Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Darajat Unit II/III Interface Debottlenecking Project

Wibisono Yamin, Miftachul Choiri, Amsal Goesmano, and Temy Nurfahmiawati

Chevron Geothermal Indonesia, Ltd., Sentral Senayan II, 24th Floor, Jl. Asia Afrika 8,Jakarta, Indonesia 10270

E-mail: wibisono@chevron.com

Keywords: Geothermal steamfield, debottlenecking, Darajat, decline rate reduction, surface facility optimization.

ABSTRACT

In Darajat asset, West Java – Indonesia, Chevron operates a steamfield which supplies Chevron's two units of power plant (Unit II and III) and also one unit of power plant, owned by the National Electricity Company (Unit I). Unit II and III's main steam line has a common pipe header which is equipped with 18-in of hydraulic actuated ball valve for each unit to control the interface pressure (Pressure Control Valve). By design, the interface pressures are controlled by 16 bar(a) for Unit II and 17.27 bar(a) for Unit III. As Unit III has the highest interface pressure, operation of Unit III PCV sets the common pressure upstream of both Unit II and III PCVs. With current condition, where upstream PCV pressure is 19.5 bar(a), the pressure drops calculated across Darajat Unit II and Unit III PCV station are 3.5 bar and 2.2 bar respectively. Reservoir model has shown that reducing pressure drop across PCVs will allow the wells to produce at a lower well head pressure, which results in decline rate reduction.

The debottlenecking process is to be done in two (2) stages. For the first stage, Unit III PCV is to be debottlenecked by installing a parallel PCV to reduce the pressure drop by 1.04 bar. At the second stage, in order to reduce the pressure drop of Unit II PCV, Unit III header must be separated from Unit II by modifying the interface header to dedicate the steam line, and then it is followed by installing a parallel PCV to further reduce the pressure drop of Unit II PCV by 1.7 bar. From the reservoir model, the surface facilities pressure drop reduction resulting from these debottlenecking projects can lower the decline rate from 9.3% to 7.6%, thus benefiting the company by deferring the drilling of 11 makeup wells.

1. INTRODUCTION

1.1 Overview

Chevron is already one of the largest producers of geothermal energy in the world, with a current capacity of 1,273 MW, Chevron has developed 27% of the world's geothermal power (Williamson et al. 2007). In Indonesia, Chevron manages two geothermal projects—Darajat and Salak, both on the island of Java. The Darajat and Salak projects generate respectively 259 and 377 megawatts of electricity. The combined output from our Darajat and Salak geothermal operations now produces sufficient renewable energy to supply approximately 4 million homes in Indonesia (Chevron Indonesia Fact Sheet 2013).

Figure 1: Chevron's Geothermal Assets in Indonesia

Darajat geothermal operation comprises three geothermal power plants; Unit I (55 MW), Unit II (95 MW) and Unit III (121 MW). Chevron supplies steam to Unit I, which is owned and operated by PLN (Indonesia's National Electricity Company) under its subsidiary PT.IP (Indonesia Power), and to Units II and III, which are owned and operated by Chevron. The total steam produced to run these three units is 476 kg/s in average. Unit I started to operate commercially in 1994, Unit II in 2000 and Unit III in 2007.

The Darajat geothermal resource produces high purity dry steam at pressures of up to approximately 28 bar(a) in average. The reservoir temperature is around 240°C and the Non Condensable Gas (NCG) contained in the steam is less than 0.5% at wellhead flowing condition.

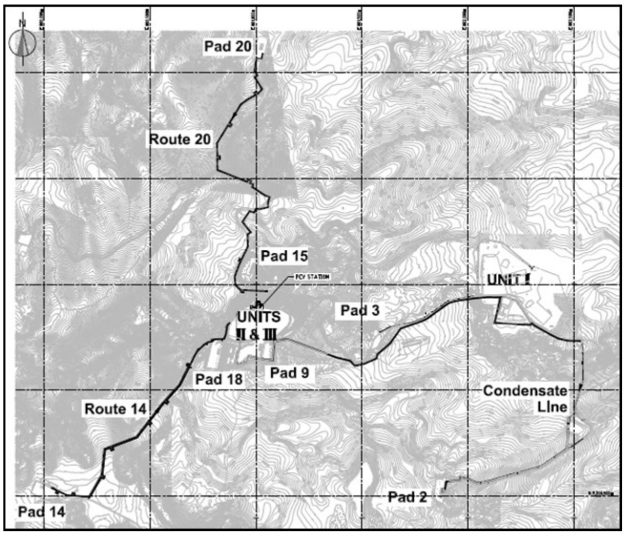

Figure 2: Darajat Geothermal Field Map

The Darajat resource area contains some 49 wells with widely varying production characteristics. The Darajat Unit II and III steamfield are supplied by four wellpads (Pads 14, 18, 15 and 20). All available wells on these pads have been connected to the steam supply mains. The steam collected in the steamfield is piped directly to the power plant without requirement for separation. Pressure control valves are installed near to the power plants to control the power plant interface pressure. Unit II and III each have a single high performance hydraulically actuated ball valve with noise attenuating trim to control interface pressure. The normal operation interface pressures are controlled to be 15.6 bar(a) and 17.3 bar(a) for Units II and III.

The design basis of the three power plant units is shown in Table 1.

