

OPTIMIZATION STEAM DISPATCHING SYSTEM AT PT. ABC TO ENHANCE PRODUCTION PERFORMANCE

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Abstract. PT. ABC injects steam to the ground for reducing oil viscosity and enhancing oil recovery. Those steams are generated from Steam Generator at SS-1/2/3 and Heat Recovery Steam Generator at COGEN. One unit COGEN produce 100,000 BSPD to supply steam for north areas (Area X/Y/Z) and each year has maintenance program that required shut down for about 1 month. In mid-2012 there was COGEN down that result in significant oil production decreased during the event. The production loss was dominated from immature areas at Area X & Y. A Lean Sigma process improvement was initiated at the end of 2012 to improve steam dispatching system and work flow process for mitigating impact to oil production especially in anticipating the next COGEN Down event. The project team involved multifunctional teams from Operations, Engineering, and Reservoir. It found significant correlation between quadrant pressure decrease and communication process to production performance during the 2012 COGEN down. By completed steam distribution model and simulation, defined key operations parameter, and improved communication process for getting the most fit dispatching plan that will deliver the highest steam pressure at north areas while one unit COGEN down, the quadrant pressure decrease and production loss could be avoided until COGEN back to normal operations with Total Accrued Financial Benefit is \$ 5.6 MM. Its required consistency in implementing improvement result and close monitoring key process parameters to achieve expected performance.

Keywords: Improvement Process, Production Performance, Steam Dispatching System, Multifunctional Teams, COGEN Operations.

1. Introduction

There are three principal forms of energy used in industrial processes: electricity, direct-fired heat, and steam. Electricity is used in many different ways, including mechanical drive, heating, and electrochemical reactions. Direct-fired energy directly transfers the heat of fuel combustion to a process. Steam provides process heating, pressure control, mechanical drive, and component separation, and, is a source of water for many process reactions.

Steam injection is a common technology in heavy oil production. It is considered an enhanced Oil recovery (EOR) method which called Steam Flood and is the main type of thermal stimulation of oil reservoirs which called Cyclic Steam Stimulation. The reservoir characteristics of heavy oil are relatively shallow and very viscous at the temperature of the native underground formation. Steam injection is widely used in the San Joaquin Valley of California (USA), the Lake Maracaibo area of Venezuela, and the oil sands of northern Alberta (Canada).

In a steam flood, some wells are used as steam injection to improve the amount of oil recovered at producer wells. The first is to heat the oil to higher temperatures and to thereby decrease its viscosity so that it more easily flows through the formation toward the producing wells. A second mechanism is the physical displacement employing in a manner similar to water flooding, in which oil is meant to be pushed to the production wells. While

more steam is needed for this method than for the cyclic method, it is typically more effective at recovering a larger portion of the oil.

Another contributing factor that enhances oil production is Cyclic Steam Stimulation with purpose for near-wellbore cleanup. In this case, steam reduces the viscosity that ties paraffin and asphaltenes to the rock surfaces while steam distillation of crude oil light ends creates a small solvent bank that can miscibly remove trapped oil.

Steam generation for the purposes of thermal recovery includes facilities to treat the water (produced water), generate the steam, and transport it to the injection wells. Steam is generated in a boiler or a heat recovery steam generator by transferring the heat of combustion gases to water. When water absorbs enough heat, it changes phase from liquid to steam. The boiler provides a heat transfer surface (generally a set of tubes) between the combustion products and the water. The most important parts of the generating system include the boiler, the fuel supply, combustion air system, feed water system, and exhaust gases venting system. These systems are related, since problems or changes in one generally affect the performance of the others. The most popular steam generators are the 25- and 50-MMBtu/hr units. The 25-MMBtu/hr units are used as mobile units and provide steam for cyclic-steaming or remote-injection wells. The 50-MMBtu/hr units provide steam from a central banked location, which simplifies the water- and fuel-treatment plants and the steam-distribution system.

A typical steam-generator and system flow schematic is shown in Figure below. It consists of a convection section and a radiant section. The convection section is designed to preheat the softened feed water, and the radiant section further heats the steam pipe for generating steam. A steam generator produces 60 to 80% quality steam, depending on the reservoir requirements. Higher-quality steam can be generated if good-quality water and fuel gas are used. When the required steam quality reaches 90%, control becomes difficult, and the chance of overheated pipe increases because of the relatively low liquid phase near the pipe effluent.

