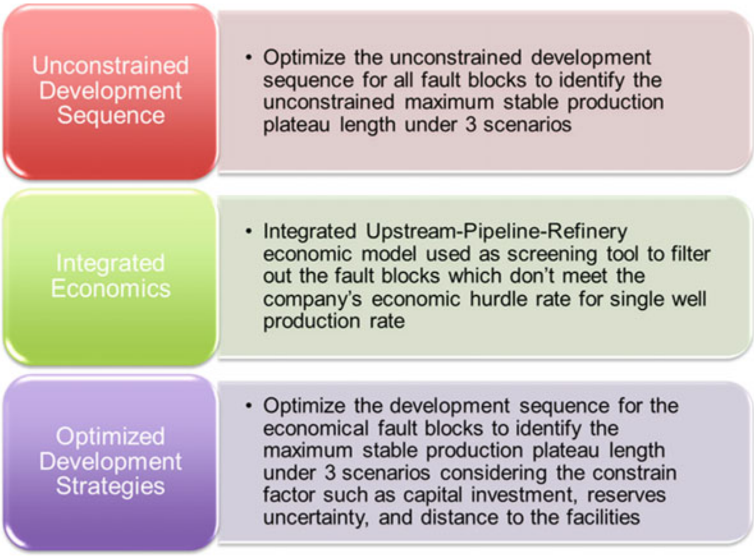
Fig. 3. Oil field refinery

3 Project Workflow

See Fig. 4.

3.1 Unconstrained Development Sequence

In order to identify the unconstrained maximum stable production plateau length under three scenarios, the unconstrained development sequence for all fault blocks was optimized.



Unconstrained Development Sequence

- Optimize the unconstrained development sequence for all fault blocks to identify the unconstrained maximum stable production plateau length under 3 scenarios

Integrated Economics

- Integrated Upstream-Pipeline-Refinery economic model used as screening tool to filter out the fault blocks which don't meet the company's economic hurdle rate for single well production rate

Optimized Development Strategies

- Optimize the development sequence for the economical fault blocks to identify the maximum stable production plateau length under 3 scenarios considering the constrain factor such as capital investment, reserves uncertainty, and distance to the facilities

Fig. 4. Project optimization workflow

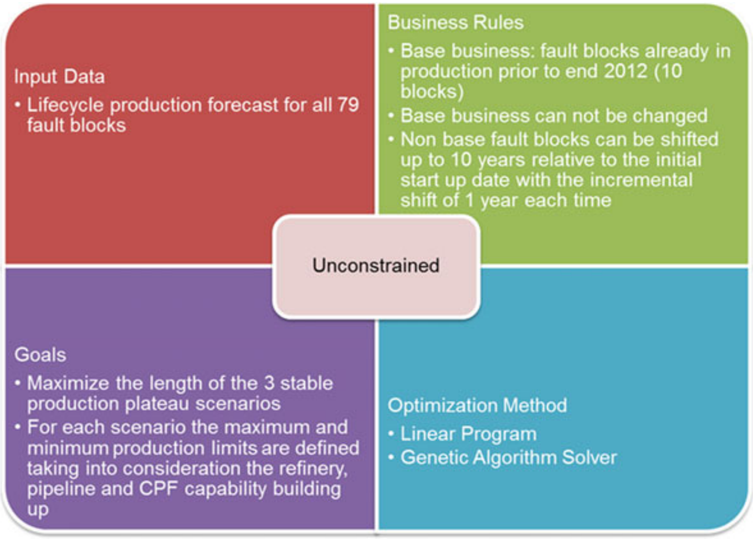
Goal 1: Consider the refinery capability, ground facilities, and pipeline capacity during early construction years and set the production ceiling goal for the first 2 years, weight: 0.5.

Goal 2: Consider the low, medium, full capacity of the ground facilities and pipeline when fully constructed and set the production floor goal the future years, weight: 1.0.

Process: Keep adjusting the number of years setting for Goal 2 to identify the maximum stable production plateau years.

Results: (Fig. 6)

(1) Low Scenario: Thirteen to 15 years of stable production, 72 fault blocks selected, 99% viability;
(2) Base Scenario: Nine to 11 years of stable production, 72 fault blocks selected, 100% viability;
(3) High Scenario: Six to eight years of stable production, 72 fault blocks selected, 99% viability (Figs. 5 and 6).