Table 1: Darajat Unit I/II/III Power Plant Design Basis

Data	Unit - I	Unit - II	Unit - III	
Generation Capacity (MW)	55	95	110	121 (uprated)
Turbine Inlet Pressure (bar(a))	10	15.1	15.2	16.6
Specific Steam Consumption (kg/s/MWe)	1.84	1.69	1.68	1.68
Operated by	PT. IP	CGI	CGI	CGI
Start Operated Commercially	1994	2000	2007	2009 (uprated)

Existing Darajat Unit II/III interface area consists of steam pipe from north area (Pad 15 and 20) and south area (Pad 14 and 18), block valves, PCVs, rupture disc banks, and venting system (vent line and rock muffler).

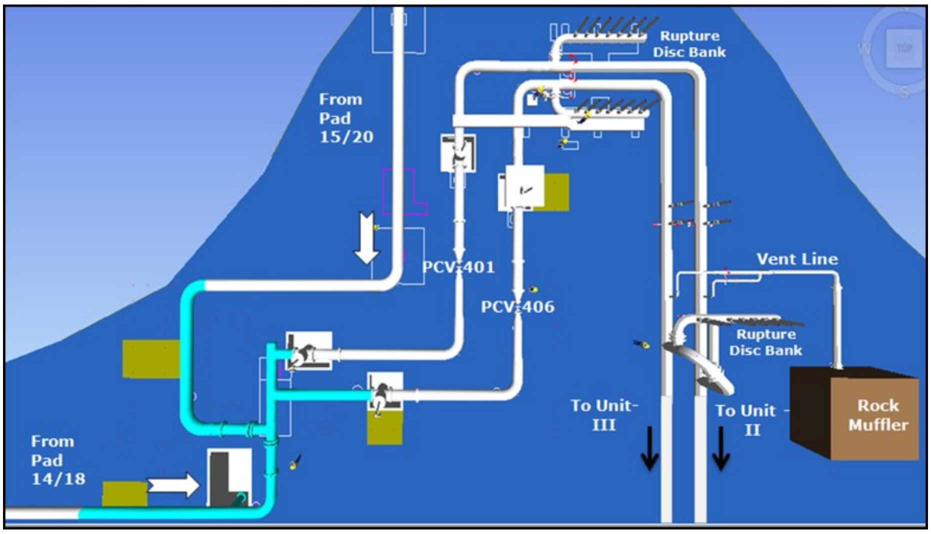

Figure 3: Darajat Unit II/III Interface Piping Arrangement

The pressure at the interface between the PCV station and power plant is controlled by PCV-401 (for Unit II) and PCV-406 (for Unit III). The set point position of PCVs is modulated by a pressure controller to maintain the interface pressure, measured by pressure indicator transmitter downstream the PCV. The PCVs and vent valves are operated by hydraulic actuators.

1.2 Objective

With the continuous plant operation, a decline of the reservoir pressure will naturally take place. Without proper reservoir management and operation strategy, resource depletion or even deterioration may occur which can harm the investment from a premature steam shortage that can cause the breakdown of a commercially viable operation. In Darajat field, after 20 years of continuous operation, the decline rate is about 9.3%.

To ensure a reliable and sustainable electricity generation, Chevron Geothermal Indonesia is performing an Integrated Production System Optimization project to reduce decline rate by reducing surface facilities pressure loss and changing steamfield operation mode to operate steamfield at lower wellhead pressure, which can lead to the extension of steam supply plateau and defer the required make up wells drilling program. This optimization project is called Darajat Unit II/III Interface Debottlenecking Project.

This paper aims to bring forward the background of the optimization project and the methods applied to achieve the target in reducing decline rate and deferring make up well drilling.

2. THEORY

Darajat Unit II and III are supplied with steam from 18 wells located on four wellpads (Pads 14, 18, 15 and 20). Prior to the debottlenecking project, the steam header pressure upstream PCV of Unit II and III was 19.5 bar(a). Pressure drop profile from wellpad to PCV station and steam production flow rates at wellhead pressures are presented in Table 2

Table 2: Summary of outputs of wells assigned to Units II and III (March 17, 2011 data)

Location	Average Wellhead Pressure (bar(a))	Total Steam rate, (kg/s)	dP from Well to PCV station, bar
Pad 14	20.5	83.2	-1.0
Pad 18	20.4	100.3	-0.9
Pad 15	20.3	67.7	-0.8
Pad 20	21.1	126.3	-1.7

The average pressure drop across PCV-401 and PCV-406 are shown in Table 3.

Table 3: Pressure Drop across PCVs

Unit	Average Upstream PCV Header Pressure, bar(a)	Downstream PCV Design Pressure, bar(a)	dP across PCV, bar
II (PCV-401)	19.5	16.0	3.5
III (PCV-406)		17.3	2.2

The data shown in Table 2 and Table 3 pointed out that the average dP across PCVs contribute to 84% of the total pressure drop from production pad to interface. This indicates a bottleneck is occurring at PCV station. To provide an illustrative pressure drop profile from reservoir to turbine, a simplified field wide pressure profile is shown in Figure 4.

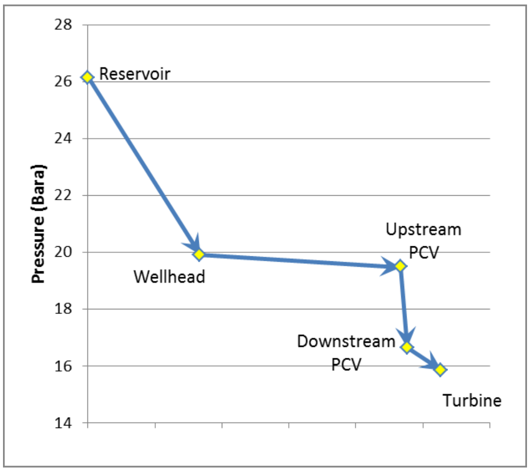

Figure 4: Simplified Field-wide Pressure Profile from Reservoir to Unit II/III Turbines

It is clearly shown that the biggest pressure drop at the surface facilities is taking place in the PCV station of Unit II and III. An optimization effort needs to be made on this particular area.