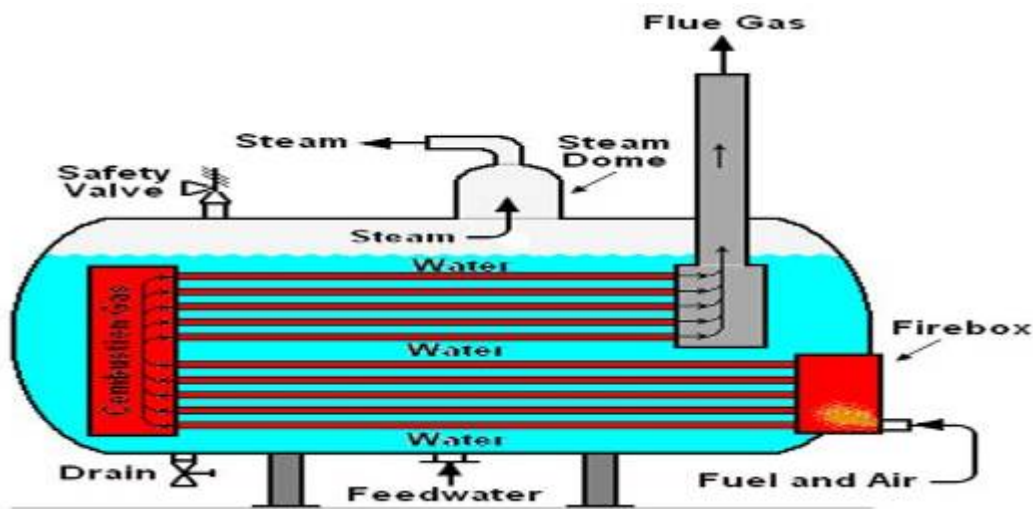


Figure 1.1 Steam Generator Flow Schematic

After steam leaves the steam generators, it is transported and distributed by pipelines to steam injectors. This pipeline network is generally insulated to reduce heat loss and to provide safety for the people working in the area. Because the steam generators are not generating 100% steam, the pipeline flow consists of a vapor phase and a liquid phase. The steam may flow with different flow patterns, depending on steam-flow rate, pipe size, temperature, and pressure. A phenomenon known as phase splitting is known to occur at piping junctions, branches, and tees, resulting in widely varying steam qualities at the steam injectors in any large steam flood project. Inconsistent steam delivery results in inconsistent heat delivery to the reservoir, interfering with the optimization of steam-injection rates, oil recovery, project economics.

Effective distribution system performance requires proper steam pressure balance, good condensate drainage, adequate insulation, and effective pressure regulation. Although distribution systems may appear to be passive, in reality, these systems regulate the delivery of steam and respond to changing temperature and pressure requirements. Consequently, proper performance of the distribution system requires careful design practices and effective maintenance. The piping should be properly sized, supported, insulated, and configured with adequate flexibility. Steam distribution systems can be broken down into three different categories: buried pipe, above-ground, and building sections, and selection of distribution components (piping, insulation, etc.) can vary depending on the category.

Steam injectors are used to inject steam into the formation. There is a concentric pipe design, made of an inner pipe for transporting steam down to the reservoir, which uses the casing as the outer pipe. The casing is cemented to the injection well with a special blend of cement, including silica flour. This cement can withstand large amounts of heat with minimal expansion. The well casing design prevents heat loss to the surroundings. The inner injection tubing holds heat from steam, and the air/steam gap between the inner pipe and casing acts as an insulator to reduce heat loss. Deep injection wells are equipped with insulation tubing around the outside of the steam pipe. This insulation tubing is specially designed with a vacuum in the jacket to provide additional heat insulation.

PT. ABC is an oil company in Indonesia which injects steam to the reservoir for reducing oil viscosity and enhancing oil recovery. The quality of steam is defined as the weight percent of steam in the vapour phase to the total weight of steam. The higher the steam quality, the more heat is carried by this steam. High-quality steam provides heat to reduce oil viscosity, which mobilizes and sweeps the crude to the producing wells. Those steams are generated from Steam Generator at SS-1/2/3 and Heat Recovery Steam Generator at COGEN.

Cogeneration (COGEN) is the use of a heat engine or power station to simultaneously generate electricity and useful heat. In separate production of electricity, some energy must be discarded as waste heat, but in cogeneration this thermal energy is put to use. One unit COGEN at PT. ABC produce 100,000 BSPD to supply steam for north areas (Area X/Y/Z) and each year has maintenance program that required shut down for about 1 month. In mid-2012 there was COGEN down that result in significant oil production decreased during the event. The production loss was dominated from immature areas at Area X & Y.

2. Conceptual Framework

Lean Sigma is a managerial concept combining Lean and Six Sigma that results in the elimination of the eight kinds of wastes which classified as Defects, Overproduction, Waiting, Non-Utilized Talent, Transportation, Inventory, Motion, and Extra-Processing. The term Six Sigma is statistically based on the provision of goods and service at a rate of 3.4 defects per million opportunities (DPMO).

