

CHAPTER 4 - ANALYSIS AND DISCUSSION

4.1 LCCA Team

Team building is a crucial strategic step in achieving the success of various projects and achieving organizational goals. Amidst the ever-changing dynamics of the business environment, the ability to form effective and synergistic teams is key to competitive advantage. A solid team is able to combine diverse individual skills, knowledge and experience, forming a collaboration that brings innovation and productivity. In the LCCA assessment to optimize excavator lifespan, cost-effectively and more productively through a general overhaul program, team building was necessary. The importance of team building is a key foundation for achieving organizational goals. We will explore the key aspects of forming a successful team, from team member selection and synergy development to taking practical steps to bring the objectives of this study to fruition.

The teams included are as follows:

- Plant Departemen Head
- Plant Section Head
- Plant engineer
- Plant Planner
- Plant Group leader Track
- Mechanic

The functions of each position are as follows:

Plant Dept Head:

Plan, evaluate, control and coordinate internal and external Plant site activities including schedule & unschedule Maintenance of all equipment aimed at achieving optimum availability, controlled costs, minimizing lost time and carried out effectively, efficiently and safely.

Section Head:

Controlling, coordinating, analyzing and evaluating all track type, wheel type, SSE, tyre, and barge loader activities which include equipment Maintenance, Repairing and Overhaul

activities in order to ensure all daily activities in the Plant site department run effectively and efficiently and achieve the set equipment availability targets.

Planner:

Planning all equipment Maintenance activities which include making periodic service schedules, Overhaul and inspection programs and evaluating the results of the implementation of the Maintenance schedule program, in order to consistently implement the equipment Maintenance schedule program.

Plant engineer:

Analyze technical problems in the field, provide recommendations and monitor and evaluate the implementation of these recommendations in order to improve the quality of the equipment / unit maintenance program.

Group leader Track:

Monitor, control, and direct maintenance work (preventive), repair (corrective), and Overhaul of all track units with the aim of ensuring activities run in accordance with standards and work procedures and work safety so that track units are ready to use (RFU) and can achieve the target physical availability that has been set.

Mechanic:

Performs maintenance (preventive), repair (corrective) and Overhaul of Track type heavy equipment units by paying attention to work standards and procedures and work safety with the aim of preparing Track type heavy equipment units that are ready to use (RFU) and can achieve the target physical availability that has been set.

All plant staff ranging from Plant Dept Head to group leaders and mechanics at the Kalsel jobsite are carried out competency mapping. This competency mapping aims to ensure that the team formed in the Komatsu PC1250-8 hydraulic excavator LCCA study is truly capable. From Table 4. 1 Hierarchy of Standard Training & Competency, it is found that the total competency that has been owned by the Plant Dept Head is 47 (all competency plant), Plant Section Head is 46, Plant engineer is 45, Plant Planner is 20, Plant Group leader is 30 and Mechanic is 17.

Table 4. 1 Hierarchy Standart Training & Competency

Code	Hierarchy Training Plant Staff	Sub Code	Competency	Plant DH	Plant SH	Plant engineer	Planner	Group leader	Mechanic
PSD 1	Plant Staff Basic 1	PSD101	BMC (Basic Mechanic Course)	Done	Done	Done	Done	Done	Done
PSD 2	Plant Staff Basic 2	PSD201	FOWAG(Fuel, Oil, Coolant, Air, Grease)	Done	Done	Done	Done	Done	
		PSD202	Basic Tyre Course (BTC)	Done	Done	Done	Done	Done	
		PSD203	Basic Welding	Done	Done	Done	Done	Done	
		PSD204	Basic KMMS	Done	Done	Done	Done	Done	Done
		PSD205	Basic ELLIPS & SIM	Done	Done	Done		Done	
		PSD206	HEEM	Done	Done	Done		Done	Done
		PSD207	MECA For GL	Done	Done			Done	
		PSD208	Basic RCM	Done	Done	Done	Done	Done	
		PSD209	Basic Leadership	Done	Done	Done	Done	Done	
PSM 1	Plant Staff Middle 1	PSM101	Preventive Maintenance	Done	Done	Done	Done	Done	Done
		PSM102	Product Knowledge	Done	Done	Done		Done	Done
		PSM103	Engine	Done	Done	Done		Done	Done
		PSM104	Elektrik	Done	Done	Done		Done	Done
		PSM105	Power Train	Done	Done	Done		Done	Done
PSM 2	Plant Staff Middle 2 (GL Unit, PE, Planner)	PSM201	AFA	Done	Done	Done		Done	
		PSM202	OVH SMALL COMPONENT	Done	Done	Done	Done	Done	Done
		PSM203	OVH ENGINE	Done	Done	Done	Done	Done	Done
		PSM204	OVH POWERTRAIN	Done	Done	Done	Done	Done	Done
	Plant Staff Middle 2 (GL Tyre, GL Fabrication)	PSM211	Tyre Inspector	Done	Done	Done		Done	
		PSM212	Tyre Power Tools	Done	Done	Done		Done	
		PSM213	Tyre Management System	Done	Done	Done		Done	
		PSM214	Plant Failure Analysis	Done	Done	Done		Done	
		PSM215	Welding Inspector	Done	Done	Done		Done	
		PSM216	Curing Machine	Done	Done	Done		Done	
		PSM217	Tyre Repair Intermediate	Done	Done	Done		Done	
		PSM218	Tyre Knowledge & Utilization	Done	Done	Done		Done	
PSM 3	Plant Staff Middle 3	PSM221	Optional System (AC, Autolube, Fire Suppression)	Done	Done	Done		Done	Done
		PSM222	Tyre Maintenance, Pressure & Calibration	Done	Done	Done		Done	Done
		PSM223	Tool Management	Done	Done	Done	Done	Done	Done
		PSM224	NDT	Done	Done	Done			Done
		PSM225	VHMS COMTRAX	Done	Done	Done			Done
		PSM226	MTS (All System)	Done	Done	Done			Done
PSL 1	Plant Staff Advance 1	PSL101	KMMS Maintenance Planning	Done	Done	Done	Done		
		PSL102	Statistic (Basic & Realibility)	Done	Done	Done	Done		
		PSL103	IBS	Done	Done	Done	Done		
		PSL104	RIM Maintenance	Done	Done	Done			
		PSL105	Tyre Rethread	Done	Done	Done			
PSL 2	Plant Staff Advance 2	PSL201	KMMS (Maintenance Resources Planning)	Done	Done	Done	Done		
		PSL202	RCM	Done	Done	Done			
		PSL203	EQ Auto & Manufacture	Done	Done	Done			
PSL 3	Plant Staff Advance 3	PSL301	KMMS (Maintenance Process Design)	Done	Done	Done	Done		
		PSL302	Risk Management For Maintenance	Done	Done	Done			
		PSL303	Management Overhaul	Done	Done	Done	Done		
LCCA		LC101	LCCA 1	Done	Done	Done	Done		

Code	Hierarchy Training Plant Staff	Sub Code	Competency	Plant DH	Plant SH	Plant engineer	Planner	Group leader	Mechanic
	Plant Staff Advance 4	LC102	LCCA 2	Done	Done	Done	Done		
		LC103	LCCA 3	Done					
		Total Competencies			47	46	45	20	30

Furthermore, manpower competency in the Life Cycle Cost Analysis PC1250-8 is carried out first by assessing the competency of all plant staff before the LCCA calculation is carried out. The assessment is carried out by means of theory testing related to Maintenance Management and LCCA competencies. Then providing material refreshment through training is also carried out to maintain existing competencies.

It can be seen in Figure 4. 1 Competency Map Plant Staff Overseas with a range of low to high competency scores on a scale of 1-5, the values found in Table 4. 2 Competency Map with a total score of 10 by the Plant Dept Head who was then selected by the team as a validator. The total score was 9.2 by the Plant Section Head who was then selected as a verifier in the team. Total score 8.9 by the Plant Planner who was then selected in the team as planner & evaluator. Total score 9.2 by the Plant engineer who was then selected in the team as an analyst. The total score was 8 by the Plant group leader who was then selected in the team as the lead executor. The total score was 7.2 by Mechanic who was then selected in the team as the GOH field executor.

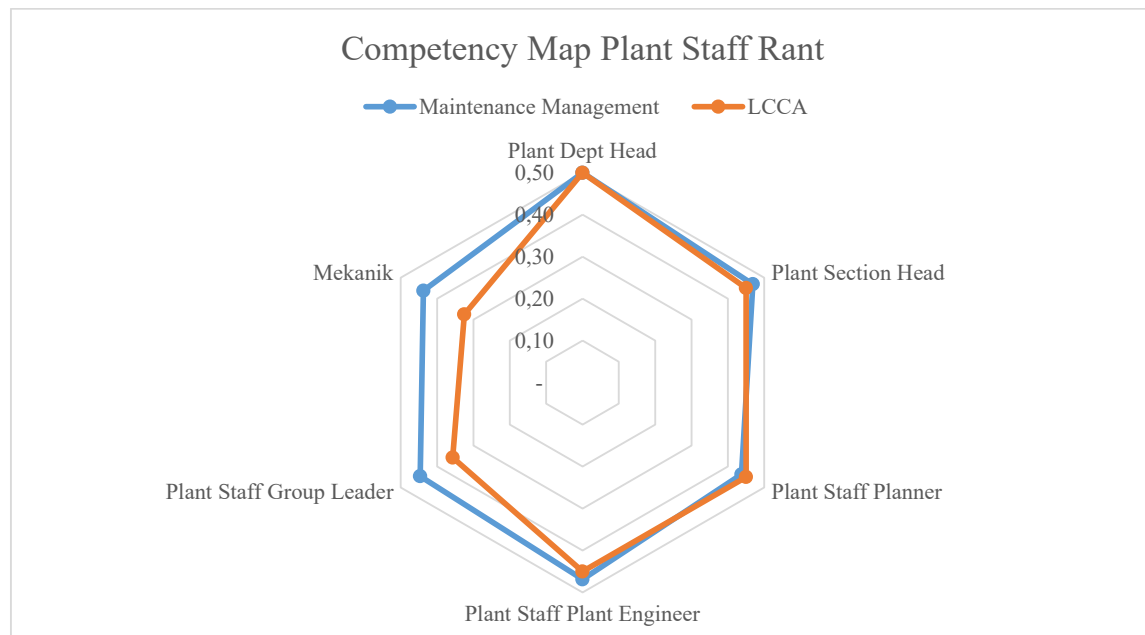


Figure 4. 1 Competency Map Plant Staff Kalsel

Table 4. 2 Competency Map

Posisi	Maintenance Management	LCCA	Total	Fungsi
Plant Dept Head	5	5	10	Selected as Validator function
Plant Section Head	4.7	4.5	9.2	Selected as Verifier function
Plant Planner	4.4	4.5	8.9	Selected as Planner & Evaluator function
Plant Plant engineer	4.7	4.5	9.2	Selected as the Analyzer function
Plant Group leader	4.5	3.6	8	Selected as the Lead Executor function
Mechanic	4.4	3.3	7.6	Selected as the GOH Field Executor function

Each position has a function in the LCCA team, the functions are as follows:

- The validator's function is responsible for checking whether the process meets the specified LCCA standards or criteria.
- The function of a verifier is to ensure the truth or accuracy of the information or LCCA data that is processed.
- Planner & Evaluator's function is to plan, manage and evaluate maintenance and overhaul activities to ensure that heavy equipment continues to operate optimally.
- The function of the analyzer involves various aspects to help identify potential problems or maintenance failures which are carried out by condition monitoring, detecting trends in

potential failure of components or parts, and providing recommendations for corrective action or maintenance to prevent premature equipment lifetime.