Input Data
- Lifecycle production forecast for all 79 fault blocks

Business Rules
- Base business: fault blocks already in production prior to end 2012 (10 blocks)
- Base business can not be changed
- Non base fault blocks can be shifted up to 10 years relative to the initial start up date with the incremental shift of 1 year each time

Goals
- Maximize the length of the 3 stable production plateau scenarios
- For each scenario the maximum and minimum production limits are defined taking into consideration the refinery, pipeline and CPF capability building up

Optimization Method
- Linear Program
- Genetic Algorithm Solver

Fig. 5. Optimization workflow for unconstrained development sequence

3.2 Integrated Economics

Integrated Upstream-Pipeline-Refinery economic model was used as a screening tool to filter out the fault blocks which do not meet the company's economic hurdle rate for single well production rate.

Single well economic production rates are identified to meet the company's IRR hurdle rates; finally, 58 out of 79 fault blocks are identified to be economical and used in the optimization process (Fig. 7).

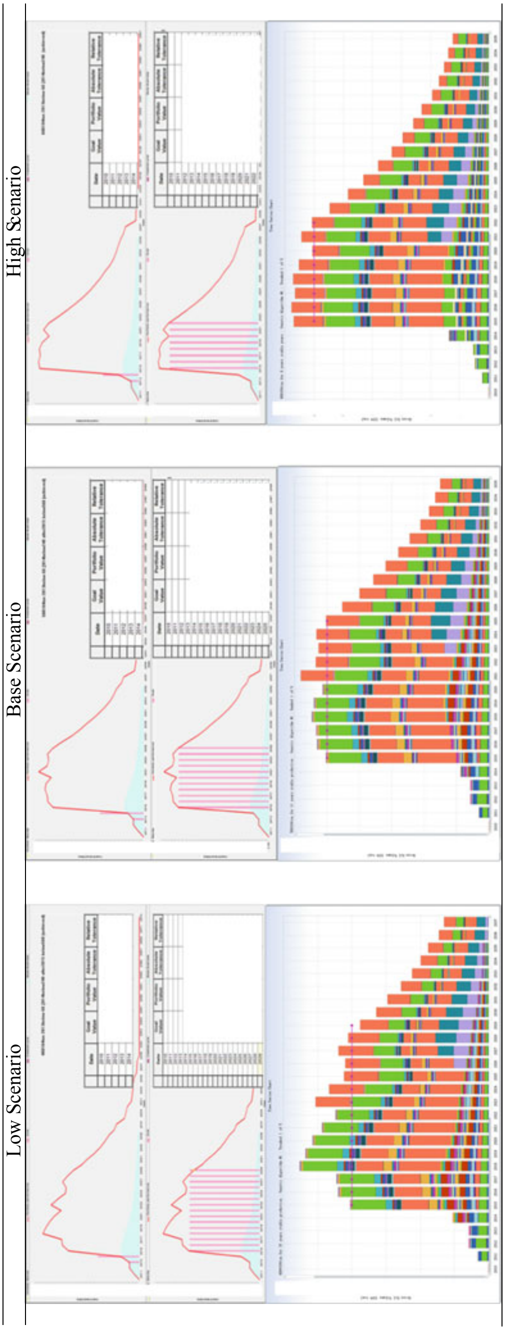


Fig. 6. Unconstrained development sequence

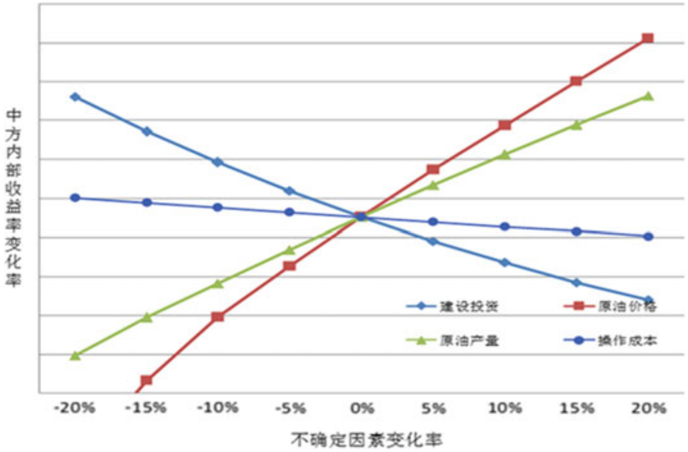
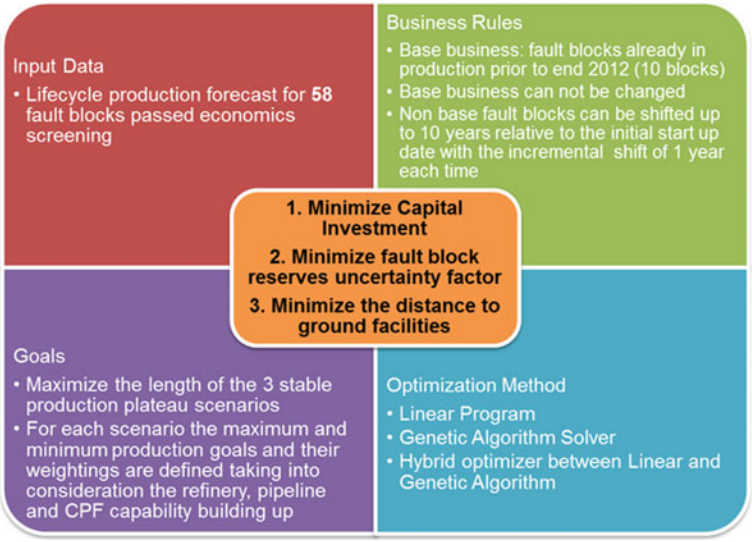