The Lean Sigma concepts were first published in the book titled Lean Six Sigma: Combining Six Sigma with Lean Speed by Michael George and Peter Vincent in 2002. Lean Six Sigma consists of 5 phases: DMAIC (Define – Measure – Analyze – Improve – Control) phases. The Lean Sigma projects comprise the Lean's waste elimination projects and the Six Sigma projects based on the critical to quality characteristics.

Lean tends to be used for shorter and less complex problems with focus on eliminating wasteful steps and practices. While Six Sigma is a bigger more analytical approach which tends to have a statistical approach with focus on optimizing the important steps. Some argue Lean moves the mean and Six Sigma moves the variance. But they are often used together and should not be viewed as having different objectives.

The training for Lean Sigma is provided through the belt based training system similar to that of Six Sigma. The belt personnel are designated as white belts, green belts, black belts and master black belts. For each of these belt levels skill sets are available that describe which of the overall Lean Six Sigma tools are expected to be part at a certain Belt level.

These skill sets provide a detailed description of the learning elements that a participant will have acquired after completing a training program.

Table 2.1 Lean Sigma Purpose and Deliverables

No	Phase	Purpose	Deliverables
1.	Define	To have the team and its sponsor reach agreement on the scope, goals, and financial and performance targets for the project.	<ul style="list-style-type: none"> - A completed project charter (covering the problem statement, business impact, goals, scope, timeline, defined team) - Defined what customers (internal and external) are or will be affected by this project and what their needs are - High level process map(s) - Completed project plans - Consensus around project purpose, deliverables, and R&R
2.	Measure	To thoroughly understand the current state of the process and collect reliable data on process speed, quality, and costs that you will use to expose the underlying causes of problems	<ul style="list-style-type: none"> - Fully developed current-state value stream map - Reliable data on critical inputs and outputs - Baseline measures on process capability - Refined definitions of improvement goals - A capable measurement system - Revised project charter
3.	Analyze	To pinpoint and verify causes affecting the key input and output variables tied to project goals.	<ul style="list-style-type: none"> - Documentation of potential causes to be considered - Data charts and other analyses - Identification of value-add and non value-add work - Calculation of process cycle efficiency
4.	Improve	To learn from pilots of the selected solutions (s) and execute full-scale implementation	<ul style="list-style-type: none"> - Tested, robust solutions shown to affect the proven causes that effect the critical output - Documentation on results of the chosen Lean best practice - An improved process that is stable, predictable, and meets customer requirements
5.	Control	To complete project work and hand off improved process to process owner, with procedures for maintaining the gains	<ul style="list-style-type: none"> - Plan to transition improved process back to process owner - Before and after data on process metrics - Operational, training, feedback, and control documents - A system for monitoring the implemented solution - Completed lessons learned and recommendations for further actions or opportunities

A Lean Sigma process improvement was initiated at the end of 2012 to improve steam dispatching system and work flow process for mitigating impact to oil production especially in anticipating the next COGEN Down event. The project team involved multifunctional teams from Operations, Engineering, and Reservoir. It found significant correlation between quadrant pressure decrease and communication process to production performance during the 2012 COGEN down.

The steam pressure at area X is decreased for ~ 36 days to average 420 psig from normal pressure average 480 psig. Once the maintenance work completed and the pressure back to normal, the production is ramp up gradually. During that event no coordination within Operations, Engineering, and Reservoir team to prepare the mitigation plan, review dispatching plan, and clear R&R process that impacted to significant oil loss.