- The lead executor's function is as leader of Maintenance and Overhaul execution in accordance with work standards and procedures as well as work safety so that the unit can be used in good condition (RFU) and can achieve the physical availability targets that have been set.
- The Field Executor's function is to carry out Maintenance and Overhaul in accordance with work standards and procedures as well as work safety so that the unit can be used in good condition (RFU).

4.2 Data Performance equipment PC1250-8

The excavators at the overseas job site consist of 8 PC1250-8 units. Of the eight excavators, each year's income varies depending on the running project each year. In 2023, of the eight units, two units with equipment numbers EX2005 and EX2015 have been off hired and are not included in the operating units as shown in Table 4. 3 List of PC1250-8 Excavator Kalsel jobsite.

Table 4. 3 List Excavator PC1250-8 jobsite Kalsel

Equip. Number	Equip. Group Id	Serial Number	Mnemonic	Equip. Status	LFA	Year Accu	Capital Cost	Book Value	GOH
EX2005	PC1250SP8	35294	KOMATSU	OH	RANT	2011	6,497,467,498	BV=0	Done
EX2009	PC1250SP8	J10020	KOMATSU	AV	RANT	2014	2,661,721,873	BV=0	Done
EX2011	PC1250SP8	35569	KOMATSU	AV	RANT	2014	10,473,591,920	BV=0	-
EX2015	PC1250SP8	35116	KOMATSU	OH	RANT	2015	6,497,467,498 (\$ 482,810.87)	BV=0	Done
EX2020	PC1250SP8	J10064	KOMATSU	AV	RANT	2017	6,931,300,214	BV=0	-
EX2026	PC1250SP8	35944	KOMATSU	AV	RANT	2018	11,928,831,686	BV>0	-
EX2041	PC1250SP8	36182	KOMATSU	AV	RANT	2022	12,414,869,570	BV>0	-
EX2044	PC1250SP8	50249	KOMATSU	AV	RANT	2023	13,751,565,000	BV>0	-

4.2.1 Program GOH PC1250-8

Of these units, there are three units that have undergone a general overhaul since the beginning of the year they were acquired. Carrying out a general overhaul is a complete rejuvenation of the main components carried out at one time. GOH work is carried out by replacing major

components, minor components, parts remove & install, and several additional works whose details are shown in Table 4.4 Program GOH Komatsu PC1250-8.

Table 4. 4 Program GOH Komatsu PC1250-8.

PROGRAM GOH KOMATSU PC1250SP-8				
1	MAJOR COMPONENT			
	No	Part Number	Component	Qty
	1.1	RM624E-C0-0020	ENGINE	1
	1.2	RM21N-38-00080	PTO	1
	1.3	RM708-2L-00680	Main pump No.1	1
	1.4	RM708-2L-00690	Main pump No.2	1
	1.5	RM708-2H-00440	Swing pump	1
	1.6	RM706-7K-01110	Swing Motor Front	1
	1.7	RM706-7K-01110	Swing Motor Rear	1
	1.8	RM21N-26-00110	Swing machinery Front	1
	1.9	RM21N-26-00110	Swing machinery Rear	1
	1.10	RM21N-60-34100	Travel Motor LH	1
	1.11	RM21N-60-34100	Travel Motor RH	1
	No	Part Number	Component	Qty
	1.12	RM21N-27-00130	Final drive LH	1
	1.13	RM21N-27-00130	Final drive RH	1
	1.14	RC707-01-0J780	Bucket Cylinder LH	1
	1.15	RC707-01-0J780	Bucket Cylinder RH	1
	1.16	RC707-01-0CA40	Arm Cylinder	1
	1.17	RC21N-63-02304	Boom Cylinder LH	1
	1.18	RC21N-63-02304	Boom Cylinder RH	1
2	MINOR COMPONENT (Replace Component with New Parts)			
	2.1	708-7W-00130	Fan Motor *Radiator	1
	2.2	708-7S-00610	Fan Motor *After Cooler	1
	2.3	703-11-53201	Swivel Joint Assy	1
	2.4	708-1L-00800	Charge Pump (SAR100)	1
3	SPO R & I PARTS			
	3.1	PLEASE CHECK SPO R&I SHEET FOR DETAIL INFORMATION		1

PROGRAM GOH KOMATSU PC1250SP-8			
4	ADDITIONAL JOB & ADDITIONAL PARTS		
	4.1	RECONDITION AUTOLUBE SYSTEM	1
	4.2	RECONDITION FIRE SUPPRESSION SYSTEM	1
	4.3	RECONDITION RADIATOR	1
	4.4	FABRIKASI ATTACHEMENT & OTHERS	1
	4.5	ADDITIONAL JOB after Dis-assembly	1
5	LABOUR COST GOH		
	5.1	LABOUR COST	1
TOTAL COST GOH		\$	193,124.35
PRICE NEW UNIT		\$	482,810.87
COST GOH PERCENTAGE			40%

The units that GOH has carried out are EX2005, EX2009 and EX2015. PC1250-8 EX2009 was chosen for study because it had previously performed GOH. EX2005 and EX2015 were not selected for study because as per this research, these units were already off-hire by management..

4.2.2 Performance PA PC1250-8 EX2009

From Table 4.5 Performance of PA PC1250-8 Jobsite Kalsel, it was found that the average decline in physical availability performance was below 90% after 5 years of operation. Judging from its performance, EX2009 was carried out by GOH at a cost of 40% of the new unit price. In the 5th year, namely 2018, the physical availability performance increased from 88% in 2018 to 92% in 2019, 91% in 2020, 92% in 2021. This indicating that the big effect of the GOH influence carried out in EX2009 was an increase in physical availability performance in the following year. From this data, for 4 consecutive years, the physical availability of EX2009 was above 90%.

Physical availability (PA) is calculated as the required availability time minus equipment downtime and then divided by the required availability time. This can be written in the form of the following formula: $\text{Availability} = ((\text{Required availability} - \text{Downtime}) / \text{Required availability}) * 100$. The required PA can be defined as the production time to operate the

equipment minus other planned downtime such as periodic service, midlife, overhaul and other. Downtime can be defined as the actual time when equipment is down for repair or replacement. This time is also known as the breakdown time several times. In the book basic operations management L&D (2019) PT. XYZ, PA is formulated as follows:

$$PA = (\text{MOHH} - \text{BD}) / \text{MOHH} \times 100\%$$

Table 4. 5 Performance PA PC1250-8 Jobsite Kalsel

Equip. Group Id	Equip. Number	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Decrease from >90 to <90 (year)
PC1250SP8	EX2005	93%	91%	91%	90%	87%	89%	87%	90%	93%	91%	87%	84%	80%	5
PC1250SP8	EX2009	-	-	-	92%	95%	90%	91%	88%	92%	91%	92%	92%	82%	5
PC1250SP8	EX2011	-	-	-	93%	92%	90%	90%	88%	88%	90%	89%	91%	89%	5
PC1250SP8	EX2015	-	-	-	-	92%	91%	90%	87%	92%	93%	92%	86%	84%	4
PC1250SP8	EX2020	-	-	-	-	-	-	93%	94%	93%	92%	88%	88%	89%	5
PC1250SP8	EX2026	-	-	-	-	-	-	-	93%	91%	92%	91%	93%	87%	6
PC1250SP8	EX2041	-	-	-	-	-	-	-	-	-	-	-	96%	94%	-
PC1250SP8	EX2044	-	-	-	-	-	-	-	-	-	-	-	-	95%	-
															5.0

In 2022, there will be a shortage of heavy equipment parts and components during the Russia-Ukraine war, the price of coal commodities will be high so that massive coal mining will return to production. This has an effect on the shortage of parts and components from supplier distributors to mining contractors such as PT. XYZ, especially at the Kalsel job site.

Many maintenance programs that require parts and components are delayed in execution due to this shortage. In fact, quite a few units breakdown for a long time just waiting for the parts and components to arrive. This happened to the EX2005 & EX2015 units, resulting in their physical availability performance being corrected down to 86% and 84% in 2022 and 2023, however, the performance of the EX2009 is still above 90%, to be precise at PA 92% in 2022 as shown in Figure 4.2 PA trend of EX2009 which is the third unit. This has been carried out by OVH.

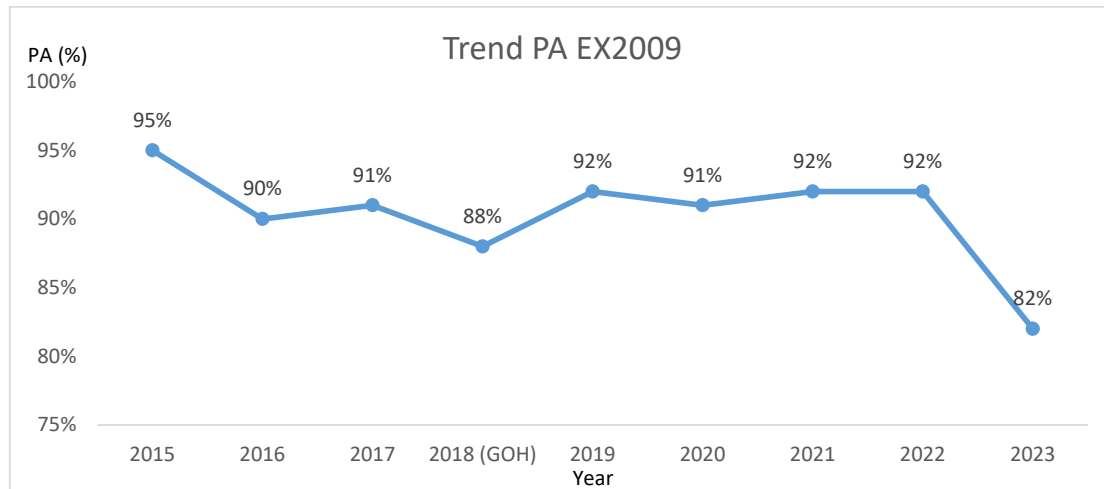


Figure 4. 2 Tren PA EX2009

From the EX2009 physical availability trend after GOH was carried out in 2018 in the 5th year of acquisition, data analysis found that the actual Repair & Maintenance (RM) cost exceeded the standard RM cost by block with a deviation of \$90.77 per hour (during GOH) in 2018, \$31.16 per hour in 2021, \$0.94 per hour in 2022, and \$18.3 per hour in 2023. Only the cost of RM per hour in 2019 & 2020 is smaller than the standard cost of RM by block, namely \$15.99 per hour & \$0.33 per hour which can be seen in table 4.7. Impact analysis after GOH EX2009. Standard RM cost by block can be seen in Table 4.6 Standard RM Cost by block. This shows that the RM cost per hour that occurred in EX2009 after GOH was carried out was not smaller than the standard RM cost by block.