From an integrated production system perspective, pressure drop reduction in the surface facilities could impact the decline rate positively and extend the steam supply plateau, which will maintain the production system operation. This concept is explained as follows:

- The whole production chain from reservoir to the turbine is basically a “pipeline” with different segments. The turbine inlet pressure is fixed to maintain the generation target.
- The most expensive segment is subsurface “pipeline” from reservoir to wellhead. This segment consists of 23 wells with approximately USD 5 million each. Optimization in wells is done by locating the largest pressure loss in the wellbore (the most expensive segment) and using the smallest possible size. Pressure loss in the other segments then shall be minimized.
- As explained, the biggest contributor of surface facilities pressure drop is the PCV station. Debottlenecking performed in this area, at which the initial and end nodes pressures remain constant; will lower the wellhead and upstream PCV pressures, as shown in Figure 5.

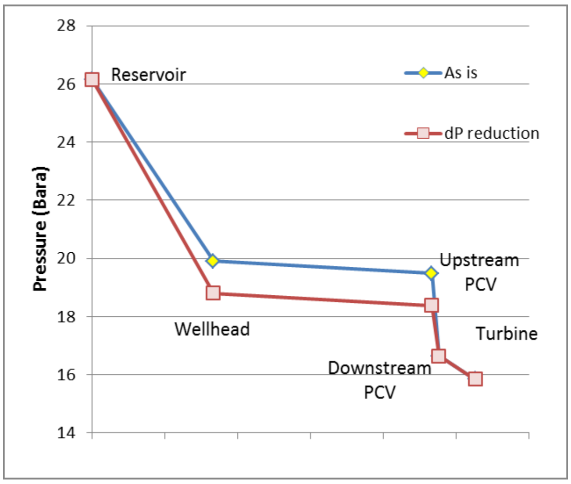

Figure 5: Simplified Field Wide Pressure Profile with dP Reduction at PCV Station

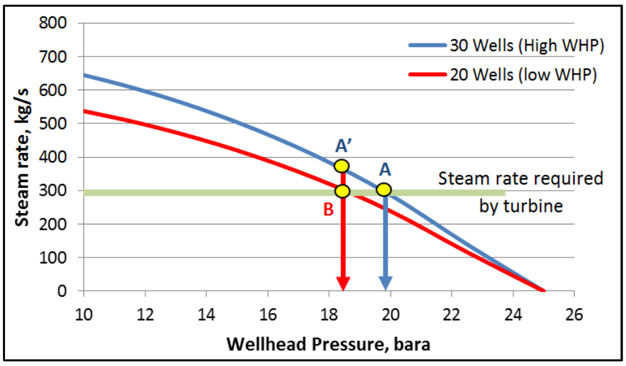

Figure 6: Operate Steamfield at Different Wellhead Pressure Scheme

- According to well deliverability profile, illustrated in Figure 6, lowering wellhead pressure (WHP) from A to A’, will allow the wells to produce at higher flowrate. With the same turbine inlet pressure and efficiency, the total steam required should be the same. Therefore, the number of wells being operated need to be reduced (from A’ to B). In this particular case, 10 wells can be taken offline without reducing the generation.

Operating production wells at lower wellhead pressure may lower the decline rate and require a smaller number of make-up required. Over time, the pressure gradient difference between the reservoir and the well head pressure will be larger for higher WHP. As the well deliverability is governed by this pressure difference, wells operating at higher WHP will have greater decline compared to being operated at lower WHP.

3. IMPLEMENTATION

According to Figure 3, Darajat Unit II and III main steamline have a common pipe header which is equipped with high performance hydraulically actuated ball valve as the pressure control valve. Each existing valve has 18” nominal size. By design, the interface pressures are controlled to 16 bar(a) for Unit II and 17.27 bar(a) for Unit III. As the Unit III interface pressure is the highest, operation of the Unit III PCV dominates the flow conditions as it sets the common pressure upstream of both the Unit II and III PCVs. Reservoir model has shown that reducing pressure drop across PCVs can allow the wells to produce at lower well head pressure, and this may impact to decline rate positively.

3.1 Alternative Analysis

During the design phase, the project team assessed several alternatives in selecting the most suitable way to debottleneck or reduce the pressure drop at interface area from the perspective of installation cost, system performance, controllability, and safety. In summary, the alternative analysis is shown in the table below:

Table 4: Set of alternatives to reduce pressure drop across PCVs

Option	Description	Cost	Performance (dP Reduction)	Remarks
1	No PCV (pressure control is done by continuously venting the excess steam to rock muffler)	Very High	Very High	Highest risk profile (change entire pressure control philosophy), jeopardize Darajat CDM by wasting steam, big scope of modification (high production loss)
2	Replace with bigger PCV(up to 24”)	Low	Low	Existing PCV and its spares will be unused, new issue in controllability with bigger valve size
3	Install new parallel with bigger PCV (up to 24”)	High	High	Requires new set of PCV and spares, issue in controllability related to different size of valves
4	Install new parallel with same size (18”)	Medium	Medium	Good maintainability (reduce number and type of spares parts), easier to control with certain logic modification

The project team selected option no (4) to keep operating the existing pressure control system and accomplished the pressure drop reduction by installing a parallel PCV at both Unit II and III interface with similar valve specification and size. This option also has higher maintainability and controllability compared to other options. The selected alternative then was proceeded to the detail engineering phase.