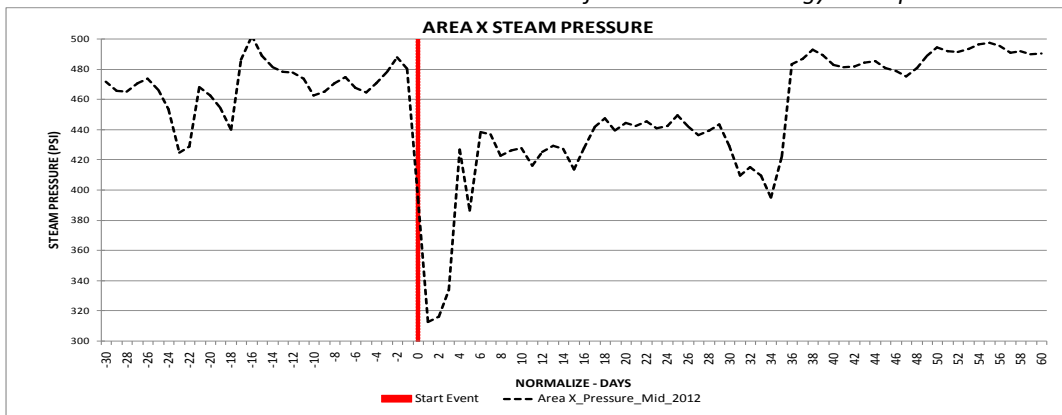


Figure 2.1 Area X Steam Pressure in 2012 COGEN down

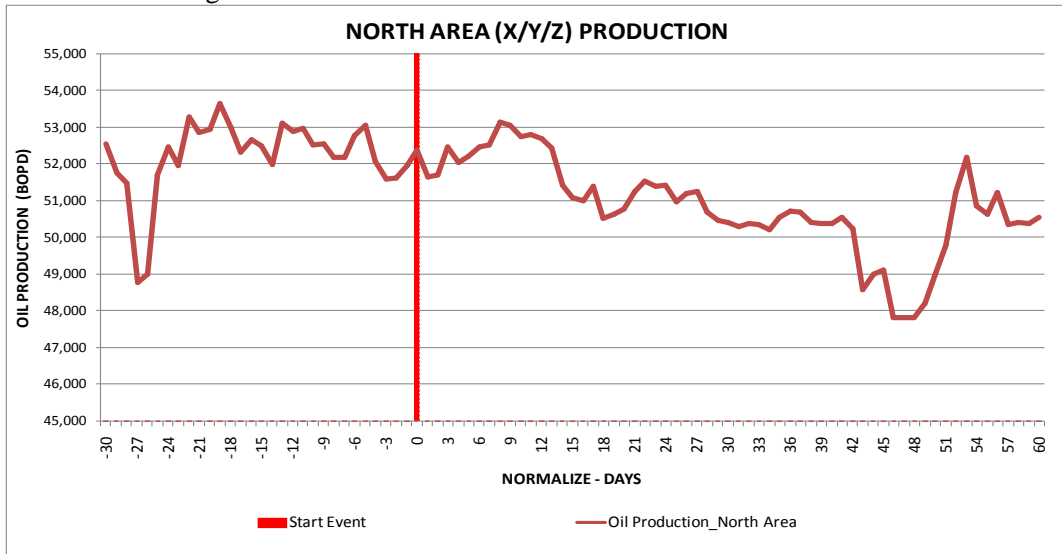


Figure 2.2 North Area (X/Y/X) Production during COGEN down

3. Methodology

Lean Sigma process was used to improve the problem and followed DMAIC Phases.

a. Define Phase

■ Opportunity Statement

In mid 2012 there was COGEN down that result in significant oil production decreased during the event. The production loss was dominated from north areas which are still immature (Area X/Y/Z).

During the event, we found significant correlation between quadrant pressure decrease & latent heat compliance to production loss.

This Lean Sigma Project will improve steam dispatching system and work flow process to mitigate those impact to production.

■ Vision of Success

Best steam dispatching configuration applicable for COGEN down event without any production loss