Fig. 7. Sensitivity analysis



Input Data

- Lifecycle production forecast for **58** fault blocks passed economics screening

Business Rules

- Base business: fault blocks already in production prior to end 2012 (10 blocks)
- Base business can not be changed
- Non base fault blocks can be shifted up to 10 years relative to the initial start up date with the incremental shift of 1 year each time

1. Minimize Capital Investment

2. Minimize fault block reserves uncertainty factor

3. Minimize the distance to ground facilities

Goals

- Maximize the length of the 3 stable production plateau scenarios
- For each scenario the maximum and minimum production goals and their weightings are defined taking into consideration the refinery, pipeline and CPF capability building up

Optimization Method

- Linear Program
- Genetic Algorithm Solver
- Hybrid optimizer between Linear and Genetic Algorithm

Fig. 8. Optimization workflow for constrained development sequence

3.3 Optimized Development Strategies

The last step is to optimize the development sequence for the economical fault blocks to identify the maximum stable production plateau length under three scenarios by considering the constrain factors such as capital investment, reserves uncertainty, and distance to the facilities (Fig. 8).

(1) Constraint 1: Minimize Capital Investment

The stable production plateau length for each scenario is slightly less than the unconstrained result. The development sequence is different in all scenarios with low capital investment development taking the priority. High capital investment and low production fault blocks are excluded in the optimized options.

(2) Constraint 2: Minimize Reserves Uncertainty Factor

Reserves uncertainty factor for each fault block is defined as the proportion of the probable reserves to the total 2P reserves. The stable production plateau length for each scenario is in line with the unconstrained result. The development sequence is different in all scenarios with fault blocks with lower uncertainty factor taking the priority.

(3) Constraint 3: Minimize the Distance to Surface Facilities

The stable production plateau length for each scenario is in line with the unconstrained result. The development sequence is different in all scenarios with fault blocks closer to the ground facilities taking the priority.

4 Summary

The main production fault blocks with high reserves certainty are the main contributors to achieve the production plateau goals. Priorities should be given consistently to these blocks under all three unconstraint conditions.

The rest of the fault blocks will contribute to sustain the future production plateau. Based on different constraint applied, the start date varies for each fault blocks (Tables 1, 2, and 3)

Table 1. Onstream date for investment minimum

Block	Investment minimum		
	Low	Medium	High
Fault block 1	2014	2015	2015
Fault block 2	2014	2015	2013
Fault block 3	2017	2015	2015
Fault block 4	2015	2015	2015
Fault block 5	2018	2015	2015
Fault block 6	2015	2015	2015
Fault block 7	2015	2015	2015
Fault block 8	2016	2020	2015
Fault block 9	2023	2021	2015
Fault block 10	N/A	2015	2015
Buried hills	2022	2015	2015

Table 2. Onstream date for CPF distance minimum

Block	CPF distance minimum		
	Low	Medium	High
Fault block 1	2015	2015	2015
Fault block 2	2015	2015	2015
Fault block 3	2015	2015	2015
Fault block 4	2015	2015	2015
Fault block 5	2018	2018	2015
Fault block 6	2015	2015	2015
Fault block 7	2015	2015	2015
Fault block 8	2023	2023	2021
Fault block 9	2023	2020	2015
Fault block 10	2023	2021	2017
Buried hills	2023	2021	2018

Table 3. Onstream date for uncertainty factor minimum

Block	Uncertainty factor minimum		
	Low	Medium	High
Fault block 1	2015	2015	2015
Fault block 2	2018	2018	2017
Fault block 3	2018	2015	2015
Fault block 4	2015	2015	2015
Fault block 5	2018	2015	2015
Fault block 6	2015	2015	2015
Fault block 7	2015	2015	2015
Fault block 8	2019	2015	2015
Fault block 9	2023	2019	2015
Fault block 10	2015	2015	2015
Buried hills	2023	2021	2018

5 Conclusions

The unconstrained maximum stable production plateau length for all 79 fault blocks under three scenarios varies from 6–8 years in the high scenario to 13–15 years in the low scenario.

