



## Pipe-It Case Study

# Multi-Field Asset Integrated Optimization Benchmark (SPE 121252)



- **Field: N/A**
- **Client: SPE**
- **Location: Amsterdam, EUROPEC**

### Challenge

Optimize the distribution of injection gas between two gas-condensate reservoirs.

### Solution

Model-based study using SENSOR and a process simulator coupled together.

### Benefit

Easy to inspect impact of different production strategies with respect to economic value.

### Summary

Pipe-It was used to create an integrated model consisting of two gas-condensate reservoirs with different fluid and rock properties, coupled together with a process simulator and an economics package. A fraction of the produced gas was re-injected into the reservoirs to increase condensate recovery. Through Pipe-It the amount of gas injection, and the distribution between the reservoirs, was optimized to maximize net present value of the produced fluids. This creates a platform where it is easy to study complex causes and effects in a truly integrated manner.

### Introduction

This case study is a summary of the paper **SPE-121252** – “Model-Based Integration and Optimization – Gas-Cycling Benchmark” presented at the EUROPEC/EAGE Conference and Exhibition, Amsterdam, 8–11 June 2009. The paper provides a benchmark for an integrated petroleum project that uses several models to integrate streams from reservoir to market value. The project was intended to provide a starting point for discussion and comparative solutions to a simple-yet-realistic integrated petroleum project.

Two compositional reservoir simulation models with different initial composition and reservoir characteristics were run in parallel. The produced streams from the two reservoirs were fed to a process simulator where sales products and injection gas properties were calculated. The sales product streams were then fed to an economics package to calculate the project economics. The

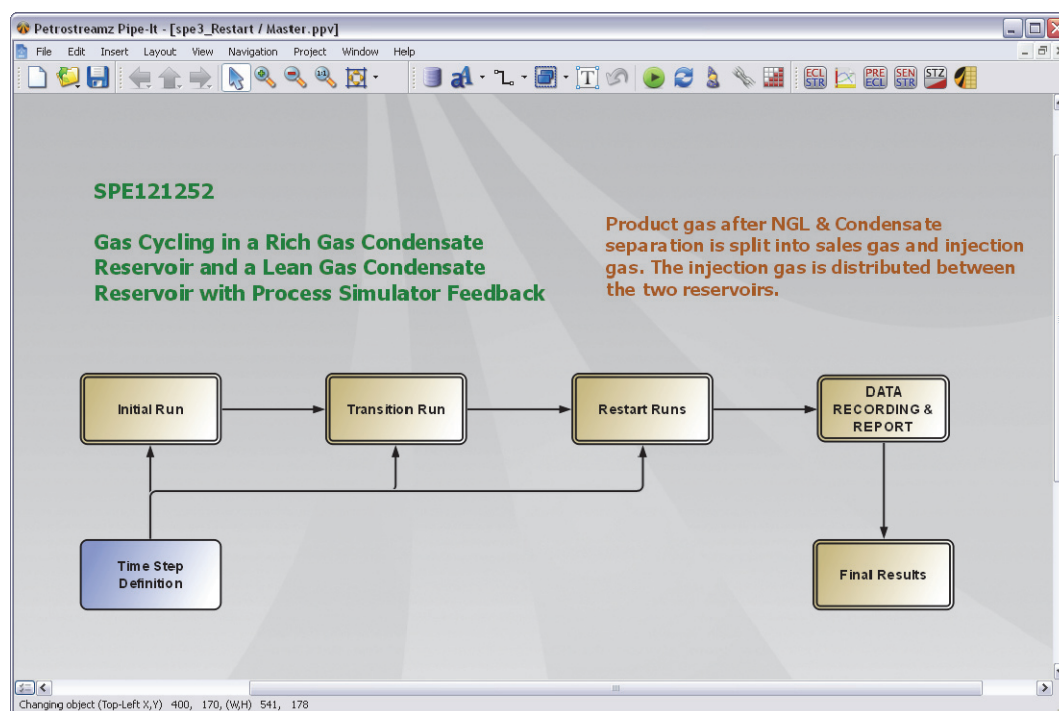
injection gas rates and composition were updated in the reservoir models during the project run to reflect the changes in the processed streams. Pipe-It was used to facilitate data transfer between the different parts of the project to ensure consistency from upstream to downstream, and to execute all parts of the project in the correct order.

Pipe-It was then used to study the impact of key variables on project economics. When the most important variables were identified, and their behavior with respect to the bottom line was assessed, a full optimization was run to maximize the net present value of the project.

Coupling effects between the different parts of the project were studied in detail, and any error due to model coupling was minimized while still ensuring short project run times.

All models used in this study are either based on previously published data, or presented in full detail in the paper. This makes the project easy to reproduce.

## Technical Solution using Pipe-It



Two gas-condensate reservoir models were created based on the model presented in the third SPE comparative project (SPE-12278). One reservoir with a lean initial fluid composition, and the other with a richer initial fluid. The produced streams from both reservoirs were fed to a process simulator. The process consisted of a three stage separation to extract condensate. Gas from the second and third stage separation was used for fuel. The first stage gas was fed to a dew point controller to extract NGL. Downstream the dew point controller, a fraction of the gas was taken out for re-injection. The output from the process simulator was fed to an economics package, where the net present value was calculated.

Since the composition of the injection gas is varying with time, the project had to be broken into several restart runs. The simulators were first run for 1000 days, before the process simulator was run to generate the new injection gas composition and rates. The injection gas properties were then updated in the reservoir models, and run for another 1000 days. This process was repeated until the desired simulation time was reached. Finally the economics package was run.

An optimization was run on the project. The goal of the optimization was to maximize net present value by changing:

- Fraction of the processed gas used for injection
- Distribution of injection gas between the two reservoirs
- Duration of gas re-injection
- Temperature of the dew point controller used to extract NGL

The effect of each variable on the net present value was studied separately. This gave a better understanding of how this multi-dimensional optimization problem behaved, and gave estimates on how much each variable affected the overall economics of the project. Another advantage of this was to get better starting points for the full optimization. The starting points were generally chosen at the value giving the maximum net present value.

## Results

The optimization resulted in an increase in net present value of about 10%, from 190 million USD, to 210 million USD. The first figure shows the net present value for each iteration of the optimization, using two different starting points. The last set of figures show the parameter analysis performed on each individual variable.

Several improvements were suggested to increase the realism of the project. These include:

- Improved surface process modeling and related cost
- Injection-gas-compression modeling and related cost
- Scaling up to full-field modeling
- Effect of late-life tie-ins from undeveloped fields, particularly in regard to selecting gas-processing solution
- Optimization on well count and location and well target rates
- Uncertainty analysis: geology, price forecasting, and market demand

Many of these issues were addressed in the follow up paper SPE-130768 – “Multi-Field Asset Integrated Optimization Benchmark”.