■ COPQ : \$ 5MM

Total production loss identified was around 48,000 Bbl Oil

■ IPO (Input Process Output) Diagram

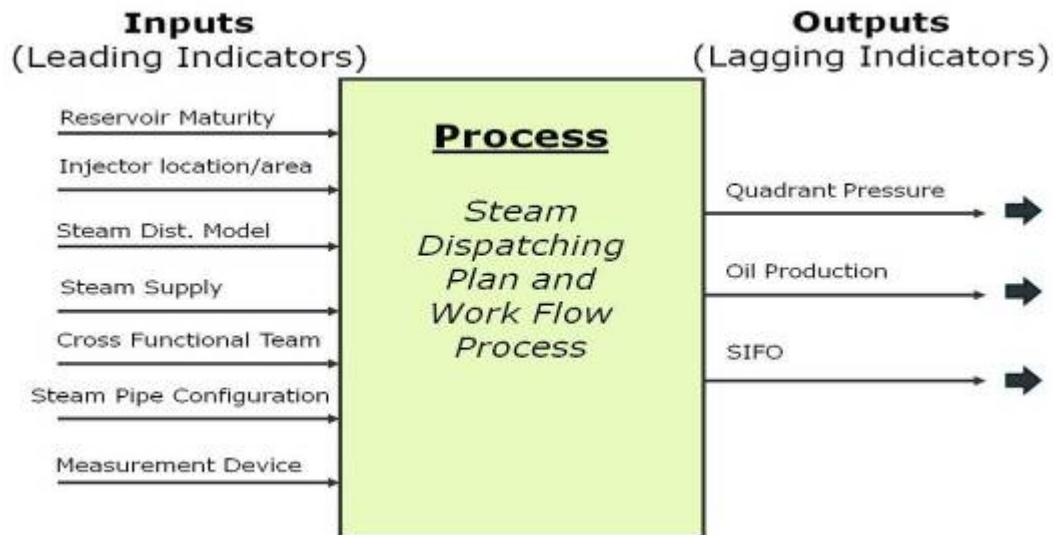


Figure 3.1 IPO Diagram

■ Macro Process Flow

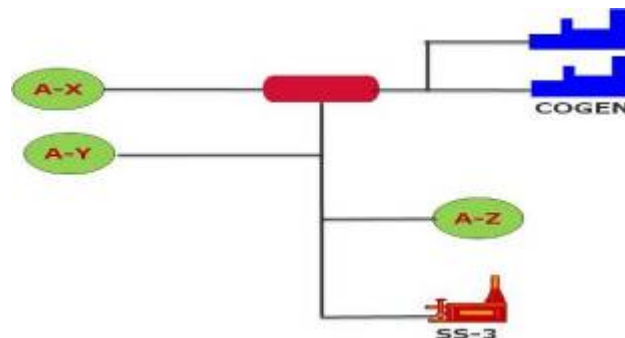


Figure 3.2 Macro Process Flow

b. Measure Phase

The chart as shown in conceptual framework was collected in this phase and it shown the steam pressure at area X is decreased for ~ 36 days to average 420 psig from normal pressure average 480 psig. Once the maintenance work completed and the pressure back to normal, the production is ramp up gradually. During that event no coordination within assets, productions, and engineering team to prepare the mitigation plan, review dispatching plan, and clear R&R process that impacted to significant oil loss.

c. Analyze Phase

- Use Correlation Matrix for the historical data to check the correlation between variable parameters
 - It doesn't show the causality between variable parameters
 - It shows single variable parameter versus the other single variable
 - It doesn't represent interaction between parameters
 - It can be used to get insight the most contributor factors not considering the causality (rely on numbers and trending) → *A-X is the most contributor factors in north area*
- Applying Pipephase to check the current compatibility and trying to predict the future dispatching scenario
 - It shows the causality between variable parameters
 - It represents variable interactions
 - It can be used to check the sensitivity some variables to the other variables

- The best dispatching plan to provide highest pressure in Area-X is Option A by closing the piping connection between Area-X and Area-Y
- The Option B by closing the piping connection between Area-X and Area-Y & Z considered as second alternative

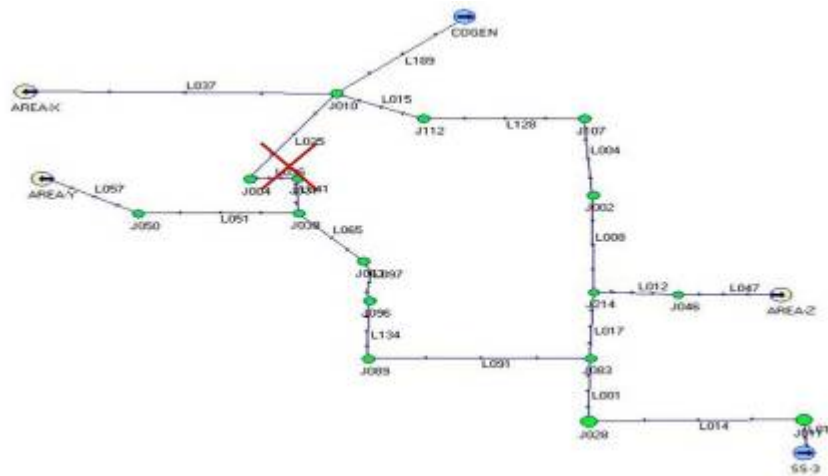


Figure 3.3 Pipephase Simulation

■ Define Key Operations Limit:

- Generation:
SS-3 as back up steam supply during one unit COGEN down has maximum discharge pressure 800 psig
- Distribution:
 - ✓ Area Z maximum quadrant pressure is 650 psig
 - ✓ Area X minimum allowable quadrant pressure is 470 psig

■ Develop mitigation plan process

Work flow process was provided to mitigate same event in the future:

- First option to be implemented is Option A (closing the piping connection between Area-X and Area-Y)
- If the pressure in Area X < 470 psig, it's recommended to increase SS-3 pressure up to 800 psig and control Area Z pressure up to 650 psig
- The last option if above scenario failed is to implement Option B (closing the piping connection between Area-X and Area-Y & Z)
- It's expected to achieve the target by consistency following the agreed work flow process between all teams involved

