ANALYSIS OF GEOTHERMAL GAS TESTING SERVICE TIME USING VALUE STREAM MAPPING AT QUALITY TESTING LABORATORY

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Abstract. Quality Testing Laboratory is a central geothermal laboratory at PT XYZ. In 2020 the company implement centralization policy which led to significant increase of gas analysis demand, resulting in 45% of gas analysis were not complied with laboratory service level agreement (30 days). This study focuses on analyzing lead time and wastes in geothermal gas testing and provide improvement suggestion. This study utilizes lean concepts through value stream mapping. The results indicate that the current state value stream mapping shows a process efficiency of 10.39%, a total lead time of 1068.38 minutes, non value added time of 1049.67 minutes, and value-added (VA) time of 111.03 minutes. The highest waste is delay/waiting (675.90 minutes), evidenced by high batch size for each analysis activity. The improvement suggestions are two scenarios of FS VSM. Scenario 1 provides process of optimization through one-piece flow implementation. Scenario 2 provides process optimization through one-piece flow implementation, increase equipment utilization & technology, and additional personnel. FS VSM 1 provides a process efficiency of 27.55%, a total lead time of 376.08 minutes, NNVA and NVA of 358.073 minutes, VA of 103.79 minutes, with an estimated implementation without additional operational and investment costs. FS VSM 2 offers a process efficiency of 68,36%, a total lead time of 94.642 minutes, NNVA and NVA of 75.932 minutes, an estimated implementation time of 12 months, with estimated investment cost Rp 2.295.000.000 in the first year with BCR 1,98 in ten years.

Keywords: Renewable Energy Laboratory, Lean, Value Stream Mapping

1 Introduction

Quality Testing Laboratory is a geothermal testing laboratory owned by PT XYZ that perform based on ISO 17025:2017. In 2020, the company has started a centralization policy. Geothermal Laboratory of PT XYZ in various areas across Indonesia were terminated for analysis activity and only focus on sampling activity while Quality Testing Laboratory covered various samples from all areas in Indonesia as the central laboratory. During transition period, this policy has caused significant increase in analysis demand up to 77% from total quantity of water samples and 138% from total quantity of gas samples in Quality Testing Laboratory. If laboratory didn't renegotiate with customer about current load and resources, 45% demand has more lead time than standard

V. Mardiansyah and B. A. Prasetyo (eds.), *Proceedings of the Widyatama International Conference on Engineering 2024 (WICOENG 2024)*, Advances in Engineering Research 252,
https://doi.org/10.2991/978-94-6463-618-5_2

of commitment. Laboratory commitment is 30 days since service level agreement (SLA) is signed by customer and laboratory.

Geothermal gas testing is one of activity to determine Non Condensable Gas components in steam as a supply of geothermal power plant to generate green electricity. Geothermal gas testing consists of analysis services for the parameter of hydrogen (H2), argon (Ar), oxygen (O_2), nitrogen (N_2), methane (CH_4), carbon dioxide (CO_2), hydrogen sulfide (H_2S), and ammonia (NH_3) in matrix of gas geothermal. Data of geothermal non condensable gases are important in exploration and exploitation to develop geothermal power plan industry and unlock other potential value. In production state, data of non condensable gases have correlation directly to vacuum process in condenser, reducing turbine efficiency, and decreasing the total power output of the geothermal power plant. (Sufyana et al, 2023)

Table 1. Previous Research

***Author*/Year**	**Title**	**Method**	**Result**
Napitu, Kristina Fitri Handayani (2022)	*Analisis Waste Reduction di PT XYZ menggunakan metode Value Stream Mapping*	*Lean Manufacturing, Value Stream Mapping, Waste Reduction, Fish Bone Diagram, Process Activity Mapping*	Four types of wastes were identified in the S23N production line: defects, motion, waiting, and overprocessing. Improvement to reduce waste were made by eliminating touch up process through the standardization of repair process which successfully reduced lead time from 29 days to 22,5 days.
Delvinna (2020)	*Penerapan Value Stream Mapping Guna Mengurangi Waste pada Pelayanan Laboratorum Unit Hawat Darurat di Rumah Sakit Dharma Nugraha*	*Lean, Value Stream Mapping*	In the laboratory services of Dharma Nugraha Hospital, 20.26% of activities were identified as non-value added based on current state mapping. After improvements, the future state mapping showed a reduction in process time form 4.015 seconds to

