Integrating Gas Lift Well Optimization from Well Model to Field-Scale Network To Assess Additional Compressor Impact

Muhammad Rully C. Shobar (1), Pertamina Hulu Mahakam
Trimaharika Widarena (2), Pertamina Hulu Mahakam
Toni O. Muhroni (3), Pertamina Hulu Mahakam
Bayu Setyo Handoko (4), Pertamina Hulu Mahakam

Abstract

Discovered in 1974, Handil field had reached its production peak in 1977 at 194,000 Bopd before it continued to decline. Water injection began in 1978 in order to maintain reservoir pressure. Later, gas lift facility to provide artificial lift was installed in 1981. Field water cut is currently close to 90% with production level of 16,000 Bopd and 30 MMscfd of gas. The produced gas is used for commercial export, to run compressor in production facilities, fuel consumption, and flare. Oil production is mainly supported by gas lift compressor running at nearly maximum capacity. Therefore, prioritization strategy of gas lift rate (*Qgl*) injected into producer becomes crucial. Well by well evaluation practice to implement the strategy is time-consuming with limited operational flexibility to implement due to numerous active wells (more than 110 active wells). This paper provides an approach of integrated optimization to improve the prioritization strategy and to assess additional gas lift rate impact beyond current gas lift compressor capacity.

An approach to link sub-surface to surface interaction that involves numerous well productivity models and production facility has been developed to construct simulation model in PETEX platform. Validated model can be useful to verify these points: (1) Optimized ΔP choke; (2) Optimized *Qgl*; and (3) Combination of optimized ΔP choke and *Qgl*.

From optimized *Qgl* verification, allocation strategy is evaluated. It shows that *Qgl* optimization provides significant incremental gain. The optimized *Qgl* scenario is developed further into sensitivity case to predict the impact of *Qgl* beyond current maximum capacity (in case of additional compressor). The sensitivity case justified gain estimation on reactivating additional gas lift compressor, from which incremental gain of several hundred barrels of oil per day is observed by production test. As a conclusion, the integrated model is proven useful and efficient for production optimization purpose.

Introduction: Liquid Lifting Issue and Gas Lift Role

Handil field produces 16,000 Bopd and 30 MMscfd of natural gas. The produced gas is used for commercial export, running compressor in production facilities, fuel consumption and flare. Major contributor of the oil production is reservoirs which typical driving mechanisms are weak-to-medium strength aquifer drive. Along with the field maturity, high field water cut (above 90%) is inevitable. Liquid lifting issue is managed by gas lift means. Nowadays, oil field production mainly depends on this type of artificial lift. Gas lift injection is supplied by partial amount of produced gas split into gas lift compressor that circulated back into oil producers. Gas lift compressor H, as seen in Figure 1, running at nearly maximum capacity (90 MMscfd at 85 Barg of discharge pressure). Due to limited capacity, prioritization strategy of gas lift rate (*Qgl*) allocation injected into producer wells is crucial. Well by well evaluation practice to implement the strategy becomes time-consuming due to numerous active wells (more than 110 active wells) with limited operational flexibility to implement.

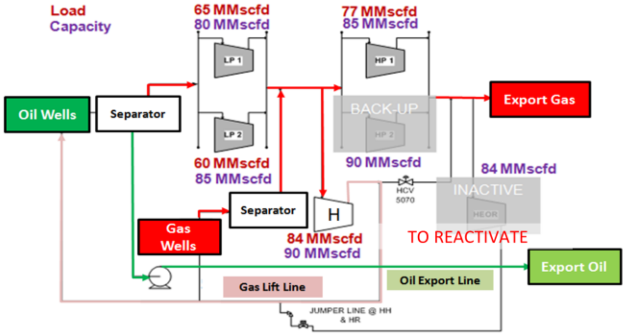


Figure 1: Simplified Production Configuration

Gas Lift Equipment Type in Handil

Most of gas lift methods in Handil are gas lift annulus-type, displayed in Figure 2a: Conventional technology with Side Pocket Mandrel (SPM), Gas Lift Pack-Off (GLPO), and Siphon String. Each design is based on economic and well configuration consideration. Gas is injected into annulus and will continue flow through orifice located in SPM or Pack-Off or Siphon String to lift the liquid in wellbore. Biggest advantage of gas lift annulus type is small pressure loss of gas injection through casing. But, it is limited by top of annulus cement or packer depth.