Table 4. 6 Standart RM Cost by block

YEAR	COST/HOUR
1	\$19.68
2	\$49.49
3	\$24.34
4	\$89.79
5 (2018)	\$71.29
6	\$37.92
7	\$75.85
8	\$38.29
Total (rate per hour)	\$50.83

Table 4. 7 Impact Analysis after GOH EX2015

Impact analisis GOH of EX2009

	2018 (GOH)	2019	2020	2021	2022	2023
PA (actual)	88%	92%	91%	92%	92%	82%
WH (actual)	4430	4785	4916	4362	4869	4086
HM	25441	30226	35142	39504	41473	45559
Productivity (actual)	548	590	599	578	543	609
Blok HM	6	7	8	8	9	10
Cost RM (actual)	\$ 570,064.12	\$ 286,412.82	\$ 186,611.00	\$ 302,942.36	247,617.88	360,008.18
Cost RM/h	\$ 128.68	\$ 59.86	\$ 37.96	\$ 69.45	\$ 50.86	\$ 88.11
Std cost by block	\$ 37.92	\$ 75.85	\$ 38.29	\$ 38.29	\$ 49.91	\$ 69.80
Deviasi cost RM/h	\$ (90.77)	\$ 15.99	\$ 0.33	\$ (31.16)	\$ (0.94)	\$ (18.30)
Plan PA	91%	91%	91%	91%	91%	91%
Plan WH	4783	4783	4783	4783	4783	4783
Plan Productivity	553	553	553	553	553	553
Plan Production (bcm)	2,644,976.88	2,644,976.88	2,644,976.88	2,644,976.88	2,644,976.88	2,644,976.88
Actual Production (bcm)	2,536,133.53	2,854,600.88	2,863,223.34	2,797,305.03	2,671,537.66	2,622,603.95
Contriburion %	-4%	8%	8%	6%	1%	-1%
Rate (\$)	\$ 1.50	\$ 1.50	\$ 1.50	\$ 1.50	\$ 1.50	\$ 1.50
\$RM/bcm	\$ 0.22	\$ 0.10	\$ 0.07	\$ 0.11	\$ 0.09	\$ 0.14
Contribution BCM	(108,843.35)	209,624.00	218,246.46	152,328.15	26,560.78	(22,372.93)
Contribution Bcm/h	(24.57)	43.81	44.40	34.92	5.46	(5.48)
Contribution \$/h	\$ (36.85)	\$ 65.71	\$ 66.59	\$ 52.38	\$ 8.18	\$ (8.21)

In terms of production achievements, a positive trend occurred after EX2009 was carried out by GOH, namely in 2019 PA made a positive contribution of 8% with a contribution of 209,624 BCM, in 2020 PA made a positive contribution of 8% with 218,246.46 BCM, and in 2021 PA made a contribution positive by 6% with 152,328.15 BCM from the production plan each year with the EX2009 production target of 2,644,976.88 BCM from the plan parameters PA 91%, UA 60%, and productivity 553 BCM/h. This shows that the impact of positive physical availability performance after carrying out GOH also has a positive impact on production achievements.

The impact of the positive contribution from revenue after GOH in year 5 or 2018 is 8% in 2019 and 2020, 6% in 2021 and 1% in 2022. Even though the contribution to revenue is

positive, the trend is decreasing. A decreasing contribution trend can be seen from 2020 to 2021 from 8% down to 6%. In this period, PA actually increased from 91% in 2020 to 92% in 2021, however there was a decline in equipment productivity, namely from 599 BCM per hour in 2020 to 578 BCM per hour in 2021. This decline in productivity also continued in 2022, namely to 543 BCM per hour which impacts the contribution to revenue to only 1%. The rise and fall of productivity is not directly related to the increase in equipment performance after GOH. This is due to several influencing factors.

Several factors that influence productivity are operator skill, type of loading material and loading area. The operator's skill greatly influences productivity, starting from the length of flying hours, whether he is senior or junior, it can have an impact on how much productivity he gets. Loading material and loading area also influence excavator productivity. The overburden loading material has a different character from the sludge material so the productivity is also different. Also, a loading area that is less than standard will correct productivity, such as a bucket level that is too close or too far from the dump truck vessel, or a front loading width that is less than standard. PC1250-8 EX2009 in 2021 and 2022 found sludge material, although the percentage was less than 15%, but it corrected productivity.

4.2.3 Performance Cost PC1250-8 EX2008

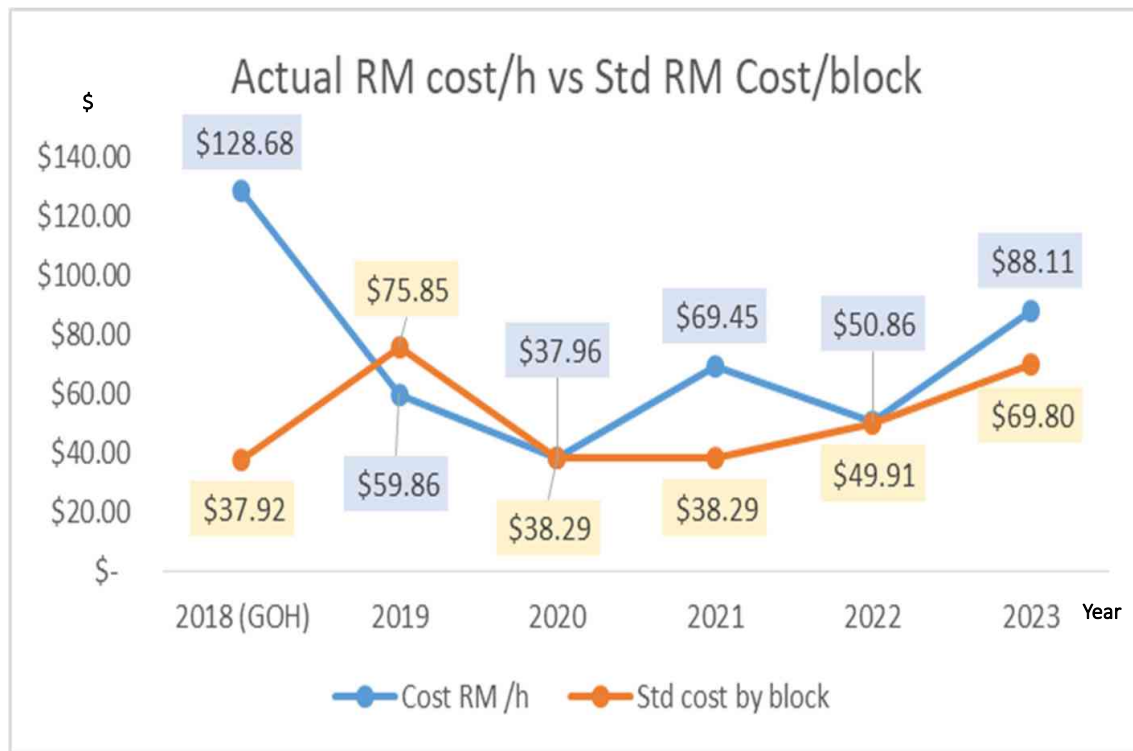


Figure 4. 3 Actual cost/h vs Standart Cost/block EX2009

In Figure 4.3 Actual cost/h vs Standard Cost/block EX2009, two years after GOH in 2019 and 2020, the actual RM cost per hour is lower than the standard cost by block, namely \$59.86 and \$37.96 from the standard cost by block of \$75.85 and \$38.29. This shows the positive impact of RM costs that occurred after GOH was carried out in 2018. Then RM costs increased in the following years which exceeded the standard cost by block, especially in 2021, namely \$69.45 per hour from the standard RM by block cost of \$38.29 (81%) . This occurred due to undercarriage work amounting to \$94,231.68 or 30% of the total cost of RM \$302,632.50. This undercarriage work is not included in the GOH work carried out in 2018 because the undercarriage work in replacing components is not only based on the lifetime hourmeter but also based on component wear trends that occur in the operational area. However, even though the RM cost spike that occurred in 2021 did not result in the performance availability of EX2009 decreasing because the undercarriage work had been planned beforehand so that downtime breakdown during undercarriage work could be maintained as can be seen in Figure 4.4 PA vs RM cost/bcm trend.

PA EX2009 performance will decrease to 82% in 2023 due to the large number of unscheduled breakdown problems. Breakdown unschedule occurs at 30% of the permitted target of 10% and has an impact on RM costs being higher than the standard cost by block.

Figure 4.5 Corrective Action shows that the Plant Kalsel team carried out an action plan for the technical problems that occurred which corrected performance availability in 2023. This corrective action refers to the concept of plan-do-check-action. In Figure 4.5. Corrective action is a check and action step carried out by the overseas Plant Site team. Check, by reviewing the problems on the PC1250-8 EX2009 with PA correction.

There are six points of problems that are reviewed, namely hydraulic piping leak, hydraulic leak (hose & oring), error 11 & error 02, bearing circle clearance (bolt mouting bearing circle loss and crack), hydraulic low power and engine low power. Of the six problems, a technical analysis was carried out with the teams involved, starting from the Plant department head, Plant Section Head, Plant engineer, Planner, Group leader to mechanics. The output of the check or review process for PA correction problems is an action plan in the form of a mandatory program. Every detail of activity is monitored for execution in accordance with the

work plan. And this continues to be repeated in periodic reviews which are carried out once a week by the Plant team.

Apart from that, OVH work was also carried out in the same year to improve the performance of PA EX2009 which can be seen in the OVH program items in Table 4.8 OVH EX2009 in 2023

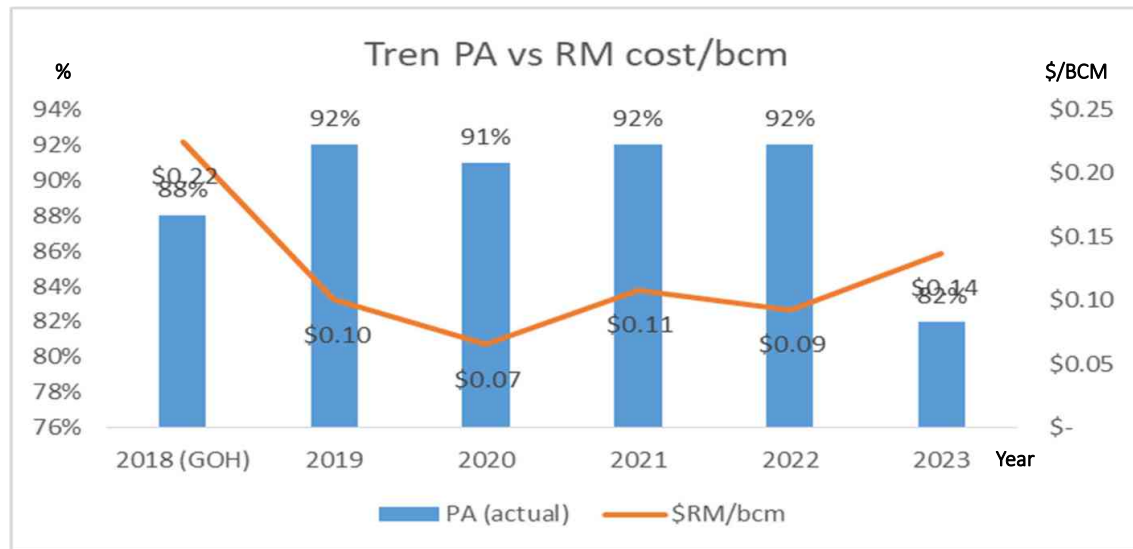


Figure 4. 4 Tren PA vs RM cost/bcm

Figure 4. 5 Corrective Action EX2009

Code Number	Problem	Analysis	Mandatory detail activity	Status
EX2009	Hydraulic piping leak	Rubber bracket piping become hard	Replace piping attachment & repair	Closed
			Replace bracket & rubber piping attachment	Closed
			Schedule replace every 18000 hours for rubber bracket	Closed
	Hydraulic hose & oring leak	Premature lifetime of hydraulic oring (piping, hoses & block) &	Schedule re hose every 6000 hours	Closed
			Schedule replace flange hose every 18000 hours	Closed
	Error 11 & error 02	Wiring injector no 1 short & wiring selenoid TVC intermitten	Replace wiring injector	Closed
			Standarization wiring HEEM	Closed
	Clearance bearing circle high, bolt mounting bearing	Fast wear of bearing circle, lifetime bolt circle <30.000 hours	Consisten to meausure clearance bearing every 250 hours	Closed
			Checking mounting bolt using ultra sonic	Closed
	Hydraulic low power	Setting pressure existing is unstandartd	Execute GMC	Closed
	Hydraulic temperature to high	Setting pressure existing is unstandartd	Execute GMC	Closed
	AC hot	Loss of v belt	Replace v-belt in 500 hours	Closed
	Pin Boom to arm broken	Overload fracture	Schedule rebushing attachment & control operational MTO	Closed