			3.725 seconds. Work efficiency increased from 93.7% to 99.1%.
Sagita, Pendra; Moses Laksono Singgih (2020)	*Application of Lean Thinking in Reducing Turn Around Time on the Quality Control Process at Nickel Processing Plant*	*Lean Thinking, Value Stream Mapping, Fishbone Diagram, Waste Reduction*	The highest waste identified was delay (waiting) at 82,97% and transportation at 3,75%. The solution in the future state map, through the installation of real time analyzer can reduce turnaround time by 98,52%
Putra, Faine Leroi Pratama (2019)	*Analisis Efisiensi Proses Distribusi Dengan Metode Data Envelopment Analysis (DEA) dan Pendekatan Lean Thinking di PT POS Indonesia (Persero)*	*Lean Thinking, VALSAT, Value Stream Mapping*	The average efficiency of the distribution section in 2018 was 0.976. The proposed improvements include layout enhancements, providing education and information to employees in the product processing and distribution sections of MPC, and eliminating certain processes deemed to have no added value. The lead time was reduced from 200 minutes to 161 minutes.

Based on Table 1, lean concept is proven concept with supporting tools and efficient framework to increase the deliverability (lead time) and quality service to customers. The concept effectively reduce lead time in manufacture and service sector is lean concept from Toyota's ways. Lean optimize speed of process, provide tools to identify value added activities and non value added activities, and simplify flow process. (George, 2003).

This study focuses on analyzing total service time (lead time) and waste in geothermal gas testing at Quality Testing Laboratory of PT. XYZ (green energy laboratory). The expected result of this study is proposed improvements in the form of Future State Value Stream Mapping as an effort to reduce total service time (lead time) and waste.

2 Method

2.1 Gas Geothermal Testing

Gas Geothermal Testing is laboratory service to analyze non condensable gas in geothermal sample. Quality Testing Laboratory adopt and develop non condensable gas analysis in geothermal system. Parameter of hydrogen (H2), argon (Ar), oxygen (O_2), nitrogen (N_2), and methane (CH_4) are analyzed by Gas Chromatography (GC Analysis) method. Carbon dioxide (CO_2) is analyzed by acid-base titration & NDIR method. Hydrogen sulfide (H_2S) is analyzed by iodometric titration. Ammonia (NH_3) is analyzed by spectrophotometry-nesslerization.

2.2 Value Stream Mapping

Value Steam Mapping is a lean method to identify of activities based on information and material flows. (Liker J. L., 2021) Both information and material flows are obtained through standard operational procedures that implemented in the laboratory. The flows are illustrated in value stream mapping current condition. Parameter time of activities and wastes are classified based on Process Activity Mapping observation form that it is resulted from *genba.* Value steam mapping is defined as a set of specific activities within a supply that are necessary for designing, ordering, establishing a specific product or value.

Data of cycle time, setup time, change over time, number of inventories, number of operators, distance of each activity, and waste identification are gathered from observation of detailed mapping tools result. Activities are classified into value added, non-value added, and necessary but non value added activity. Overall result of field data analysis is captured by current state value stream mapping to describe current condition. Takt time (equation 1) is used to measure the rate of customer demand in the process of synchronizing the analysis service with customer needs.

$$Takt\ Time = \frac{Available\ Time}{Customer\ Demand} (1)$$

$$\text{Total Lead Time} = \sum NVA + \sum NNVA + \sum VA\ (2)$$

$$\text{Total Process Time} = \text{Total Cycle Time} = \sum VA\ (3)$$

$$\text{Process Efficiency} = \frac{Total\ Process\ time}{Total\ Lead\ Time} \times 100\% (4)$$

$$\text{Average C/T} = \frac{Cycle\ Time}{Average\ batch\ size} (5)$$

$$\text{Average C/O} = \frac{Change\ Over\ Time}{Average\ batc\quad size} (6)$$

2.3 Wastes

There are wastes that can be identified as non value added activities based on customer needs. They are Overproduction, Waiting/ Delay, Unnecessary transport or conveyance, Overprocessing, Excess Inventory, Unnecessary Inventory, Unnecessary Movement, Defects. (Liker, 2021)

3 Result and Discussion

3.1 Current State Value Stream Mapping.

Information flow in Quality Testing Laboratory is based on standard operational procedures and quality compliance that follow ISO 17025:2017 principles. Information and material flow is described in figure 2. Based on database, demand data in one year period (July 2021-May 2022) is described in figure 1.