3.2 Project Development

Taking into account pipe stress compliance, installation cost, constructability, and the level of pressure drop, the engineering details resulted in piping arrangement as shown in Figure 7.

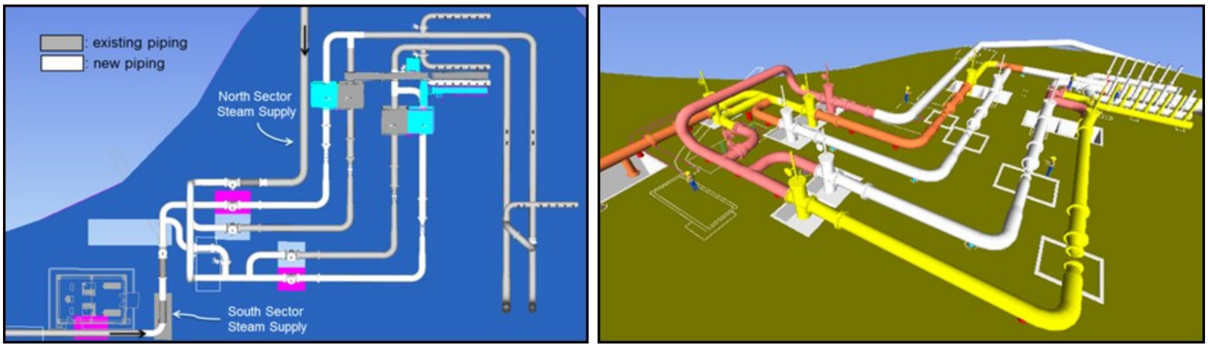

Figure 7: Unit II/III Interface Piping Post Debottlenecking

With this arrangement, North Sector steam supply line from Pad 15/20 that is dedicated to Unit III was connected to Unit III header through an overhead pipe loop, while the South Sector steam line from Pad 14/18 was connected to Unit II. A cross over line between the two headers was provided with butterfly valves and a spectacle blind to provide flexibility, allowing for operation in separate or common header modes.

The engineering design also assessed the capacities of the existing overpressure protection and hydraulic systems required for the installation of new parallel PCVs. The result of the assessment suggested the installation of an additional rupture disc bank and a hydraulic package for Unit III due to the increased required venting capacity and hydraulic rate.

Considering the different interface pressure of Unit II and Unit III, the debottlenecking process proceeded in two stages as follows:

1). Stage 1.

With Unit III operating at higher inlet pressure (1.5 bar higher that Unit II), and with the connected header; Unit III PCV needs to be debottlenecked first to reduce the header pressure. This first stage will be performed by installing the parallel PCV for Unit III.

2). Stage 2.

At the second stage, in order to reduce the pressure drop across the Unit II PCV, the Unit II and Unit III header must be separated to isolate the Unit II system pressure from Unit III along with Unit II PCV debottlenecking.

The new control equipment installed under this project will consist of:

- Two (2) 18-in PCVs each with a hydraulic actuator,
- Two (2) hydraulic power packs which operate on a duty/standby basis,
- Steam pressure indicators and transmitters.

Aside from the installation of new equipment, modifications to the existing Yokogawa Integrated Control and Monitoring Systems (ICMS) installed in the Darajat Unit II and III Power Plants are required as part of the overall project. The control mode selected for parallel PCV operation was a split-range mode that provides additional features such as enabling or disabling each PCV and the ability to select which of the two PCVs in each pair will be the 'lead' PCV.

The expected operating condition of the PCVs is:

- During normal continuous operation, where both Unit II and III are at rated capacity, both its PCVs will be nearly fully open, operating in automatic control maintaining the Unit's interface pressure at the required set point value.
- The PCVs will not operate at 100% open during normal operation. This is because, it is necessary to maintain spare steamfield capacity so that the PCVs can be automatically opened to maintain the interface pressure set point value during events such as:
    - Reduction in steamfield production (for example: during periods of rain)
    - Increased Unit steam flow demand (for example: due to fluctuations in grid conditions)
- During normal operation, the steamfield production will be managed to ensure that the PCVs are operating at the required position to provide sufficient spare capacity.

The economics of the project was estimated based on the pressure reduction target post implementation of Unit II/III parallel PCV project is as follow:

Table 5: Pressure Reduction Target of Debottlenecking Project

Description	Upstream U-III PCV, bar(a)	Upstream U-II PCV, bar(a)	U-III Pads, bar(a)		U-II Pads, bar(a)	
			Pad 15	Pad 20	Pad 18	Pad 14
Reference Case(i)	19.5	19.5	20.30	21.15	20.4	20.5
Stage 1 dP reduction, bar	-1.04	-1.04	-1.01	-0.98	-1.01	-0.97
Post Stage 1 Condition	18.5	18.5	19.3	20.2	19.4	19.5
Stage 2 dP reduction, bar	No impact	-1.68	No impact	No impact	-2.06	-1.9
Post Stage 2 Condition	18.5	16.8	19.3	20.2	17.4	17.6

(i). average operation data taken on March 17, 2011 during the design phase of the project

By having the above WHP reduction, the Stage 1 and 2 were targeted to defer 6 and 5 make up wells, respectively. The target was made with the assumption of 20 kg/s production rate per well to be drilled at 9.3% decline rate.