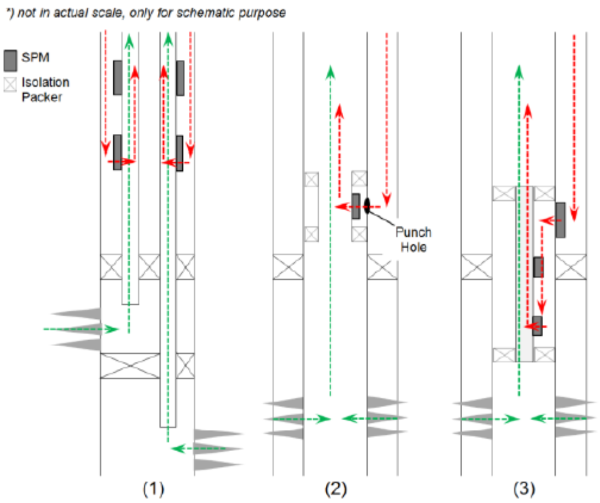


Figure 2a: Side Pocket Mandrel (1), Gas Lift Pack-Off (2), Siphon String (3)

Other types of gas lift method in Handil are Gas Lift Macaroni (GLM) and Gas Lift Deepening (GLD), as seen in Figure 2b. Each of these two types of gas lift method requires special modification / equipment that could be, in few cases, long-lead item. Both have similar advantage: "depth injection is not limited by annulus cement or top packer". Gas Lift Macaroni method injects gas through a string inserted into tubing called "Macaroni". In PROSPER, this type of method is approached by "Coiled Tubing Gas Lift". The main drawback of the method is frictional pressure drop of injection in macaroni. Gas Lift Deepening combines advantages of gas lift annulus and macaroni-like. But, several trial shows that GLD assembly was not sand-resistant which eventually reduced its lifting capacity.

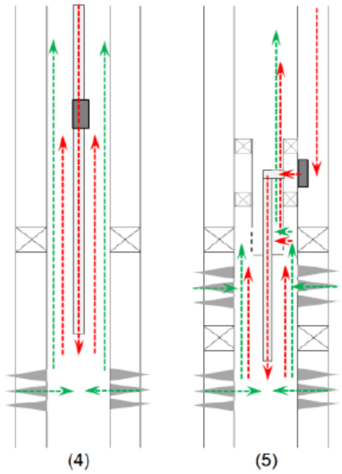


Figure 2b: Gas Lift Macaroni (4), Gas Lift Deepening (5)

Gas Lift Optimization

Gas lift performance of a well significantly depends on gas lift injection depth and well productivity. Therefore, liquid rate vs *Qgl* performance needs to be characterized in order to implement optimum *Qgl* (highlighted in box in Figure 3). The optimum *Qgl* is referred as efficient usage of gas lift injection. Increasing *Qgl* beyond optimum point leads to small increment of liquid production.

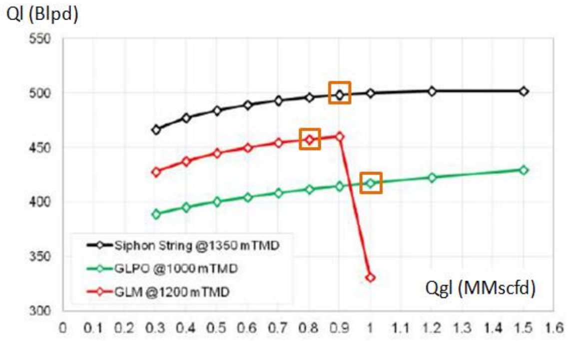


Figure 3: Examples of Gas Lift Performance Curve for GLM, GLPO, and Siphon String

Integrated Production Performance Analysis

Nodal Analysis by Well Model

Key component of gas lift design lies on well dynamic model (Petex PROSPER based) which resembles a physical well: operating flow rate, VLP/IPR or flow performance, and pressure traverse / gradient along the wellbore using input such as liquid rate, gas lift injection rate, well head parameter (well head flowing pressure -temperature) and type of equipment installed from top-to-bottom of the well: choke, joint, obstruction, and gas lift valve. These well models are updated in regular basis for production optimization purpose. Estimate current number of well models (PROSPER.out files) is more than 120. Keeping them update when needed is a major issue.