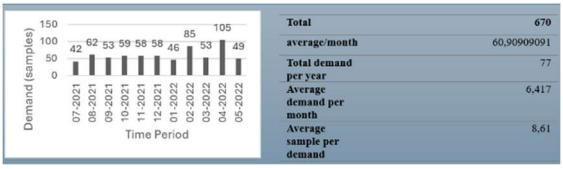

Fig. 1. Demand of Gas Analysis (July 2021-May 2022) and recapitulation

Current state value stream mapping describes that geothermal gas testing service is batch activity from end to end process, start from sample reception, GC Analysis (H_2, Ar, O_2, N_2, CH_4), H_2S Analysis, CO_2 Analysis, NH_3 Analysis, %NCG Calculation, Data Verification, Generating report & Validation, Register Report & Submission. Laboratory analyst commonly run the process based on batch process and multiple activity of analysis.

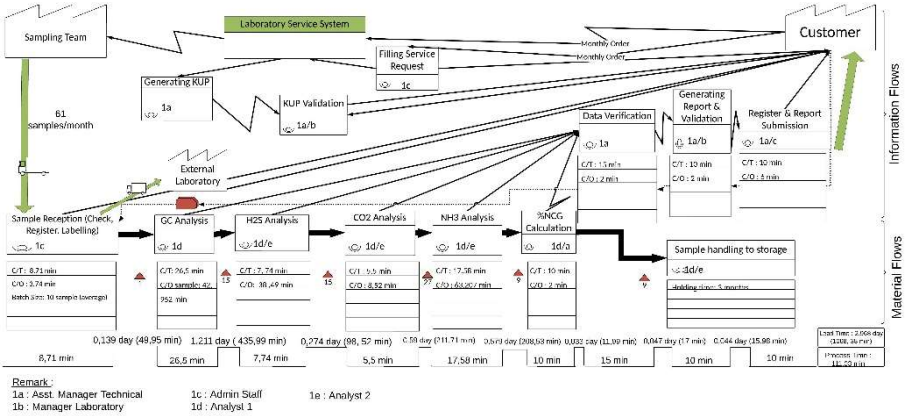

Fig. 2. Current State Value Stream Mapping

3.2 Waste Identification

The data of time activities are collected based on field observations and standard operating procedures (SOP). Result of activities in Process Activity Mapping are evaluated and classified based on Non-Value Added (NVA), Non-Value Added but Necessary (NNVA), Value Added (VA). The activities are identified into operation (O), transportation (T), inventory (I), storage (S), and delay (D) classification. Process Activity Mapping summary of each gas analysis steps are tabulated in table 2. Waste data is shown in figure 4. The highest total NVA & NNVA time is delay/waiting (4 activities, 675.90 minutes).

Table 2. Current State VSM – Process Activity Mapping Summary

		O	T	I	S	D	Total
NVA	Total	0	1	0	0	3	4
	Time (min)	0	1,74	0	0	662,1	663.842
NNVA	Total	16	6	8	1	2	33
	Time (min)	74,34	5,69	9,26	45	15,29	149,58
VA	Total	7	0	2	0	0	8
	Time (min)	55,41	0	11,74	0	0	67,152
Total activities						46	
***Total Time* (min)**						258,21	
Available Time (mins/month)						6480	
Takt Time (mins/sample)						106,2	

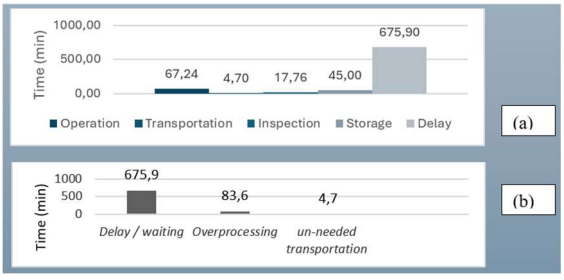

Fig. 3. Waste Identification (a) PAM (b) 7 Wastes

Based on observation of fig 2, root cause of waste of delay/waiting is caused by batch paradigm in analyst activities. Samples are waiting until quantity of batch is fulfilled in each stage (step) of analysis. Limited of human resources is also as a cause delay/waiting, because one analyst handle multiple task of stage analysis.