3.2.1 First Stage Debottlenecking

The installation of Unit III parallel PCV was completed July 8, 2013 and commissioned July 9-20, 2013. The commissioning was done along with the startup process of the Unit III and planned to be done in five (5) steps. This commissioning steps were designed to ensure the controllability of the new PCV system over the full range of operation regime, therefore the tests were performed initially at no Unit load with only limited steam flow, then at progressively higher loads (low, medium, high) until the Maximum Continuous Rating (MCR) condition of the Unit (121 MW) was attained. The reason that progressively higher loads were used is that the transient behavior of the interface pressure is determined by both the steam flow rate, and the speed of action of the PCVs and/or vent valve.

The commissioning test was stopped during high load step on July 17, 2013 due to a PCV problem. It was then continued September 3-5, 2013 after the problem resolved to test PCV control at MCR.

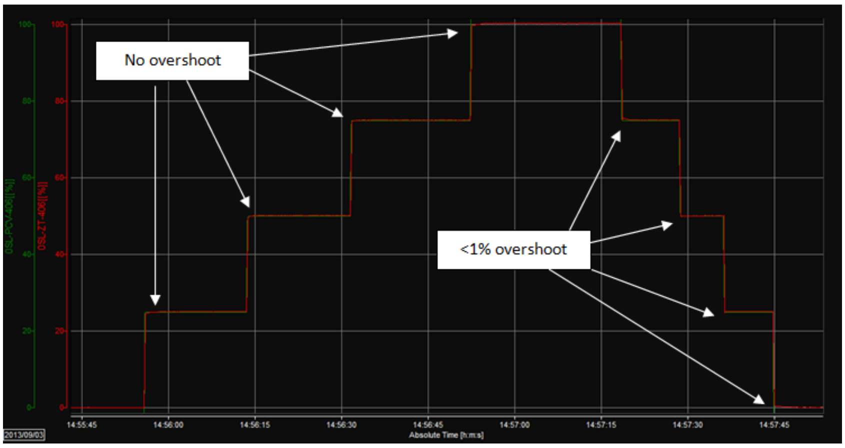

Figure 8: Unit III PCV Response with Step Change Position Demand

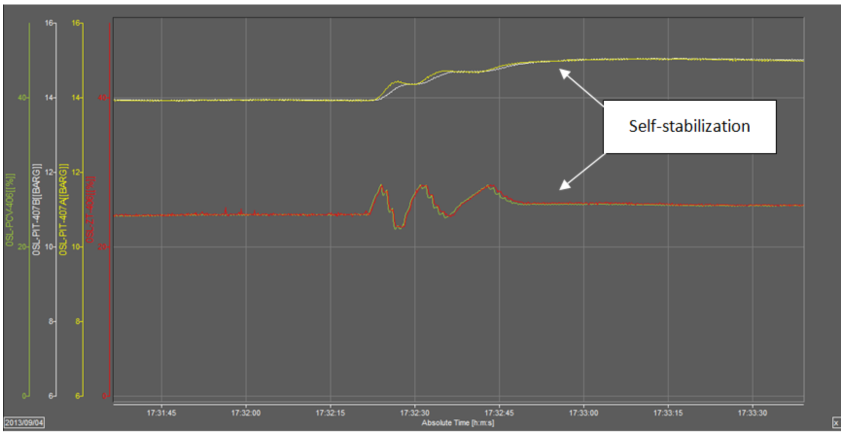

Figure 9: Unit III PCV Response with Pressure Set Point Step Change

Overall, the commissioning tests successfully confirmed the tuning of the new control logic, PCV control at split range point, the PCVs change over capability, the governor feed forward action on trip-to-house load, the ESD action on turbine trip scenario, and the vent valve capacity to support parallel PCV operation. Unit III parallel PCV has been in operation since then.

3.2.2 Second Stage Debottlenecking

The installation of the Unit II parallel PCVs was completed November 27, 2013. The commissioning tests for Unit II PCV is similar with the test for Unit III but with fewer steps (4) because the MCR is lower (95 MW). The tests started December 4-5, 2013 to confirm PCVs and vent valves response at no load. The tests continued in January 17-22, 2014 for progressive load increases along with the startup of Unit II post the generator repair program. The tests of Unit II were not completed due to operational problems at Unit II that forced the test to stop at the medium load step (50 MW). However the tests that had been conducted were able to confirm the safe and reliable operation of parallel PCVs for normal mode and during load rejection case.

The commissioning was planned to be continued with full load scenario after the problem resolved.

4. ANALYSIS

Post commissioning of Unit III parallel PCV, as part of the project scope, FE and Operations conducted performance test between September 23 and October 2, 2013 for the new PCV station of Darajat Unit III. At the time the test was conducted, Unit II repair program had not been completed, thus only Stage 1 of debottlenecking was to be tested. The test was intended to confirm the ability of the new Unit III dual PCV system to achieve the project goal of reduced PCV dP and lowered steamfield WHP without sacrificing the generation, as iterated in the project design. With the constant downstream PCV station pressure (PCV set point), the dP reduction is indicated by the decrease of upstream PCV pressure. The test was conducted in two steps to confirm the maximum impact of the project in reducing the upstream PCV pressure.