Integrated Model

In order to simulate interaction between production network and well productivity, dynamic well model alone must be linked to production network model created with GAP platform (Figure 4).

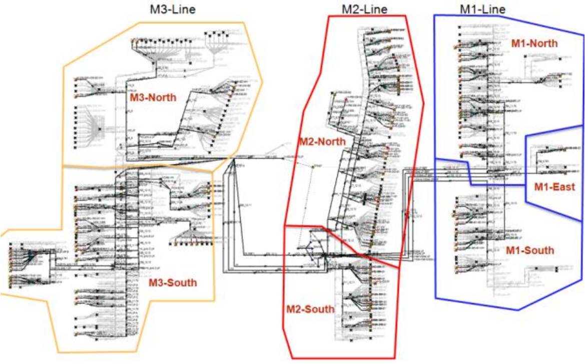


Figure 4: Production Network with GAP

This approach that links sub-surface to surface interaction ultimately provides integrated tools for production performance analysis.

Well Model Validation and Automation

General workflow to create integrated network model consists of three main parts: (1) Well model construction using input from database, (2) Well model validation using PROSPER esp. Open-Server feature, and (3) Network Model Validation, illustrated in Figure 5. Continuous improvement toward automation and digitalization to utilize the well models efficiently has been initiated since 2016. The workflow allows periodic update and simultaneous QC on multiple wells in order to optimize gas lift allocation with respect to gas lift compressor capacity. Detailed workflow can be seen in Figure 6.

System Evaluation

Using validated model, GAP network solver was ran to perform network optimization with two constraints: Maximum 2.0 MMscfd of *Qgl* per well (best practice according to years of field experience) and 84 MMscfd of available total gas lift in the system (average total gas lift rate supplied by existing gas lift compressor). Three scenarios are evaluated: (1) “ΔP choke optimization” which represents choke opening optimization; (2) “*Qgl* optimization” which represents gas lift injection rate optimization; and (3) “ΔP choke and *Qgl* optimization” that combines scenario (1) and (2).

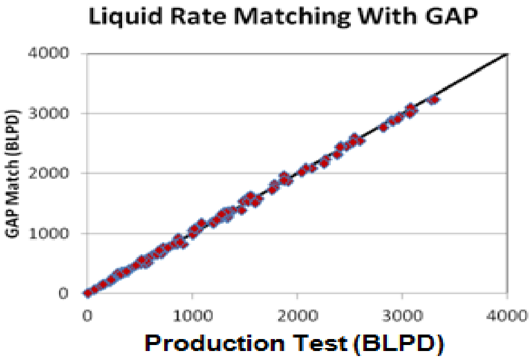


Figure 5: Liquid Balance Check In Network Model Validation Step

By comparing results of scenarios (1), (2), and (3), the combined scenario shows highest potential gain of 3000 bopd. However, to implement the results that involve choke optimization in scenario (1) and (3) is strictly difficult. Some wells with high-productivity are sand-critical risk and being choked for safety issue (e.g. gravel pack completion, less consolidated sand, and other sand control treatment). This drawdown limitation was not inputted in the aforementioned constraints. Scenario (2) “*Qgl* Optimization” is considered to be the easiest to implement despite of smallest gain. The scenario measures under-utilization or over-utilization of gas lift injection rate on multiple wells simultaneously and estimates the impact on total system production. Gain comparison seen in Figure 7. It proposes *Qgl* on several wells to be increased and *Qgl* on some others to be reduced. This re-allocation potentially contributes additional 380 bopd of oil production. Furthermore, prioritization of gas lift injection allocation to meet gas lift availability can be also determined