3.3 Bottleneck Analysis and Waste Identification

The longest cycle time and per unit processing time principally is the bottleneck of whole process gas analysis. Based on figure 4, the highest cycle time is NH_3 analysis, and takt time limit value is above value of each gas analysis activity. Thus, NH_3 is

decided as a bottleneck based on cycle time and per unit processing time parameter. Special case is occurred when gas analysis requires gas chromatography (GC analysis) must be performed at the first gas analysis (contamination issue). The result condition makes H_2S and NH_3 are above takt time value. Thus, GC analysis is decided as special case bottleneck.

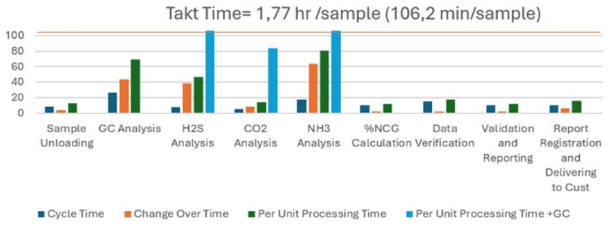

Fig. 4. Bottleneck Analysis

3.8 Future State Map Scenario 1 and Scenario 2

Bottleneck & waste identification result analysis are the major problem that should be improved in laboratory at PT XYZ. Future State Map scenario 1 is proposed by implementing one piece flow as lean concept. Minimize number of inventory or batch size that require in Future State Map Scenario 1. Delay/waiting time is reduced by continuous flow of sample and makes H_2S, and CO_2 analysis run parallel (figure 5). Future State Map Scenario 2 (figure 6) is proposed as advance one piece flow option to fulfil fluctuates of demand by increasing capacity. Minimizing batch size is performed to decrease delay/waiting time. Increase 2 additional manpower to utilize automation of NH_3 preparation and second GC instrument is required to make shorter cycle time of GC analysis and NH_3 analysis. Dedicated manpower increase available time to 120 hours/month (7200 mins).

Table 3. Summary of VSM

	Capacity (sample /month)	VA (minutes)	NVA & NNVA (minutes)	Total Lead Time (minutes)	% Process Effi-ciency	% Improve-ment
Current State Map	6	111,03	1049,67	1068,38	10,39	0
Future State Map- Scenario 1	17	103,79	358,073	376,08	27,55	265,06
Future State Map-Scenario 2	76	84,54	75,932	94,64	68,36	657,94

Note: Calculation CS VSM estimates without overtime and assistance from other backup operators.