4.1 First Performance Test

This first step was to confirm project economics as planned in design phase by reducing the Unit III upstream PCV pressure to 18.3 bar(a). The upstream pressure target was achieved by shutting in some wells. All of the related parameters were monitored continuously though the Plant Information system (PI).

At the initial condition, upstream pressure at the Unit III PCV station was stable at 21.6 bar(a) and steam was supplied from three (3) pads, Pad 14, 15 and 20. At the beginning of the test, only one PCV (Lead) was in operation. When the wells started to be shut-in, second PCV (Follower) started to open. At the end of the first test, the upstream pressure at the Unit III PCV station was lowered to 18.1 bar(a) with the Lead and Follower PCV opening at 100% and 81% respectively, reducing the PCV station dP by 3.5 bar. During the test, Unit III generation was stable at 121 MW.

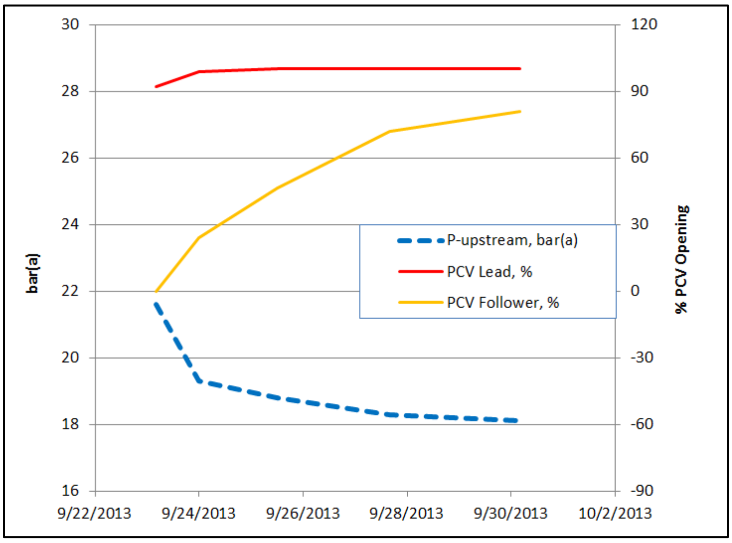

Figure 10: Unit III Upstream Pressure Changes vs. PCV Opening

The tests showed that operating the piping upstream of the PCV station with lower pressure had the desired impact on the reduction of the WHP of wells being operated with an increase on the steam produced. The average WHP reduction on each pad varied based on its distance from the PCV station and the change of steam rate. Lowering the upstream pressure of the PCV station by 3.5 bar decreased the WHP by 3.3 bar on average. An example of the reduction of average well head pressure on a pad is shown in Figure 11.

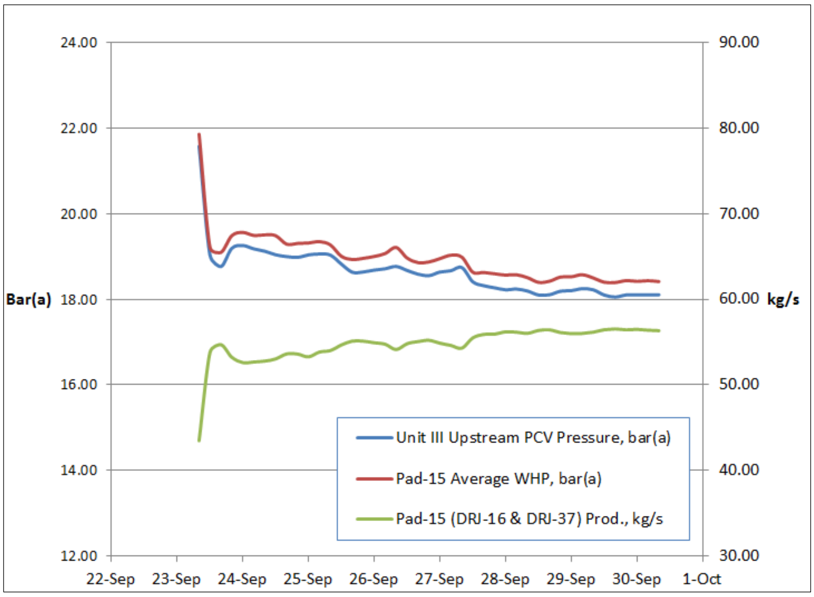

Figure 11: Pad-15 WHP and Flowrate Changes during First Step

It was observed that Pad-15 average WHP changed proportionally to the change of Unit III upstream PCV pressure. The observed pressure difference between these two locations during the test was relatively constant at 0.3 bar on average. At the end of the test, Pad-15 average WHP was at 18.4 bar(a); this was 0.2 bar lower than the predicted value (18.6 bar(a)).

It was also observed that the well production increased in correspondence with the decrease of the WHP according to the well deliverability characteristic. At the beginning of the test, Pad-15 was recorded to produce the total of 43.8 kg/s steam from DRJ-16 and DRJ-37. At the end of the test, the total production from these two (2) wells increased by 28.7% to 56.3 kg/s.

The summary of the first step result is shown in Table 6.

Table 6: First Performance Test Results

Data	Initial Condition	Post Test
Upstream PCV Press, bar(a)	21.6	18.1
Average WHP, bar(a)		
Pad 14	21.8	19.3
Pad 15	21.9	18.4
Pad 20	22.2	18.4
Total Steam Rate, kg/s		
Pad 14	68.7	94.9
Pad 15	43.8	56.3
Pad 20	30.2	40.4

Total measured steam gain from Pad 14, 15 and 20 after the first step was 49.0 kg/s or 34.3% of the initial wells production rate.