Table 4. 8 OVH EX2009 year 2023

DISTRICT	EQUIP No	Type	ITEM NAME	Amount
RANT	EX2009	OVH	Final Drive LH / RH PTA	\$ 25,227.61
RANT	EX2009	OVH	Final Drive LH / RH PTA	\$ 25,227.61
RANT	EX2009	OVH	PACKAGE MIDLIFE	\$ 20,376.61
RANT	EX2009	OVH	LABOUR MAN POWER UT	\$ 15,294.37
RANT	EX2009	OVH	PACKAGE MIDLIFE UT	\$ 14,429.27
RANT	EX2009	OVH	BUSHING	\$ 10,910.02
RANT	EX2009	OVH	LABOUR ASSEMBLY ARM	\$ 9,627.59
RANT	EX2009	OVH	LABOUR MIDLIFE	\$ 7,623.63
RANT	EX2009	OVH	Travel Motor PTA	\$ 7,497.49
RANT	EX2009	OVH	Travel Motor PTA	\$ 7,497.49
RANT	EX2009	OVH	PTO PTA	\$ 7,210.70
RANT	EX2009	OVH	VALVE ASSY	\$ 5,853.16
RANT	EX2009	OVH	TURBOCHARGE	\$ 5,691.02
RANT	EX2009	OVH	Swing Motor PTA	\$ 5,009.05
RANT	EX2009	OVH	Swing Motor PTA	\$ 5,009.05
RANT	EX2009	OVH	BUSHING	\$ 4,195.92
RANT	EX2009	OVH	BUSHING	\$ 3,100.49
RANT	EX2009	OVH	GREASE PUMP	\$ 2,846.36
RANT	EX2009	OVH	PIN	\$ 2,728.59
RANT	EX2009	OVH	HOSE	\$ 2,707.78
RANT	EX2009	OVH	PILOT VALVE	\$ 2,599.82
RANT	EX2009	OVH	SERVICE KIT	\$ 2,569.19
RANT	EX2009	OVH	LABOUR REPAIR BOOM pc1250	\$ 2,567.76
RANT	EX2009	OVH	PIN	\$ 2,486.46
RANT	EX2009	OVH	SERVICE KIT	\$ 2,460.11
RANT	EX2009	OVH	GREASE EXTREME PRESSURE	\$ 2,454.27
RANT	EX2009	OVH	GREASE EXTREME PRESSURE	\$ 2,454.27
RANT	EX2009	OVH	PIN	\$ 2,147.02
			Total	\$ 207,802.73

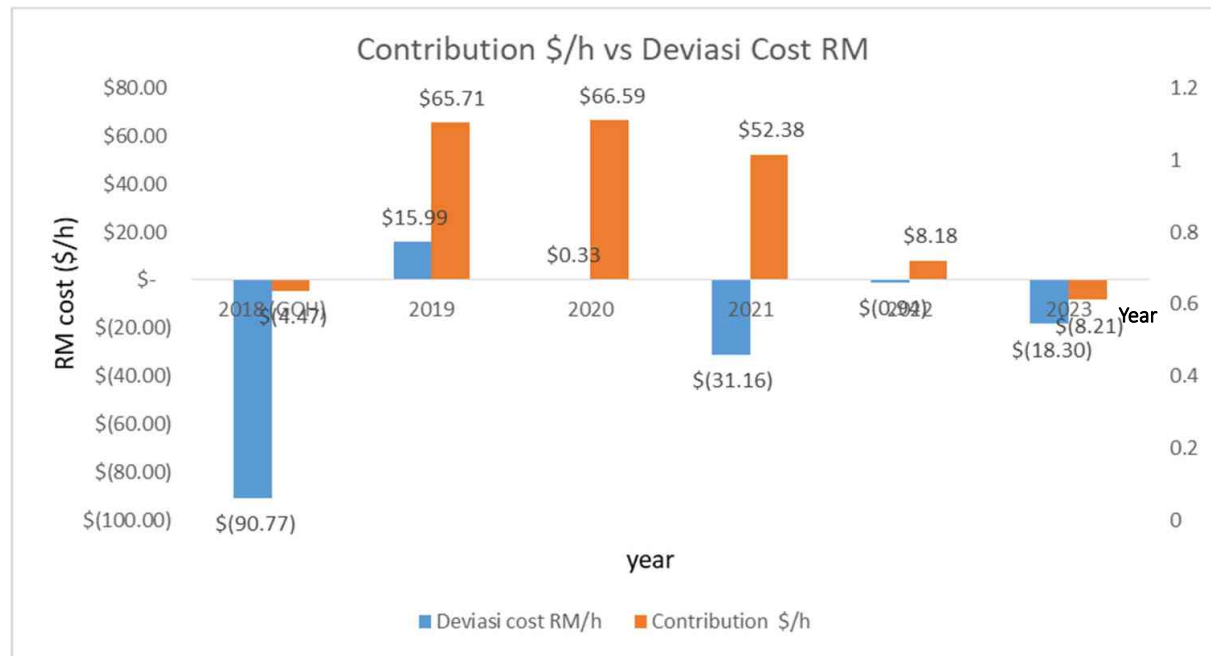


Figure 4. 6 Impact to Revenue, Deviasi Cost RM/h by block & Impact PA (cost RM/BCM)

PC1250-8 EX2009 after OVH was carried out in 2018, the actual hourly cost was \$15.99 per hour and \$0.33 per hour smaller in 2019 and 2020 compared to the standard RM by block cost. Meanwhile, in the following year, namely 2021-2023, the actual RM costs are respectively \$31.16, \$0.94, and \$18.30 per hour compared to the standard RM cost by block. This can be seen in Figure 4.6 Impact to Revenue, Deviation Cost RM/h by block & Impact PA (cost RM/BCM).

In terms of contribution to post-GOH revenue in 2019-2022, it shows a positive contribution, namely \$65.71, \$66.59, \$52.38, and \$8.18 per hour even though in 2021-2023 the RM cost is greater than the standard block cost. It can be concluded that GOH made a positive contribution to revenue after PC1250-8 EX2009, even though the actual RM cost was trending upwards. However, the contribution trend decreases in the fifth year, namely in 2023, because equipment performance also decreases in that year.

4.2.4 Corellation Analysis PA, UA & Productivity

From the PA, UA and productivity data in 2022-2023, a correlation analysis was carried out on how big or strong the influence between these parameter variables was. Correlation analysis is a statistical technique used to evaluate the relationship between two or more variables. The

main goal is to measure the extent to which two variables move together. Correlation does not show causation, but only measures the level of relationship between these variables. For data taken from the variables PA, UA and Productivity, the analysis used was Pearson correlation. Pearson correlation measures the extent to which the relationship between two variables can be explained by a straight line (linear). Pearson correlation values range between -1 and 1, where 1 indicates a perfect positive relationship, -1 indicates a perfect negative relationship, and 0 indicates no linear relationship.

Formula :

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}} \dots(4.1)$$

In the context of regression analysis, "Multiple R" refers to the multiple correlation coefficients between the independent variable and the dependent variable in a multiple regression model. This correlation coefficient is also known as the "coefficient of determination" or "coefficient of multiple determination" and is denoted by R square. Multiple R is a measure of the extent to which the variability of the dependent variable can be explained by the variability of the independent variables in a multiple regression model. Multiple R can be calculated as the square root of the coefficient of determination R square. The coefficient of determination (R square) itself can be calculated as the ratio of the variability explained by the regression model to the total variability in the data.

Formula:

$$R^2 = \frac{\sum (\hat{Y}_i - \bar{Y})^2}{\sum (Y_i - \bar{Y})^2} \dots(4.2)$$

R Square itself does not provide information about the statistical significance of the model or about whether the observed relationship is causal. Because in this research the regression model involves more than one independent variable (PA and UA), looking at the adjusted R square (adjusted R square) is seen for interpretation which takes into account the number of variables in the model. According to Sugiyono (2011) the R square correlation value is as follows:

Table 4. 9 Corellation R square

R square adj	Korelasi
0,00 – 0,199	Very low
0,20 – 0,399	Low
0,40 – 0,599	Currently
0,60 – 0,799	Strong
0,80 – 1,000	Very strong

Analysis in calculating the correlation of PA, UA and Productivity in this research uses Microsoft Excel 2013 software with a data analysis program using regression analysis to get the influence value on the variables.

Anova or Analysis of Variance was also carried out to strengthen determining whether there were significant differences between the PA, UA and Productivity variables. Anova is a statistical technique used to compare the average between two or more variables. The significance value is > 0.05 , which means that the independent variable has no significant effect on the dependent variable, and vice versa.

PA, UA and Productivity data were taken as input for regression analysis starting from 2022-2023 on all PC1250-8 loader units at the Kalsel jobsite. The total population of loader units on the Kalsel jobsite is 9 units. Each unit's performance data is taken which consists of PA (physical availability), UA (utilization availability) and Productivity so that it is summarized in Table 4. 14 PA UA Prody 2022-2023.

In Basic Operation Management L&D (2019) PT. XYZ, productivity is formulated as follows:

$$\text{Productivity} = \text{Production} / \text{WH}$$

Remarks :

Production = Total product (Ton)

WH = Working hour

Meanwhile, utility availability is formulated as follows:

$$UA = (WH)/(MOHH-BD) \times 100\% \dots (4.3)$$

Remarks :

WH = Working hour

MOHH = Machine On Hand Hours

Table 4. 10 PA UA Productivity 2022-2023

Site	EGI	EqNum	PA	UA	Prdtvty
RANT	PC1250	EX2009	82%	61%	551
RANT	PC1250	EX2005	83%	61%	536
RANT	PC1250	EX2015	85%	62%	533
RANT	PC1250	EX2020	87%	61%	528
RANT	PC1250	EX2011	90%	63%	540
RANT	PC1250	EX2026	90%	64%	606
RANT	PC1250	EX2044	94%	70%	479
RANT	PC1250	EX2041	95%	65%	575
RANT	PC1250	EX2048	98%	72%	675

After the PA, UA and Productivity data for all Kalsel Jobsite PC1250-8 loaders were taken, they were then analyzed using data analysis in Microsoft Excel 2013 for the correlation values between these variables. Relationship analysis calculates how strong the relationship is between PA-UA-Productivity, PA-UA, and PA-Productivity.