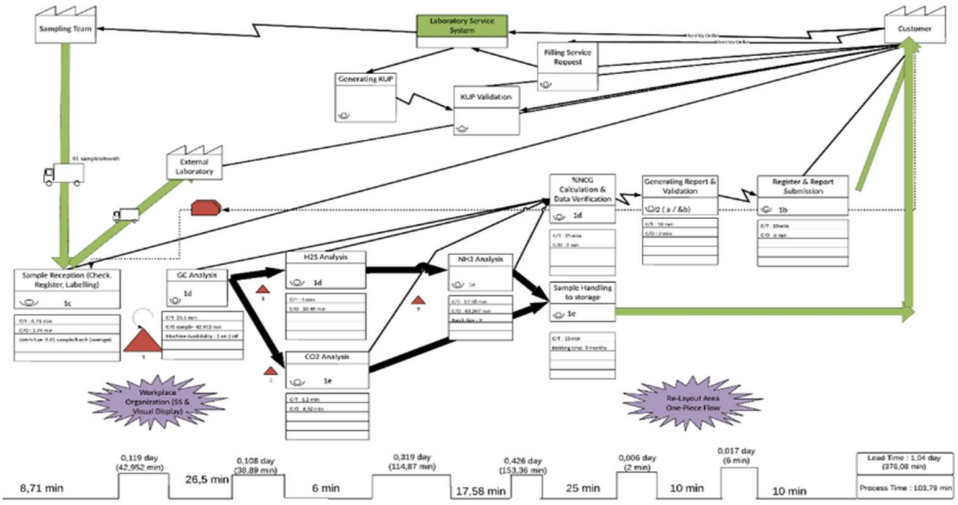

Fig. 5. Future State Map Scenario 1

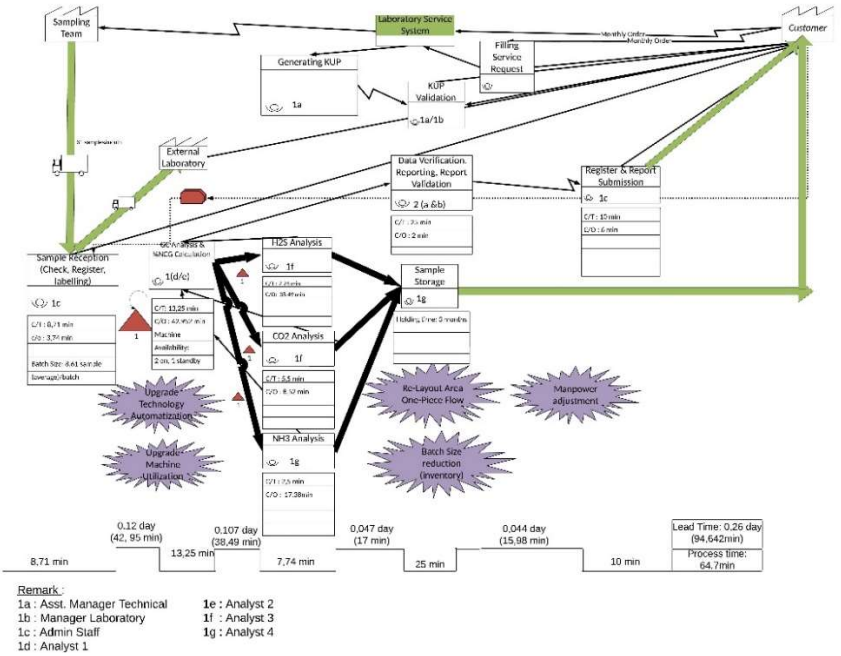

Fig. 6. Future State Map Scenario 2

The Benefit Cost Ratio calculation was carried out and the index result was 1.98 (company interest rate 10%) in accordance with the financial evaluation and table 4. PV of Cash Inflow is calculated as potential recovery loss if Laboratory request external laboratory services in ten years. PV of cash outflow is calculated based on investment

cost, maintenance-calibration cost, consumable material cost, manpower cost, and depreciation in ten years. This shows that the difference of profits each year is greater than the costs incurred, so the proposed Future State Map 2 is feasible.

Table 4. Financial Evaluation

PV of Cash Inflow	***IDR***	**30.608.936.908**
PV of Cash Outflow	*IDR*	(15.488.462.181)
Net Present Value	*IDR*	15.120.474.727
Benefit Cost Ratio	*index*	1,98

4 Conclusion

Based on the study result, following conclusions are obtained:

a. Factors contributing to the high total lead time in geothermal gas analysis at Quality Testing Laboratory of PT XYZ is caused by NVA & NNVA delay/waiting due to the accumulation of sample inventory in each analysis activity (675.90 mins).
b. Proposed 2 scenario of future state map to reduce the total lead time in geothermal gas analysis at Quality Testing Laboratory of PT XYZ. Scenario 1 involves the implementation of a one-piece flow by reducing batch size resulting in a total lead time of 1,04 days and process efficiency of 27,55%. Scenario 2 involves the implementation of one-piece flow by reducing sample inventory, adding operators, and increasing the utilization of GC and NH3 Analyzer equipment. Scenario 2 is projected to achieve a total lead time of 0,26 days (94.642 mins) with a process efficiency of 68,36% (BCR 1,98 in 10 years).

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