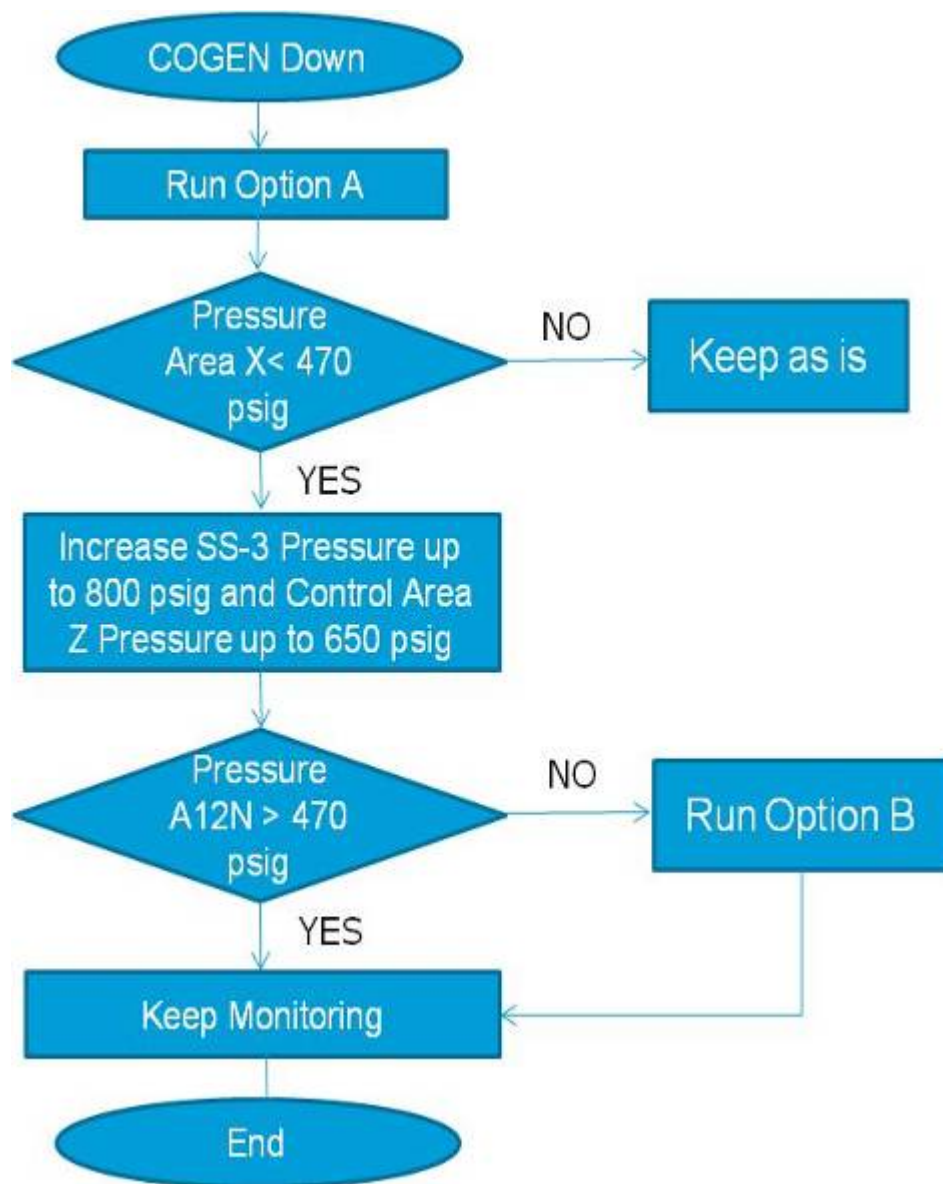


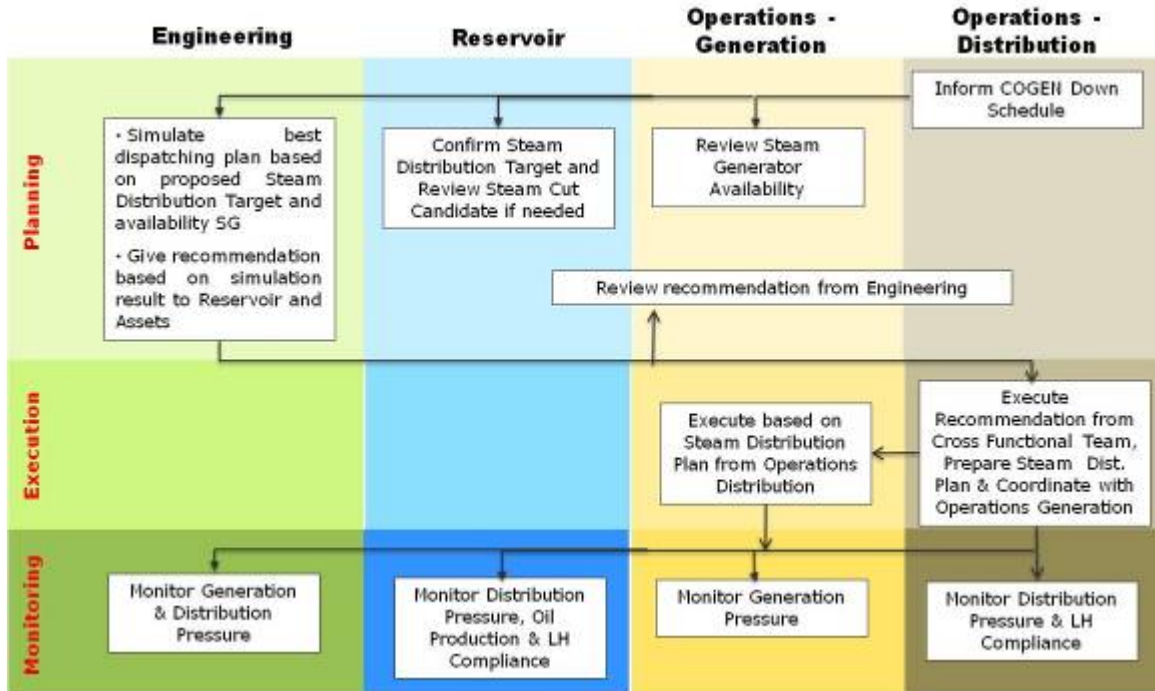
Figure 3.4 Mitigation Plan Work Flow Process