Table 4. 11 Regression Statistic Productivity, PA dan UA

Regression Statistics		Intepretation
Multiple R	0.448611768	The correlation value of PA, UA to Prody is 0.44, which is a medium value
R Square	0.201252518	

Adjusted R Square	0.64996643	Determination value 65%. PA & UA influence Prody by 65%, the rest is influenced by other factors
Standard Error	57.56387184	
Observations	9	

Table 4. 12 Anova Productivity, PA dan UA

ANOVA

	df	SS	MS	F	Significance F	Itepretasi
Regression	2	5009.369492	2504.68	0.7559	0.509598928	Significance value (0.5) > alpha 0.05, then PA UA has no significant effect on Productivity
Residual	6	19881.59605	3313.6			
Total	8	24890.96554				

From the regression analysis data carried out using data processed by Microsoft Excel 2023, the relationship between productivity, PA and UA can be seen in Table 4.11 Regression Statistics for Productivity, PA and UA, the correlation value is 0.44 (multiple R). This means that the relationship between PA and UA towards Productivity is moderate. 0.44 is converted into Table 4.9 The R square correlation value has a medium value. And the adjusted R square value has a value of 0.65 or 65%, which means that PA and UA have an influence on productivity of 65% and the rest is influenced by other factors. These other factors, which have been explained in the previous discussion, can also be influenced by operator skill, type of loading material and loading area. Performed again using ANOVA analysis, it was found that the significance value was 0.509 ($>\alpha 0.5$) which means that PA and UA do not significantly influence productivity.

Table 4. 13 Analysis of Relation PA & UA

Regression Statistics		Interpretation
Multiple R	0.8874	The correlation value of PA to UA is 0.88, which is a very strong value
R Square	0.7875	
Adjusted R Square	0.7571	Determination value 75%. PA influences UA by 75%, the rest is influenced by other factors
Standard Error	0.0208	
Observations	9	

Table 4. 14 Anova PA and UA

ANOVA

	df	SS	MS	F	Significance F	Interpretasi
Regression	1	0.011213136	0.01121	25.936	0.001410796	Significance value (0.0014)
Residual	7	0.003026321	0.00043			< alpha 0.05, then PA has a
Total	8	0.014239458				very significant effect on UA

The relationship between PA and UA is in Table 4.13. Analysis of the Relationship between PA & UA, it was found that the correlation value was 0.88 (multiple R). This means that PA's relationship with UA is very strong. The value of 0.88 is converted into Table 4.9 The R square correlation value has a very strong value. And the adjusted R square value has a value of 0.75 or 75%, which means that PA has an influence on UA of 75% and the rest is influenced by other factors. Performed again using ANOVA analysis, it was found that the significance value was 0.0014 (<alpha 0.5) which means that PA has a very significant effect on UA as seen in Table 4. 20 Anova PA and UA.

Table 4. 15 Regression Equations PA and UA

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.0575	0.11491299	0.499	0.632	0.214274	0.329177	-0.21427	0.329177
PA	0.6527	0.12815517	5.092	0.001	0.349627	0.955705	0.349627	0.955705

From Table 4. 15. The PA and UA Regression Equations are found to be as follows:

$$UA = 0.057 + 0.652PA$$

From this equation, it can be simulated the projection of the magnitude of UA from the PA parameters. It can be seen in Table 4.16 the results of the PA and UA Regression Equation Calculation starting from PA 85% to PA 100% with an impact on the UA amount of 0.611 or 61% to 0.702 or 70.2%. Furthermore, the UA figure from the calculation of the regression equation can be used as a reference for the projection simulation.

Table 4. 16 Calculation Results of PA and UA Regression Equations

PA	UA
82%	59%
85%	61%
86%	62%
87%	62%
88%	63%
89%	64%
90%	64%
91%	65%
92%	66%
93%	66%
94%	67%
95%	68%
96%	68%
97%	69%
98%	70%
99%	70%
100%	71%

Table 4. 17 Analysis of Relation PA & Productivity

Regression Statistics		Interpretation
Multiple R	0.449	The correlation value of PA to Productivity is 0.45, namely the value is Medium
R Square	0.201	
Adjusted R Square	0.087	Determination value 8.7%. PA influences Productivity by 8.7%, the rest is influenced by other factors
Standard Error	0.055	
Observations	9	

Table 4. 18 Anova PA dan Productivity

ANOVA

	df	SS	MS	F	Significance F	Interpretasi
Regression	1	0.005297684	0.005	1.764	0.226	Significance value (0.226) > alpha 0.05, then PA has no significant effect on Productivity
Residual	7	0.021025884	0.003			
Total	8	0.026323568				

Meanwhile, the relationship between PA and productivity in Table 4. 17 Analysis of the Relationship between PA & Productivity found a correlation value of 0.44 (multiple R). This means that the relationship between PA and Productivity is moderate. The value of 0.44 is converted into Table 4.9 The R square correlation value has a medium value. And the adjusted R square value has a value of 0.087 or 8.7%, which means that PA has an influence on UA of 8.7% and the rest is influenced by other factors. Performed again using ANOVA analysis, it was found that the significance value was 0.22 ($>\alpha 0.5$) which means that PA has no significant effect on productivity as seen in Table 4. 18 Anova PA and Productivity.

4.3 Calculation of Owning Cost

Equipment ownership costs are the costs required to purchase and own equipment as the property of the owner and consist of the following two items:

- Depreciation
- Interest, insurance, & taxes

Table 4. 19 Data Cost PC1250-8 EX2009

EGI	PC1250	
CN	EX2009	
Year accu	2014	
Delivery Price	Rp 6,497,467,497.87	\$ 482,810.87
Kurs \$ 2015	13,457.58	
Depre period (y)(h)	8	40,000
WH a year	5,000	
Trade in value	0.25	
Annual Rates	6%	
Factor	0.67	
Insurance, Tax & Interest	\$ 3.89	
Total Owning per h	\$ 15.96	
Depre per h	\$ 12.07	
Fuel Price	Rp 10,751.25	\$ 0.80

4.3.1 Depreciation

Depreciation is the process of reducing the total cost of fixed assets purchased or owned by a company for business purposes.

$$\text{Depreciation} = \frac{\text{Net Depertiation Value}}{\text{Depreciation Period in Hours}} \dots (4.4)$$

$$\text{Depreciation} = \$482,810.87 / 40,000 \text{ h} = \$12.07$$

Depreciation per month can be calculated from data in Table 4.19 PC1250-8 EX2009 cost data, namely the Net depreciation value or delivery price in the table is \$482,810.87 divided by the depreciation period of 8 years or 40,000 hours. So it is found that the hourly depreciation value is \$12.07. Or the annual depreciation amount is \$482,810.87 divided by eight years of \$60,351.36. So that the owning costs in the eighth year will run out and the value will be \$0 as in table 4.20 Owning Costs below:

Table 4. 20 Owning Cost

Year	Owning Cost
1	\$ 422,459.51
2	\$ 362,108.15
3	\$ 301,756.79

Year	Owning Cost
4	\$ 241,405.43
5	\$ 181,054.08
6	\$ 120,702.72
7	\$ 60,351.36
8	\$ -
9	\$ -
10	\$ -
11	\$ -
12	\$ -
13	\$ -
14	\$ -
15	\$ -

4.3.2 Interest, insurance, & taxes

Interest is the interest that applies to investments. insurance and taxes are (insurance and taxes) imposed on the annual residual value of equipment determined by tax law.

$$\text{Interest, Insurance \& Taxes} = \frac{\text{Factor} \times \text{Delivery price} \times \text{Annual Rates}}{\text{Annual use in hours}} \dots (4.5)$$

Annual rates = 6% (Table 4.27 Data Cost PC1250-8 EX2009)

$$\text{Factor} = 1 - \frac{(n-1)(1-r)}{2n} \dots (4.6)$$

n : depreciation period

$$r : \text{Trade-in value rate} = \frac{\text{Machine worth at trade-in or resale time}}{\text{Delivered price}} \dots (4.7)$$

Interest, Insurance & Taxes from the formula above can be obtained from multiplying the factor by the delivery price and annual rates, the three multiplications are divided by the annual use in hours. The first step in this calculation is to calculate the trade-in value rate.

$$\text{Trade-in value rate} = (25\% \times \$482,810.87) / \$482,810.87$$

Note: 25% is the estimated trade in value.

$$\text{Trade-in value rate (r)} = 0.25$$

The second is the calculation of factor values. The factor value is obtained by calculation ($n = 8$):

$$\text{Factor} = 1 - (8-1)(1-0.25) / 2(8)$$

$$\text{Factor} = 0.67$$

The last one is the calculation of Interest, Insurance and Taxes. Which can be calculated as follows:

$$\text{Interest, Insurance \& Taxes} = (0.67 \times \$482,810.87 \times 6\%) / 5000$$

$$\text{Interest, Insurance \& Taxes} = \$3.89$$

4.4 Calculation of Operating Cost

Operating costs are the costs of operating equipment while the equipment is working. Operating costs also mean the amount of money spent by a business or entity to run and maintain its operations over a certain period of time. Operational costs include various elements necessary to maintain the continuity of business activities. This includes costs such as fuel costs, lubricants costs (oil & grease), tire costs (because in this study a hydraulic excavator was used, tires were omitted), Repair & Maintenance costs, and operator wages.

4.4.1 Fuel Cost

These are the fuel costs incurred for the operation of the equipment. More exact fuel consumption data must be measured in the field. The Komatsu Hand Book provides a standard description of fuel consumption in Table 4.21 Fuel Consumption PC1250-8:

Table 4. 21 Fuel Consumption PC1250-8

Range	Low		Medium		High		
Machine	Amount	U.S. Gal/hr	ltr/hr	U.S. Gal/hr	ltr/hr	U.S. Gal/hr	ltr/hr
PC600, LC-8E0, PC650LC-8E0, PC700LC-8E0		6.5 ~ 8.6	24.5 ~ 32.7	8.6 ~ 10.8	32.7 ~ 40.8	10.8 ~ 17.3	40.8 ~ 65.3
PC600, LC-8R1, PC700LC-8R		6.5 ~ 8.6	24.5 ~ 32.7	8.6 ~ 10.8	32.7 ~ 40.8	10.8 ~ 17.3	40.8 ~ 65.3
PC650LC-11, PC700LC-11		6.1 ~ 8.1	23.0 ~ 30.7	8.1 ~ 10.1	30.7 ~ 38.4	10.1 ~ 16.2	38.4 ~ 61.4
PC800, LC-8E0, PC850-8E0		6.7 ~ 8.9	25.2 ~ 33.7	8.9 ~ 11.1	33.7 ~ 42.1	1.1 ~ 17.8	42.1 ~ 67.3
PC800, LC-8R1, PC850-8R1		6.7 ~ 8.9	25.2 ~ 33.7	8.9 ~ 11.1	33.7 ~ 42.1	1.1 ~ 17.8	42.1 ~ 67.3
PC1250, SP-7		12.2 ~ 15.3	46.0 ~ 58.0	15.3 ~ 18.5	58.0 ~ 69.9	18.5 ~ 26.0	69.9 ~ 105.9
PC1250, LC, SP-8		12.1 ~ 15.2	45.7 ~ 57.6	15.2 ~ 18.4	57.6 ~ 69.6	18.4 ~ 27.8	69.6 ~ 105.3
PC1250, LC, SP-8R		11.7 ~ 14.7	44.2 ~ 55.7	14.7 ~ 17.7	55.7 ~ 67.1	17.7 ~ 26.8	67.1 ~ 101.3
PC1250-11		11.2 ~ 14.2	42.5 ~ 53.6	14.2 ~ 17.1	53.6 ~ 64.7	17.1 ~ 25.9	64.7 ~ 97.9
PC2000-8		17.9 ~ 22.1	67.7 ~ 83.6	22.1 ~ 26.3	83.6 ~ 99.5	26.3 ~ 38.9	99.5 ~ 147.2
PC2000-11		17.0 ~ 22.1	64.3 ~ 79.4	22.1 ~ 26.3	79.4 ~ 94.5	26.3 ~ 38.9	94.5 ~ 139.7

Low: Intermittent work with job efficiency less than 65 %
Material, Easy to excavate

Medium: Digging and loading 65 - 80 % of machine operation hours
Material, Not easy to excavate

High: Work with job efficiency more than 80 %
Direct excavation needed sometimes.