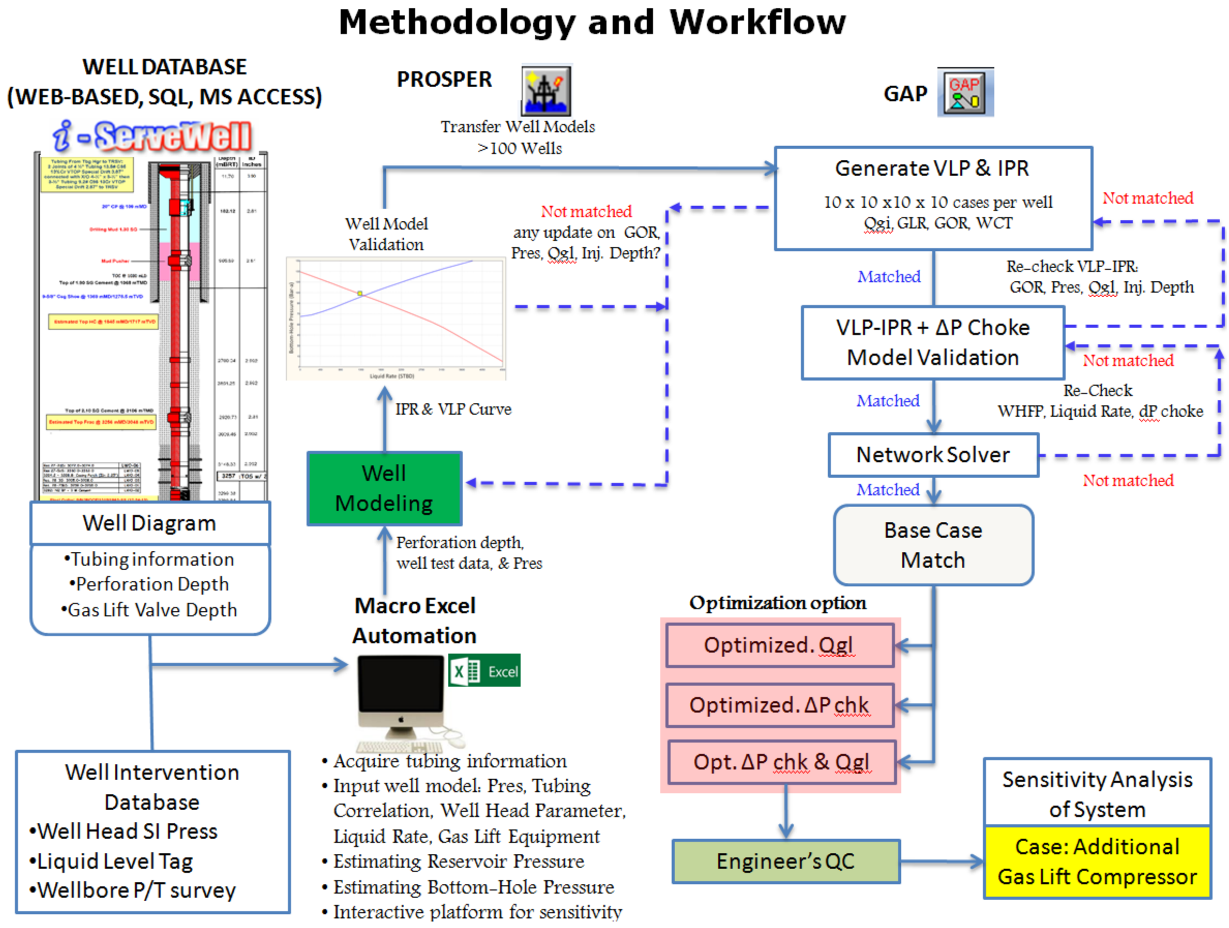
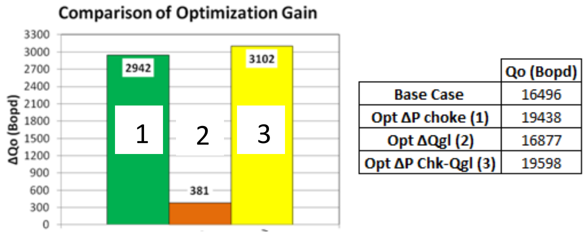


Figure 6: Automation Workflow of Integrated Production Performance Analysis



	Qo (Bopd)
Base Case	16496
Opt ΔP choke (1)	19438
Opt ΔQgl (2)	16877
Opt ΔP Chk-Qgl (3)	19598