d. Improve Phase

■ Develop R&R process improvement

There's no formal R&R process to mitigate one unit COGEN down in 2012, so Roles and Responsibilities from each team during planning, execution, until monitoring was developed as follow:

Table 3.1 Roles and Responsibility Process



■ Determine Key Performance Indicator (KPI)

KPI was determined to evaluate the project success using Balanced Scorecard framework. The Balanced Scorecard translates mission and strategy into objectives and measures, organized into four different perspectives:

1. Financial: To succeed financially, how should we appear to our shareholders
2. Customer: To achieve our vision, how should we appear to our customers
3. Internal Business Process: To satisfy our shareholders and customers, what business processes must we excel at
4. Learning and Growth: To achieve our vision, how will we sustain our ability to change and improve

Table 3.2 Key Performance Indicator (KPI)

Objectives	Measures	Targets	Initiatives	PIC
Financial Perspective				
Achieve Cost of Poor Quality (COPQ)	Cost Saving	- \$ 5MM	- Execute result of analyze phase	- Project team
Customer Perspective				
Increase Customer Satisfaction	Production loss	- Zero loss	- Complete the analyze phase before 2013 COGEN down	- Project team
Internal Business Process Perspective				
Achieve Operational Excellence	Number of accident	- Zero accident	- Follow SOP consistently	- Project team
Learning & Growth Perspective				
Improve Organizational Capability	Multi functional teams involvement and commitment	- High involvement and commitment	- Establish weekly meeting and progress update - Gain management support	- Project team

e. Control Phase

After completed the improve phase for 1 month, the improvement process move to control phase. The shut down has been extended 1 month from original plan and no oil loss resulted from the event.

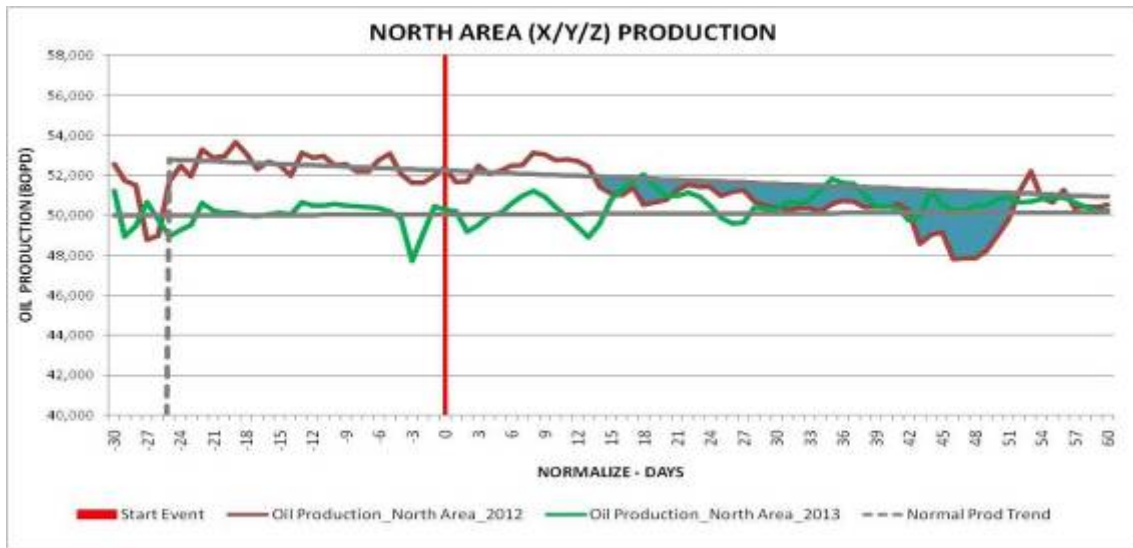


Figure 3.5 North Area Oil Production in 2012 and 2013 COGEN down

In 2013 the pressure at Area X could be maintained stable as target operating parameter that give significant contribution for no oil loss.