In Table 4.21 Fuel Consumption PC1250-8, it is explained that there are three operating field criteria that have an impact on the equipment's fuel consumption. Three types of operating fields are divided in the Komatsu handbook, namely Low, Medium and High. A low operating field indicates that the work area requires work efficiency of less than 65% and the material is relatively easy to excavate. The medium operating field shows that digging and loading require 65 - 80% operating hours and the material is not easy to dig. The high operating field shows that in terms of work duration it has a work efficiency of more than 80%. For the PC1250-8 EX2009 jobsite Klasel work area, the operating field is in the high operating field, which requires work efficiency of more than 80% with a fuel consumption range of between 69.6 liters per hour to 105.3 liters per hour. The average actual fuel consumption of the PC1250-8 EX2009 Kalsel job site is 75.67 liters per hour. So this figure is used as a reference for calculating life cycle cost analysis as operating costs.

To find out how much fuel consumption costs are needed, the formula is as follows:

Hourly fuel cost = Hourly fuel consumption x Local unit price of fuel....(4.8)

Hourly fuel consumption is obtained from the PC1250-8 range figure in the Komatsu manual handbook which is 75.67 liters per hour from the range of 69.6 liters per hour to 105.3 liters per hour. Meanwhile, the fuel price is obtained from the local price that applies in Indonesia, which is adjusted to increase each year as in Table 4.22 Fuel Price. This fuel price is released

by Pertamina as a fuel provider every month and every year. The data is processed so that it is summarized in the table. The fuel price used in the calculation adjusts to the table in the life cycle cost analysis calculation. For fuel prices in 2023 and above, the increase rate figure from the last ten years is used, namely an increase rate of 6%.

Table 4. 22 Fuel Price

Year	\$/liter	Increase rate
2012	\$ 1.10	-
2013	\$ 1.02	-7%
2014	\$ 1.12	10%
2015	\$ 0.80	-29%
2016	\$ 0.62	-23%
2017	\$ 0.73	19%
2018	\$ 0.95	30%
2019	\$ 0.94	-1%
2020	\$ 0.75	-20%
2021	\$ 0.98	30%
2022	\$ 1.47	50%
	Total	6%

4.4.2 Oil & Grease Cost

Table 4. 23 Oil Consumption

Application	*(1) Crank case		Swing Machinery		*(2) Final Drives		Hydraulic Control		Generator motor		Grease	
Machine Model	US Gal	Liter	US Gal	Liter	US Gal	Liter	US Gal	Liter	lb	kg	lb	kg
PC500LC-8	0.020	0.074	0.0053	0.020	0.0029	0.011	0.013	0.050	—	—	0.26	0.12
PC500LC-8R	0.020	0.074	0.0053	0.020	0.0029	0.011	0.013	0.050	—	—	0.26	0.12
PC500LC-10MD	0.030	0.074	0.0045	0.017	0.0024	0.009	0.015	0.058	—	—	0.26	0.12
PC500LC-10R	0.020	0.074	0.0045	0.017	0.0024	0.009	0.015	0.056	—	—	0.26	0.12
PC550LC-8	0.020	0.074	0.0053	0.020	0.0029	0.011	0.013	0.050	—	—	0.26	0.12
PC600-8ED	0.021	0.080	0.0069	0.026	0.0028	0.010	0.019	0.072	—	—	0.35	0.16
PC600-8R1	0.021	0.080	0.0069	0.026	0.0028	0.010	0.019	0.072	—	—	0.35	0.16
PC650LC-11	0.025	0.096	0.0070	0.026	0.0026	0.010	0.019	0.072	—	—	0.35	0.016
PC700LC-8ED	0.021	0.080	0.0069	0.026	0.0028	0.010	0.019	0.072	—	—	0.35	0.16
PC700LC-8R	0.021	0.080	0.0069	0.026	0.0028	0.010	0.019	0.072	—	—	0.35	0.16
PC700LC-11	0.025	0.096	0.0070	0.026	0.0063	0.024	0.013	0.050	—	—	0.35	0.016
PC800-8ED	0.028	0.106	0.013	0.049	0.0053	0.020	0.025	0.094	—	—	0.35	0.16
PC800-8R1	0.028	0.106	0.013	0.049	0.0053	0.020	0.025	0.094	—	—	0.35	0.16
PC850-8ED	0.028	0.106	0.013	0.049	0.0053	0.020	0.025	0.094	—	—	0.35	0.16
PC850-8R1	0.028	0.106	0.013	0.049	0.0053	0.020	0.025	0.094	—	—	0.35	0.16
PC1250-7	0.032	0.120	0.013	0.050	0.006	0.022	0.037	0.140	—	—	0.40	0.18
PC1250-8	0.045	0.172	0.013	0.049	0.0055	0.021	0.035	0.134	—	—	0.44	0.20
PC1250-8R	0.045	0.172	0.013	0.049	0.0055	0.021	0.035	0.134	—	—	0.44	0.20
PC1250LC-11	0.045	0.172	0.010	0.040	0.0055	0.021	0.035	0.134	—	—	0.44	0.20
PC2000-8	0.063	0.240	0.016	0.060	0.0220	0.085	0.069	0.260	—	—	0.18	0.08
PC2000-11	0.066	0.256	0.016	0.060	0.0225	0.085	0.069	0.260	—	—	0.18	0.08

*(1) Includes lubricant of PTO case.

*(2) Includes lubricant of differential gear box.

In Table 4. 23 Oil Consumption taken from the Komatsu manual Handbook, it is explained that there are four components that have oil consumption and one part for grease, with the unit of consumption for oil being liters per hour and for grease being kilograms per hour. The four components that consume oil are the crank case, swing machinery, final drive and hydraulic control. On the PC1250-8 it was found that the oil consumption for the crank case was 0.172 liters per hour, the swing machinery was 0.049 liters per hour, the final drive was 0.021 liters per hour and the hydraulic control was 0.134 liters per hour. Meanwhile, grease consumption is 0.2 kilograms per hour.

To find out how much oil consumption and grease consumption costs are needed, the formula is as follows: Hourly Lubricating Cost = Hourly lubricating consumption x Local unit price of lubrication oil/grease....(4.9)

Note : local oil price per liter = \$1.63 & price of grease local per kilogram is \$3.72

Hourly Lubricating Cost crank case = $0.172 \times \$1.63$

Hourly Lubricating Cost crank case = \$0.28

Hourly Lubricating Cost swing machinery = $0.049 \times \$1.63$

Hourly Lubricating Cost swing machinery = \$0.08

Hourly Lubricating Cost final drive = $0.021 \times \$1.63$

Hourly Lubricating Cost final drive = \$0.03

Hourly Lubricating Cost hydraulic control = $0.134 \times \$1.63$

Hourly Lubricating Cost hydraulic control = \$0.21

Hourly Grease Cost = $0.2 \times \$3.72$

Hourly Grease Cost = \$0.74

4.4.3 Repair & Maintenance Cost

Heavy equipment repair and maintenance costs are costs incurred in connection with maintaining, repairing and maintaining heavy equipment (Maintenance Program: Periodic Service, Backlog, Midlife, OVH etc.). Also the BUS costs incurred are included in this cost component.

Table 4. 24 Repair & Maintenance Cost (Periodical Service)

NO	MAINTENANCE	LIFE TIME	COST SERVICE			COST PAP		
			PARTS	OIL	BACKLOG	QTY BOTTLE	COST	TOTAL
1	PS 250	250	\$475.29	\$263.29	\$404.00	1	\$10.00	\$10.00
2	PS 500	500	\$994.94	\$622.99	\$845.69	2	\$10.00	\$20.00

NO	MAINTENANCE	LIFE TIME	COST SERVICE			COST PAP		
			PARTS	OIL	BACKLOG	QTY BOTTLE	COST	TOTAL
3	PS750	750	\$475.29	\$263.29	\$404.00	1	\$10.00	\$10.00
4	PS 1000	1,000	\$1,816.07	\$1,766.12	\$1,543.66	4	\$10.00	\$40.00
5	PS 2000	1,000	\$2,334.47	\$2,317.45	\$1,984.30	6	\$10.00	\$60.00
6	PPM	1,000	\$0.00	\$0.00	\$0.00			
7	HYDRAULIC	4,000	\$0.00	\$1,315.84	\$0.00			

As for Table 4.24 Repair & Maintenance Cost (Periodical Service), it is explained that the costs for each maintenance activity for each have different costs because the work items for each are not the same. The costs incurred on PS250, PS500, PS1000, PS2000, PPM and Hydraulic work can be seen in Table 4.24 PS250 means that the work is carried out according to the hour meter interval every multiple of 250 hours, PS500 is carried out every multiple of 500 hours and so on.

NO	MAINTENANCE	LIFE TIME	COST PARTS
1	CARRY ROLLER LH	10,000	\$ 16,764.00
2	CARRY ROLLER RH	10,000	\$ 16,764.00
3	GUARD F/D LH	20,000	\$ -
4	GUARD F/D RH	20,000	\$ -
5	IDLER LH	20,000	\$ 9,518.00
6	IDLER RH	20,000	\$ 9,518.00
7	TEETH SPROCKET LH	20,000	\$ 2,740.79
8	TEETH SPROCKET RH	20,000	\$ 2,740.79
9	TRACK LINK LH	20,000	\$ 17,069.70
10	TRACK LINK RH	20,000	\$ 17,069.70
11	TRACK ROLLER LH	10,000	\$ 16,818.94
12	TRACK ROLLER RH	10,000	\$ 16,818.94
13	Track Shoe LH	20,000	\$ 57,002.88
14	Track Shoe RH	20,000	\$ 57,002.88

Figure.26 Repair & Maintenance Cost (Undercarriage)

Undercarriage maintenance work is carried out by replacing each component according to its age interval. Before replacing undercarriage components, the Plant Engineer analyzes wear trends arising from measurements carried out in the undercarriage inspection program. And found the average age and price of the undercarriage as shown in Figure. 26 Repair & Maintenance Cost (Undercarriage). Undercarriage components that need to be replaced according to age standards are the carrier roller, idler, sprocket teeth, track link, track roller and track shoe.