Figure 7: Gain of Various Scenarios

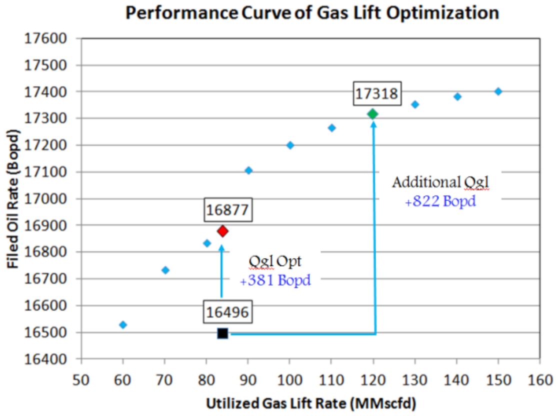


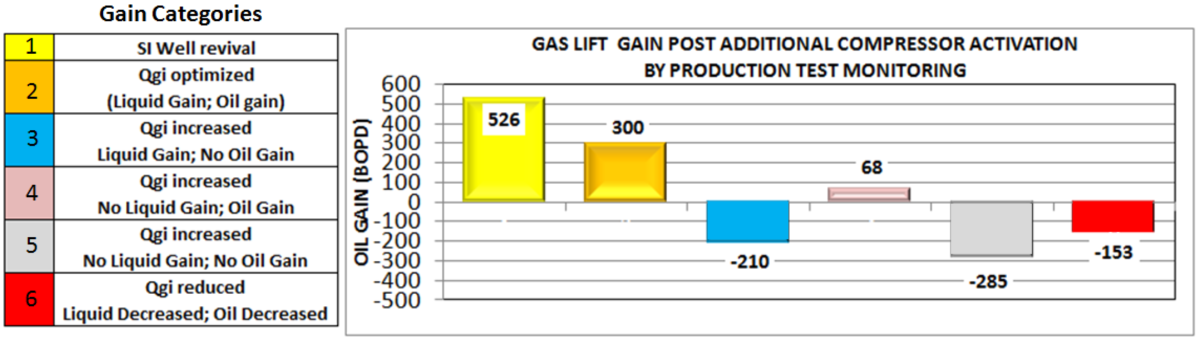
Figure 8: Sensitivity of Gas Lift Performance

Impact of Additional Gas Lift Compressor

Additional gas lift compressor has been planned to activate to increase total gas lift injection capacity until 120 MMscfd. Therefore, production gain estimation is required to justify the decision. Performing sensitivity case using validated integrated model can provide valuable assessment of *Qgl* variation impact. Sensitivity on *Qgl* variation is simulated within range 60 – 150 MMscfd.

According to the sensitivity, increasing total gas lift injection from 84 MMscfd to 120 MMscfd at optimized configuration leads to potential production gain over 800 bopd (Figure 8).

This potential gain seems interesting regardless drawdown limitation on sand-risk wells. In more simple way, by optimizing and increasing injection capacity, it is more likely to improve production in magnitude of 300 – 800 bopd. Another benefit of additional compressor is opportunity to revive wells have been shut-in due to existing gas lift capacity. Due to additional capacity, we can restart gas lift injection in order to produce them. Generally, these wells were producing < 100 bopd with water cut > 95 %. Well revival gain is targeted to contribute around 500 bopd.



Gain Categories

1	SI Well revival
2	Qgi optimized (Liquid Gain; Oil gain)
3	Qgi increased Liquid Gain; No Oil Gain
4	Qgi increased No Liquid Gain; Oil Gain
5	Qgi increased No Liquid Gain; No Oil Gain
6	Qgi reduced Liquid Decreased; Oil Decreased