4.2 Second Performance Test

A second step was conducted to bring the upstream PCV pressure from the first step condition down to the lowest possible without generation impact. This was to confirm the maximum effect of the debottlenecking to steam field WHP reduction. At this step, the upstream pressure was to be lowered to 17.8 bar(a) by further shutting in or throttling wells; the opening of the PCV Follower was not expected to be more than 96%.

At the initial condition, the upstream pressure of Unit III PCV station was stable at 18.1 bar(a) and steam was supplied from three (3) pads, Pad 14, 15 and 20. At the beginning of the test, the PCV Follower was at 81% opening. When the wells were shut-in, the PCV Follower opening increased. At the end of the second test, the upstream pressure at Unit III PCV station was lowered to 17.8 bar(a) with the Lead and Follower PCV opening at 100% and 96% respectively as shown on Figure 12. This test was able to reduce the PCV station dP by 0.3 bar from the first step condition. During the test, Unit III generation was stable at 121 MW.

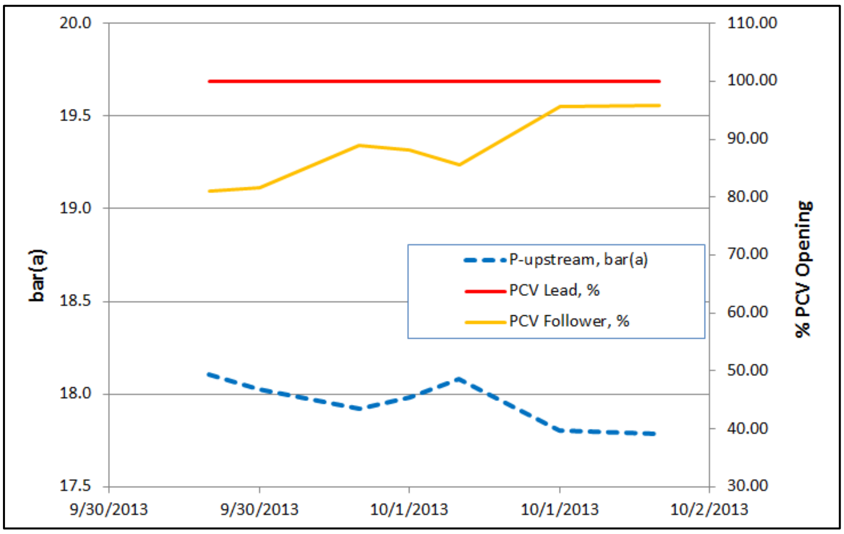

Figure 12: Unit III Upstream Pressure Changes vs. PCV Opening during Second Step

The tests showed lowering the upstream PCV station by 0.3 bar decreased the WHP by 0.28 bar in average. An example of the reduction of average well head pressure on the pad is shown in Figure 13.

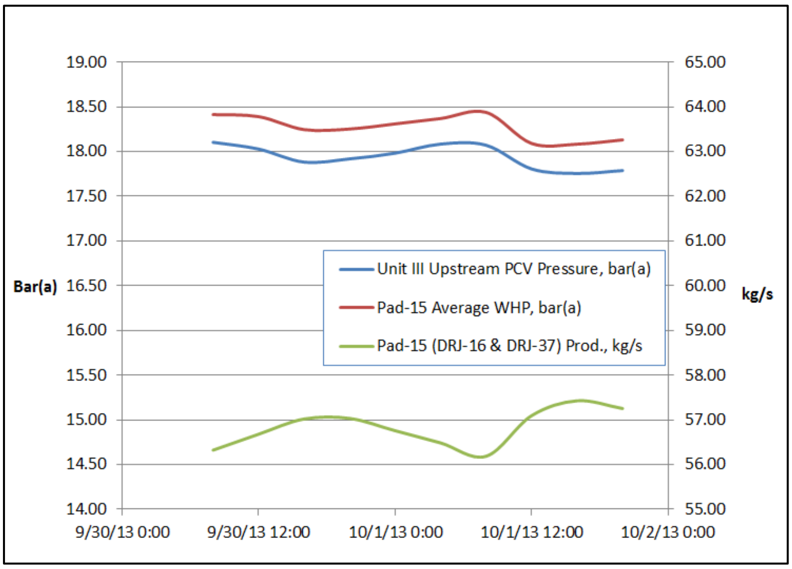

Figure 13: Pad-15 WHP and Flowrate Changes during Second Step

It was observed that Pad-15 average WHP changed proportionally with the change of Unit III upstream PCV pressure. At the end of the test, Pad-15 average WHP was 18.1 bar(a). With this 0.28 bar WHP decrease, the total production from Pad 15 (DRJ-16 and DRJ-3) wells increased by 1.6%, from 56.3 to 57.2 kg/s.

The summary of the second step result was shown in the following table:

Table 7: Second Performance Test Results

Data	Initial Condition	Post Second Step
Upstream PCV Press, barg	18.1	17.8
Average WHP, barg		
Pad 14	19.3	18.9
Pad 15	18.4	18.1
Pad 20	18.4	18.1
Total Steam Rate, kg/s		
Pad 14	94.9	97.1
Pad 15	56.3	57.2
Pad 20	40.4	40.7

Total measured steam gain from Pad 14, 15 and 20 after the second step was only 3.6 kg/s or less than 2% of the production rate post the first step. At this point, the PCV Follower opening was more than 95%, a value that was not favored from PCV controllability perspective. Considering the limited impact of the second step to the steam gain and the need to maintain a room to anticipate an upset condition, it was then recommended to operate the double PCVs system with the PCV Follower at 80-85% range of opening; with 18.1 – 18.3 bar(a) upstream pressure at Unit III PCV station.