Table 4. 25 Repair & Maintenance Cost (Attachment)

NO	MAINTENANCE	LIFE TIME	COST PARTS
1	TANK	6,000	\$ 3,356.09
2	CHASIS	12,000	\$ 6,515.27
3	ARM	12,000	\$ 3,014.65
4	BOOM	12,000	\$ 2,653.03
5	BUCKET	6,000	\$ 11,939.91
6	LINE BORING	16,000	\$ 4,462.88
7	ATTACHMENT	6,000	\$ 5,026.02

In Table 4.25 Repair & Maintenance Cost (Attachment) is found for each part that is grouped as attachments such as tanks, chassis fabrication, arm, boom, bucket, line boring work, and other attachment fabrication work (bottom cover and other body covers) has age intervals and respective prices.

Table 4. 26 Repair & Maintenance Cost (Midlife)

NO	MAINTENANCE	LIFE TIME	COST PARTS
1	ALTERNATOR	12,000	\$ 961.45
2	INJECTORS	20,000	\$ 7,311.39

Midlife programs are programs that are carried out on an Engine in the middle of its standard life. This midlife program is carried out with the aim of achieving the expected engine life. Midlife is carried out by replacing the alternator at 12,000 hours and injectors at 20,000 hours

with the expected engine life being 30,000-35,000 hours with a genuine engine and 20,000-25,000 hours with an ex-Ovh engine. What is meant by a genuine engine is an engine purchased new from the manufacturer. Meanwhile, the ex-Ovh engine is a rebuilt engine. In Table 4.26 Repair & Maintenance Cost (Midlife) it is found that replacing an alternator every 12,000 hours costs \$961.45 and replacing an injector every 20,000 hours costs \$7,311.39

Table 4. 27 Repair & Maintenance Cost (Major Component)

NO	MAINTENANCE	LIFE TIME BRAND NEW	LIFE TIME EX-OVH	COST PARTS
1	ARM CYL	8,000	10,000	\$18,802.50
2	BOOM CYL LH	12,000	10,000	\$16,295.50
3	BOOM CYL RH	12,000	10,000	\$16,295.50
4	BUCKET CYL LH	6,000	10,000	\$7,624.50
5	BUCKET CYL RH	6,000	10,000	\$7,624.50
6	MP1	20,000	10,000	\$9,320.37
7	MP2	20,000	10,000	\$9,320.37
8	SWP	12,000	10,000	\$9,320.37
9	ENG	30,000	20,000	\$104,341.80
10	FD LH	25000	18000	\$34,340.50
11	FD RH	25000	18000	\$34,340.50
12	PTO	30,000	14,000	\$9,447.08
13	SMC	25,000	10,000	\$14,783.06
14	SW MTR1	25,000	10,000	\$6,574.94
15	SW MTR2	25,000	10,000	\$6,574.94
16	TM LH	20,000	14,000	\$9,841.29
17	TM RH	20,000	14,000	\$9,841.29
18	SMC2	12,000	10,000	\$14,783.06

Table 4.27 Repair & Maintenance Cost (Major Component) explains the replacement hour intervals and prices for each major component consisting of arm cylinder, boom cylinder, bucket cylinder, main pump, swing pump, engine, final drive, power take off, swing machinery, swing motorbikes, and travel motorbikes. In the figure, the clock interval with lifetime brand

new is the original component since the unit was purchased or could also be referred to as a new component. Meanwhile, lifetime ex-Ovh is a component that is rebuilt. In general, what is used is ex-Ovh considering that purchasing new components is much more expensive than ex-Ovh components.

The planner, as the planner of all equipment maintenance activities, which includes creating periodic service schedules, overhaul and inspection programs as well as evaluating the results of the implementation of the maintenance schedule program, always collaborates with the Plant Engineer to ensure that the planned component ages are as expected. Plant engineers monitor and analyze the results of taking oil sample components in each program run, measuring VHMS (vehicle health monitoring system) technical data, measuring wear rate, measuring lubrication quality, and working temperature which are combined into the CMI Score (condition monitoring index) results.).

From the CMI score, the Plant Engineer provides input on the action plan to the planner and also to the Group Leader as the maintenance executor in the field by issuing a FUI (follow up instruction). The FUI issued by the Plant Engineer to the Group Leader is a recommendation for certain actions that must be immediately acted upon or executed. With the hope that the execution of FUI can maintain the excavator's performance in prime condition according to its planned lifespan. This can also have an impact on the level of accuracy of costs arising from Repair & Maintenance.

RM Cost by Block HM

Table 4. 28 Detail Repair & Maintenance Cost by Block HM

BLOCK YEAR	HM ESTIMATION	PERIODIC SERVICE & BACKLOG	UNDERCARRIAGE	FABRIKASI	MIDLIFE	PAP	OVERHAUL	UNSCHEDULE BREAKDOWN	TOTAL COST	\$/h
1	0-5000	\$ 65,094.64	\$ -	\$20,322.03	\$ 5,447.09	\$540.00	\$ 15,249.00	\$ 10,611.28	\$ 117,264.03	\$ 19.68
2	5000-10000	\$ 66,410.48	\$ 67,165.88	\$32,504.98	\$10,777.24	\$540.00	\$ 90,745.93	\$ 26,760.45	\$ 294,904.95	\$ 49.49
3	10000-15000	\$ 65,094.64	\$ -	\$24,784.91	\$ 7,454.95	\$540.00	\$ 34,051.50	\$ 13,138.60	\$ 145,064.60	\$ 24.34
4	15000-20000	\$ 66,410.48	\$239,828.63	\$32,504.98	\$18,088.63	\$540.00	\$ 129,069.24	\$ 48,590.20	\$ 535,032.16	\$ 89.79
5	20000-25000	\$ 65,094.64	\$ 67,165.88	\$20,322.03	\$ 7,454.95	\$540.00	\$ 225,651.81	\$ 38,568.93	\$ 424,798.24	\$ 71.29
6	25000-30000	\$ 66,410.48	\$ -	\$36,967.87	\$10,777.24	\$540.00	\$ 90,745.93	\$ 20,490.15	\$ 225,931.65	\$ 37.92
7	30000-35000	\$ 65,094.64	\$239,828.63	\$20,322.03	\$12,758.49	\$540.00	\$ 72,374.82	\$ 41,037.86	\$ 451,956.46	\$ 75.85
8	35000-40000	\$ 66,410.48	\$ -	\$36,967.87	\$12,785.10	\$540.00	\$ 90,745.93	\$ 20,690.94	\$ 228,140.30	\$ 38.29
9	40000-45000	\$ 65,094.64	\$ 67,165.88	\$20,322.03	\$ 5,447.09	\$540.00	\$ 111,862.94	\$ 26,989.26	\$ 297,421.83	\$ 49.91
10	45000-50000	\$ 66,410.48	\$239,828.63	\$32,504.98	\$20,096.49	\$540.00	\$ 18,802.50	\$ 37,764.31	\$ 415,947.39	\$ 69.80
11	50000-55000	\$ 53,709.65	\$ -	\$24,784.91	\$ 5,447.09	\$440.00	\$ 242,858.12	\$ 32,679.98	\$ 359,919.76	\$ 60.40
12	55000-60000	\$ 55,220.02	\$ 67,165.88	\$32,504.98	\$10,777.24	\$460.00	\$ 15,249.00	\$ 18,091.71	\$ 199,468.83	\$ 33.47
13	60000-65000	\$ 53,709.65	\$ -	\$20,322.03	\$ 7,454.95	\$440.00	\$ 187,359.86	\$ 26,884.65	\$ 296,171.15	\$ 49.70
14	65000-70000	\$ 56,535.86	\$239,828.63	\$ 4,462.88	\$ 7,311.39	\$460.00	\$ 72,374.82	\$ 38,051.36	\$ 419,024.95	\$ 70.32
15	70000-75000	\$ 53,709.65	\$ -	\$32,504.98	\$10,777.24	\$440.00	\$ 71,943.43	\$ 16,893.53	\$ 186,268.83	\$ 31.26

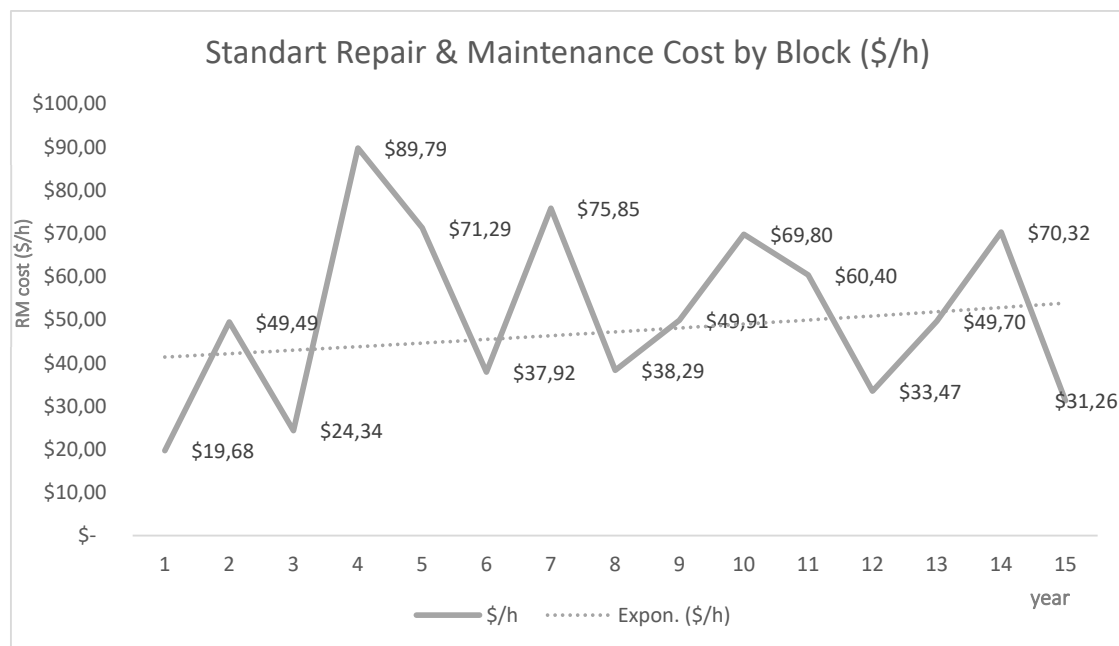


Figure 4. 7 Trend Standart Repair & Maintenance Cost by Block HM

All components of repair & maintenance costs starting from periodic service, undercarriage, fabrication, midlife, PAP (lubricant analysis program), and overhaul are combined into one as a standard cost. This standard cost is then projected for the next few years, namely from year 1 to year 15, each year is 5000 hours which can be seen in Table 4.28 Details of Repair & Maintenance Cost by Block HM and Figure 4.7 Trend of Standard Repair & Maintenance Cost by Block HM.

4.4.4 Operator wages

Operator hourly wages vary by country and region. This is included in the operating cost component. As for this research, the operator wage is \$ 5 per hour which has been set by PT. XYZ.

4.5 Calculation of Life cycle Cost

The life cycle cost calculation for the PC1250-8 EX2009 unit is carried out by looking at the overall owning costs and operating costs. The life cycle cost calculation starts from the initial year to the fifteenth year to see what the optimum period is by analyzing the revenue parameters generated from OVH which has been carried out every fifth year.