Economic screening using an integrated Upstream-Pipeline-Refinery model filtered out the uneconomical fault blocks. Twenty-one fault blocks which did not meet the single well economic production hurdle rate were excluded from the optimization process.

The development sequence for the economical fault blocks to identify the maximum stable production plateau length under three scenarios was optimized by

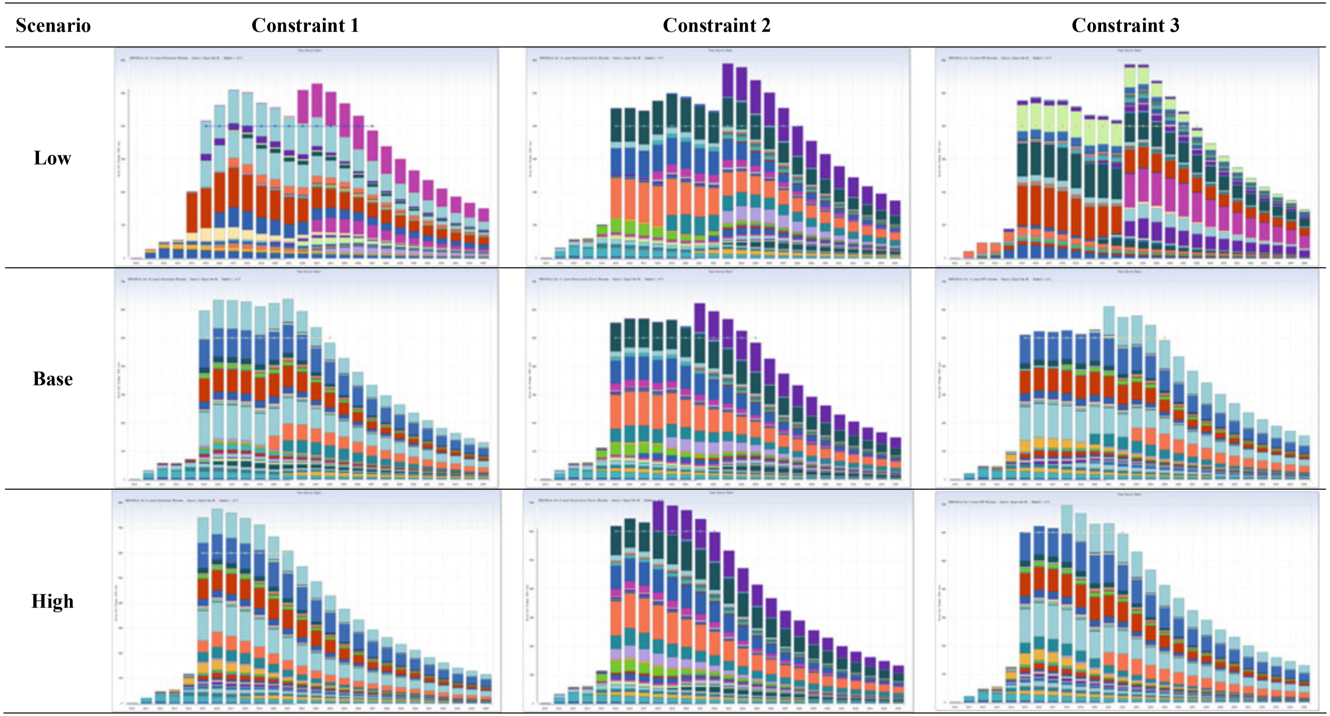


Fig. 9. Optimized development strategies

considering the constrain factors such as capital investment, reserves uncertainty, and distance to the ground facilities. The optimization results are as follows:

The seven main production fault blocks with high reserves certainty are the main contributors to achieve the production plateau goals. Priorities should be given consistently to these blocks under all three unconstraint conditions.

The rest of the fault blocks will contribute to sustain the future production plateau. Based on different constraint applied, the start date varies for each fault blocks.

Compared to the initial development strategies, the optimized development strategies are able to increase the stable production plateau period for block X for 2–3 years under each scenario (Fig. 9).

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