From project economic standpoint, to meet the target of Stage 1 in deferring six (6) makeup wells at the initial 9.3% decline rate, the new system should be able to get 109 kg/s steam gain from lowering WHP. This steam gain target is around 29.6 % of the total Unit II and III steam demand. Overall, the first performance step was able to increase wells deliverability by 34.3% from the initial well production rate, thus exceeded the said steam gain target. This is a clear indication that the project is able to achieve the target improvement of reservoir condition. However, a full project lookback to evaluate the performance of the new system will be done once the Unit II parallel PCV is put in service.

The performance test for Unit II parallel PCV is planned to be conducted after the Unit is back to normal operation.

5. CONCLUSION

Chevron Geothermal Indonesia considered doing optimization of the pressure drop around the interface area of the Darajat Unit II and Unit III power plants. The pressure drop across the PCVs of Unit II and III had been identified as a bottleneck which if reduced could provide economic and operational benefits. The pressure drop reduction can potentially increase the flowrates of the existing production wells and reduce the need of drilling new make-up wells in the Darajat field. The debottlenecking process was performed by installing parallel PCV at Unit III and Unit II, and separating the header of the two power plants

Performance test conducted for the Unit III parallel PCV showed that pressure drop reduction at PCV station was able to effectively lower the WHP of the production wells and increase flowrates significantly. Since Unit II is not back to its normal operation, the newly installed parallel PCV could not be tested at the current time. Nevertheless, indication of the project output demonstrated by the Unit III parallel PCV performance test has given confidence to the project team and stakeholders that the debottlenecking will result in improvement in steamfield operation as expected.

Darajat Unit II/III Interface Debottlenecking Project is one of best practices of geothermal steamfield optimization as part of the Surface Facilities Optimization and Integrated Production System Optimization processes. This project has been a show case of good synergy between surface and subsurface teams in identifying and developing debottlenecking efforts for the geothermal surface facility which can benefit the company by deferring makeup wells and extending steam supply capacity to meet operation target. In response to changes in reservoir condition and operation mode, improvement efforts must be done as an integration process between Resource Management, Facility Engineering, and Operation and Maintenance.

ACKNOWLEDGMENT

The authors thanks all Darajat Unit II/III PCV Debottlenecking Project Team members who contributed to this effort, including Reynhard Siahaan, Albert M. Lukman, Sonny Ardihansyah, Mike Klassen, Colin Peters and Adhiati Priharini from Chevron, and Ross Oliver, Tracy Mills, and Steve Rutherford from SKM for giving us advice and cooperation during project development and execution stages.

NOMENCLATURE

CGI : Chevron Geothermal Indonesia

dP : differential pressure, pressure drop

DRJ : Darajat

HPU : Hydraulic Power Unit

ICMS : Integrated Control and Monitoring Systems

MCR : Maximum Continuous Rating

MWe : Mega Watt (electrical)

NCG : Non Condensable Gas

PCV : Pressure Control Valve

PT.IP : Perseroan Terbatas (Limited Liability Company) Indonesia Power

WHP : Well Head Pressure

REFERENCES

Chevron: Indonesia Fact Sheet, Chevron Corporation Homepage (2013), Accessed 5 May 2013. http://www.chevron.com/documents/pdf/indonesiafactsheet.pdf.

Chevron: Darajat Geothermal Project - Unit III Steamfield: STEAMFIELD LAYOUT PLAN C-ST3-GE-G-DR-010/00, Jakarta (2004).

Chevron Geothermal Indonesia: Unit II PCV Debottlenecking Project Commissioning Report January 2014, Jakarta (2014).

Chevron Geothermal Indonesia: Darajat Daily Production Report 17 March 2011, Garut (2011).

Chevron Geothermal Indonesia: Darajat Unit II/III Interface Debottlenecking Project: Project Execution Plan, Jakarta (2012).

Chevron Geothermal Indonesia, and Sinclair Knight Merz: Darajat Unit III PCV Debottlenecking Project: Review and Evaluation of Unit III PCV Debottlenecking Options ZP00961-RPT-GE-002- Rev 0, Jakarta (2011).

Chevron Geothermal Indonesia, and Sinclair Knight Merz: Darajat Unit III PCV Debottlenecking Project: Control System Software Requirements Specification ZP00961-SPC-IN-001 Rev 1, Jakarta (2012).

Chevron Geothermal Indonesia, and Sinclair Knight Merz: PCV Debottlenecking Project: Process Design Summary ZP00961-RPT-PE-001 Rev C, Jakarta (2012).

Chevron Texaco Energy Indonesia Ltd, and Sinclair Knight Merz: Chevron Texaco Energy Indonesia Ltd Darajat Unit III Geothermal Power Project STEAMFIELD DESIGN BASIS, (2005).

Williamson, Ken, et al: Geothermal Heat and Power Whitepaper on Conventional & Unconventional Technologies, Chevron Advanced Energy Focus Area ETC-SR-214 - Emerging Energy Technologies, Richmond, CA (2007).

Yamin, Wibisono: Darajat Unit II/III Interface Debottlenecking Execution Plan, Presentation, Chevron Geothermal Indonesia, Jakarta (2012).