Figure 9: Gain Observation Post Additional Compressor Activation

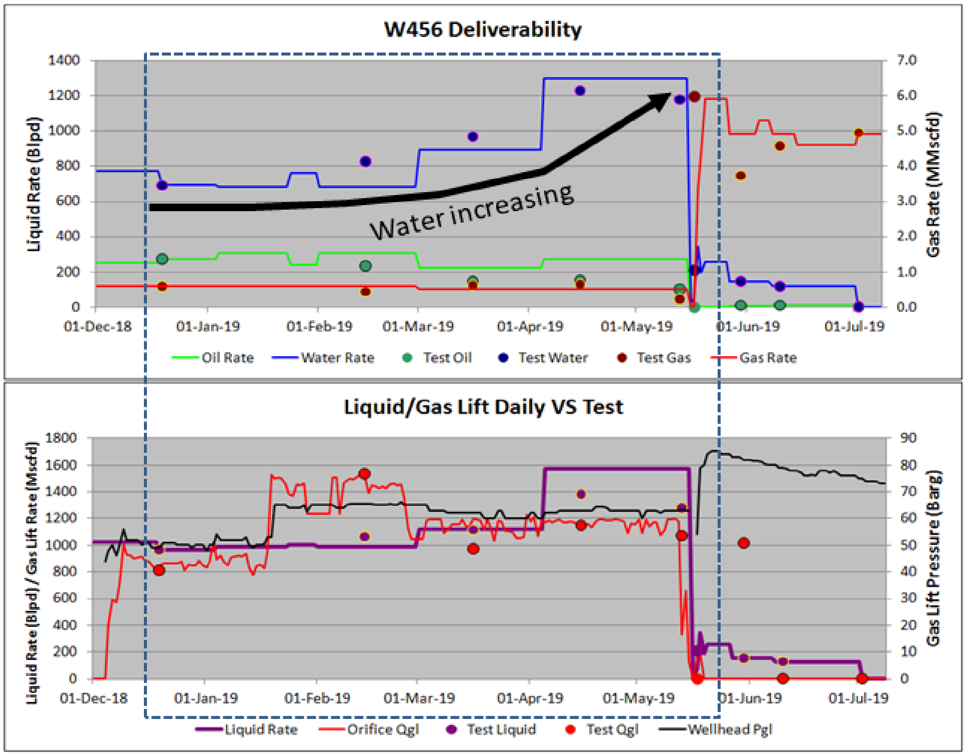


Figure 10: Example of Water Breakthrough

Actual Results by Observation (Why it works / does not work)

Additional gas lift compressor was activated in mid January 2019. Observation of the impact took months until total gas lift injection rate achieved 120 MMscfd and stabilized. The observation relies on routine production test by mobile testing unit in every 1 week up to 4 weeks on wells having *Qgl* change after additional compressor activation.

Referring to production tests in period of December 2018 – mid April 2019, gas lift well revival and optimization contributes significant gain > 800 bopd (Gain Category 1 and 2 in Figure 9). Meanwhile, Gain Category 4 is considered as water-cut sampling normal fluctuation. However, optimized *Qgl* on some wells does not always gain.

This case is represented by Gain Category 3, 5, and 6 in Figure 8. Most of wells in those categories experience rapid water increases / water breakthrough (Figure 10). Increasing Qgl can increase liquid rate, but oil rate keeps decreasing. Another complication also comes from detrimental perforation activity which produces more water than oil gain. Thus, Qgl optimization gain observation is only valid for baseline wells (no intervention activity), stable water-cut producer, and routinely tested in less than 4 weeks.

Conclusions

1. Integrated Model is proven useful and more efficient method than well by well evaluation for field-scale production optimization purpose
2. The model is able to determine gas lift prioritization in a limited gas lift supply condition
3. Model sensitivity result justified potential gain of 300-800 bopd by additional compressor activation and the gain is validated by actual observation from production test
4. The method has limitation in quantifying optimized *Qgl* impact on well experiencing water breakthrough / rapid BSW increase. Immediate production test after *Qgl* change could be the solution to this issue

References

Krishna, A. and Noverri, P., 2016, Retrievable Gas Lift, **Proceeding IPA16-105-E**, 2–3.

Ashfahani, A. S., and Wijaya, G.L., 2018, Gas Lift Guidance, **Proceeding IPA18-276-E**, 2–9.

Widarena, T. and Sulistiyo, 2018, Well Performance Technical Notes, **WPTMTH-28-1812**, 1-5.

Acknowledgements

The authors gratefully acknowledge permission from SKK MIGAS, Pertamina , Pertamina Hulu Indonesia, and Pertamina Hulu Mahakam to publish this paper. Our biggest gratitude is also given to all the parties who kindly provided valuable comments and inputs during the preparation of this paper especially Geoscience and Reservoir Engineering Division and Well Performance Department of PHM.