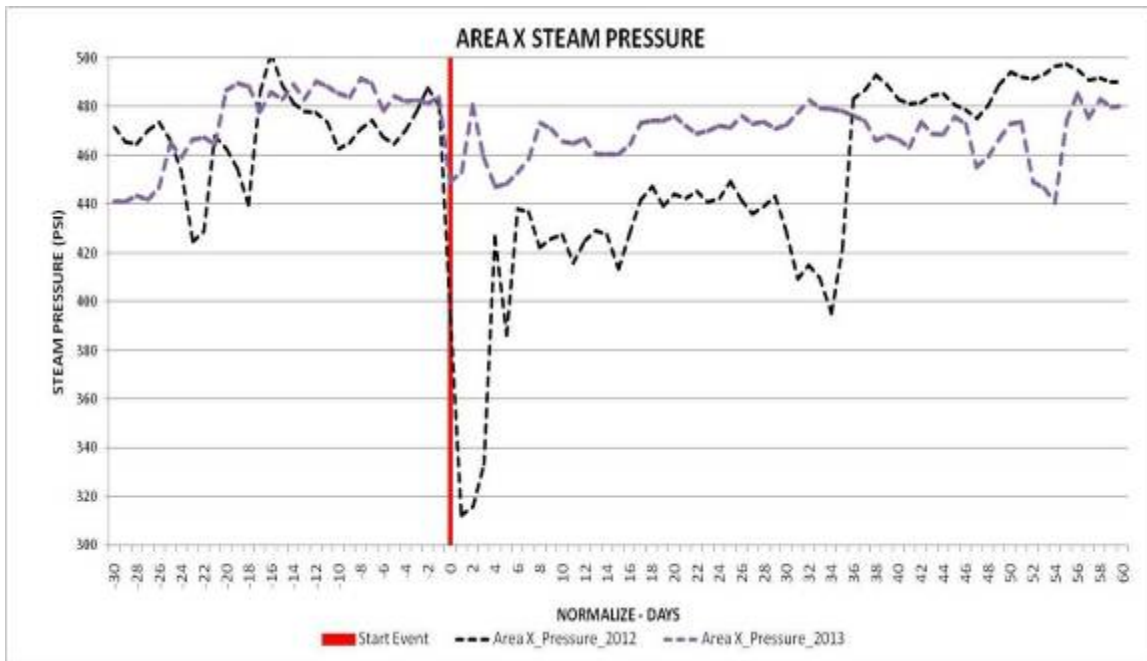


Figure 3.6 Area X Steam Pressure in 2012 and 2013 during COGEN down

The financial impact of this Lean Sigma project is \$5.6 MM for 60 days COGEN down. It was achieved by completed steam distribution model and simulation and improved communication process which resulted to avoid quadrant pressure decrease and production loss until COGEN back to normal operations.

4. Research Finding

By completed steam distribution model and simulation, defined key operations parameter, and improved communication process through implementing Lean Sigma DMAIC process for getting the most fit dispatching plan that will deliver the highest steam pressure at north areas while one unit COGEN down, the quadrant pressure decrease and production loss could be avoided until COGEN back to normal operations with Total Financial Benefit is \$ 5.6 MM.

Lean Sigma as a process improvement program that combines two ideas: Lean - a collection of techniques for reducing the time needed to provide products or services, and Six Sigma - a collection of techniques for improving the quality of products and services, substantially contributing to avoided production loss during COGEN down and proven process improvement while dealing with a big steam supply loss that feed to immature areas (Area X/Y/Z)

Lean Sigma application in PT. ABC has been growing rapidly in the past 5 years and need to be sustained for achieving competitive operating cost and supporting organization to operate more efficiently. The management support also contributed in the Lean Sigma success stories.

5. Discussion and Recommendation

- a. Best Practices adopted and to share are as below:
 - Steam Distribution Model & Simulation to prove the dispatching plan scenario
 - Provide work flow process to mitigate same event in the future
 - Key process parameters close monitoring
 - Improved communication and coordination within multifunctional team (Operations, Engineering, and Reservoir)
- b. Challenges during the execution shown as below:
 - Short time preparation and technical review in three (3) months
 - Existing steam pipe configuration
 - Optimum steam cut in mix-mature areas at Area Y/Z
- c. Recommendation for the future shown as below:
 - Consistency in implementing improvement result
 - Close monitoring key process parameters to achieve expected performance
 - Handover the process if there're any rotation personnel

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