4.5.1 Owning Cost by year

Owning costs are calculated by adding up the cost parts that have been calculated, such as depreciation costs, interest costs, insurance costs, and taxes. Cost ownership is planned to end its economic life in the eighth year since the PC1250-8 excavator heavy equipment was purchased in 2014. Its useful life will end in the eighth year, namely in 2021. As in Table 4.29 Year of Equipment, it is found that the year of purchase in 2014 is also interpreted as Y1 and apply next. Even though its economic life ends in the eighth year or Y8 or 2021, in this research it was extended to Y15 or 2028 to find out the optimum extent of the PC1250-8 EX2009.

Table 4. 29 Year of Equipement

Year	
y1	2014
y2	2015
y3	2016
y4	2017

Year	
y5	2018
y6	2019
y7	2020
y8	2021
y9	2022
y10	2023
y11	2024
y12	2025
y13	2026
y14	2027
y15	2028

From all the parts of owning costs which consist of depreciation costs, interest costs, insurance costs and taxes, the total value per year is found in Table 4.30 Owing Cost PC1250-8 EX2009 and ends in the eighth year or 2021. In terms of trends, owning costs high at the beginning of the year of acquisition and decreases in subsequent years as in Figure 4.8 Trends in Owing Cost PC1250-8 EX2009.

Table 4. 30 Owing Cost PC1250-8 EX2009

Year		Owning Cost
1	2014	\$422,459.51
2	2015	\$362,108.15
3	2016	\$301,756.79
4	2017	\$241,405.43
5	2018	\$181,054.08
6	2019	\$120,702.72
7	2020	\$60,351.36
8	2021	\$ -
9	2022	\$ -
10	2023	\$ -
11	2024	\$ -
12	2025	\$ -
13	2026	\$ -
14	2027	\$ -
15	2028	\$ -

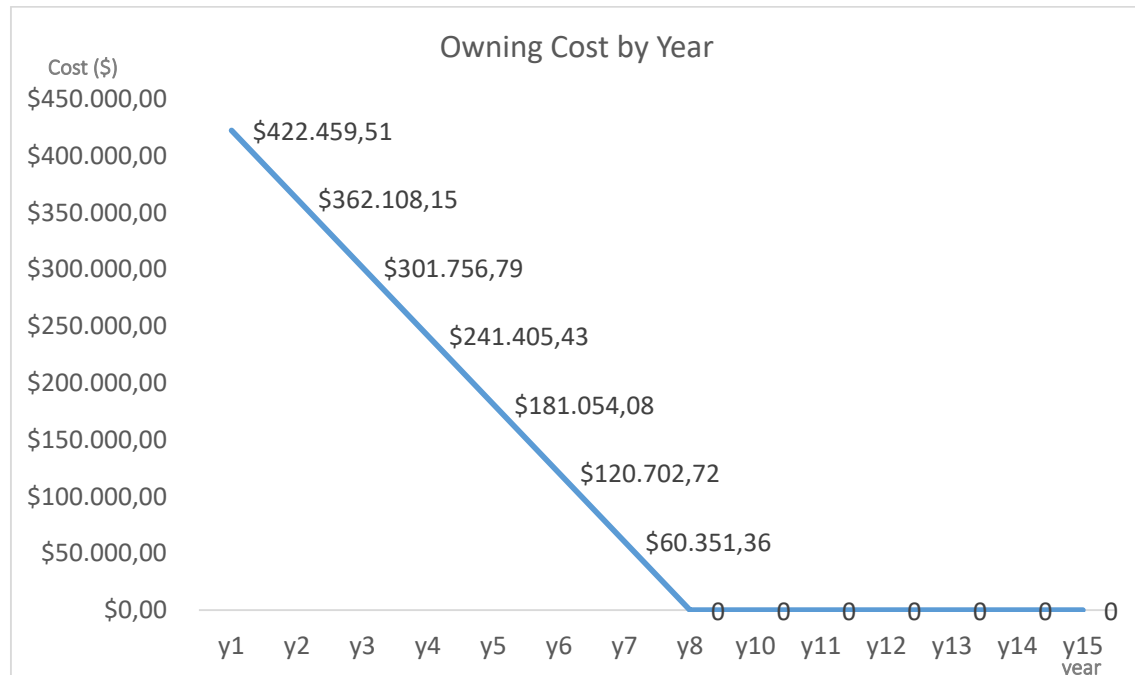


Figure 4. 8 Trend Owning Cost PC1250-8 EX2009.

4.5.2 Operating Cost by Year

Operating costs are calculated by adding up the cost parts that have been calculated, such as fuel costs, oil & grease costs, repair & maintenance costs, and operator wages. Table 4.31 Operating Cost Details PC1250-8 EX2009 (in mio) is a combination of fuel costs, oil & grease costs, repair & maintenance costs, and operator wages. Operating costs have increased from year to year as can be seen in Figure 4.9 Trends in Operating Costs PC1250-8 EX2009 (in mio). This increase in operating costs is due to several factors, namely the increase in operator wages, the average increase of which is 3-6% each year, the increase in the price of parts, oil and components, the average increase of which is 3-4% each year, and the increase in fuel prices. the average increase is 6% every year.

Table 4. 31 Operating Cost Detail PC1250-8 EX2009 (in mio)

Operating Cost	y1	y2	y3	y4	y5	y6	y7	y8	y9	y10	y11	y12	y13	y14	y15
Fuel	\$ 302.27	\$ 311.34	\$ 320.68	\$ 330.30	\$ 340.21	\$ 350.41	\$ 360.92	\$ 371.75	\$ 382.91	\$ 394.39	\$ 406.22	\$ 418.41	\$ 430.96	\$ 443.89	\$ 457.21
Engine Oil	\$ 1.39	\$ 1.43	\$ 1.47	\$ 1.52	\$ 1.56	\$ 1.61	\$ 1.66	\$ 1.71	\$ 1.76	\$ 1.81	\$ 1.87	\$ 1.92	\$ 1.98	\$ 2.04	\$ 2.10
Transmis sion Oil	\$ 0.41	\$ 0.42	\$ 0.43	\$ 0.45	\$ 0.46	\$ 0.47	\$ 0.49	\$ 0.50	\$ 0.52	\$ 0.53	\$ 0.55	\$ 0.57	\$ 0.58	\$ 0.60	\$ 0.62

Operating Cost	y1	y2	y3	y4	y5	y6	y7	y8	y9	y10	y11	y12	y13	y14	y15
Finaldrive Oil	\$ 0.16	\$ 0.17	\$ 0.17	\$ 0.18	\$ 0.18	\$ 0.19	\$ 0.20	\$ 0.20	\$ 0.21	\$ 0.21	\$ 0.22	\$ 0.23	\$ 0.23	\$ 0.24	\$ 0.25
Hydraulic Oil	\$ 1.06	\$ 1.09	\$ 1.13	\$ 1.16	\$ 1.20	\$ 1.23	\$ 1.27	\$ 1.31	\$ 1.35	\$ 1.39	\$ 1.43	\$ 1.47	\$ 1.52	\$ 1.56	\$ 1.61
Grease	\$ 3.72	\$ 3.83	\$ 3.94	\$ 4.06	\$ 4.18	\$ 4.31	\$ 4.44	\$ 4.57	\$ 4.71	\$ 4.85	\$ 4.99	\$ 5.14	\$ 5.30	\$ 5.46	\$ 5.62
Filters	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
RM Cost	\$ 254.15	\$ 261.77	\$ 269.63	\$ 277.72	\$ 479.17	\$ 300.42	\$ 309.44	\$ 318.72	\$ 328.28	\$ 436.61	\$ 351.23	\$ 361.76	\$ 372.62	\$ 383.79	\$ 510.45
Operator Wage	\$ 25.00	\$ 25.75	\$ 26.52	\$ 27.32	\$ 28.14	\$ 28.98	\$ 29.85	\$ 30.75	\$ 31.67	\$ 32.62	\$ 33.60	\$ 34.61	\$ 35.64	\$ 36.71	\$ 37.81
Total Operating Cost	\$ 588.16	\$ 605.80	\$ 623.98	\$ 642.70	\$ 855.10	\$ 687.63	\$ 708.28	\$ 729.51	\$ 751.39	\$ 872.42	\$ 800.11	\$ 824.11	\$ 848.83	\$ 874.30	\$ 1,015.67

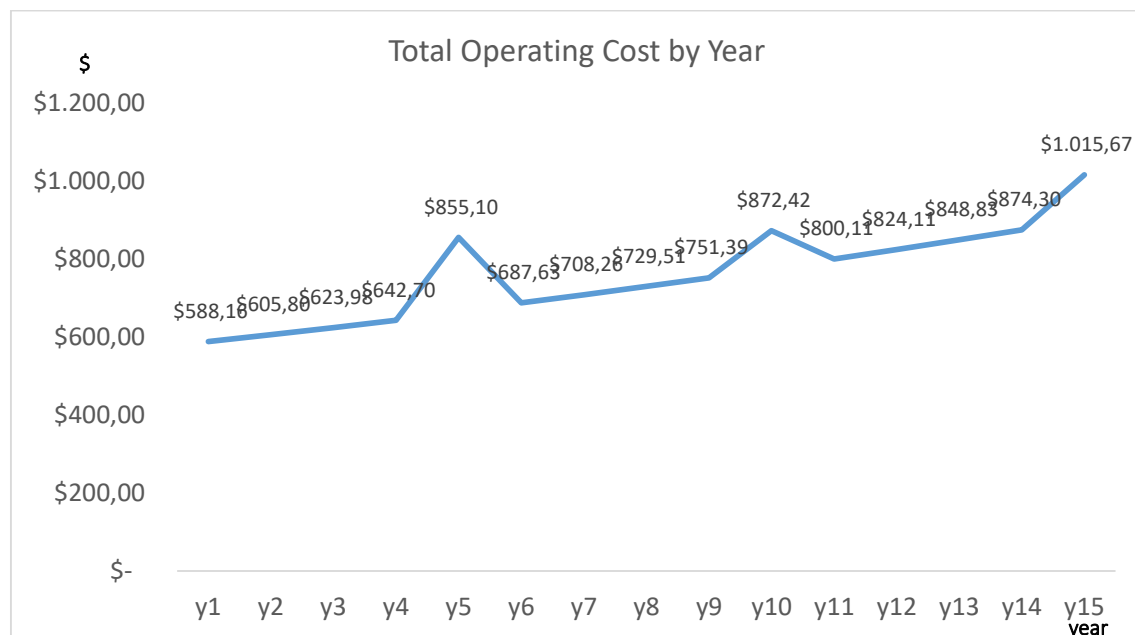


Figure 4. 9 Trend Operating Cost PC1250-8 EX2009 (in mio).

4.5.3 Total Cost (Owining + Operating)

From the owning cost and operating cost of the PC1250-8 EX2009, it is found that the total cost trended downward starting from y1 or 2014 to y8 or 2021. It can be seen in Table 4.32 Total Cost of the PC1250-8 EX2009, Y1/2014 that the owning cost in millions is \$422.46, Y2/2015 is \$362.11, y3/2016 is \$301.76, y4/2017 is \$241.41, y5/2018 is \$0, and the year after

that has run out of earning value. What we can say is that owning costs continue to fall from y1/2014 to y8/2018 because depreciation runs out in the eighth year according to PT's plan. PT. XYZ. In contrast to owning costs, operating costs actually increase from year to year as explained previously. Operating costs in y1/2014 were \$588.16, y2/2015 were \$605.80, y3/2016 were \$623.98, y4/2017 were \$642.70, y5/2018 were \$855.1, y6/2019 were \$687.63, y7/2020 were \$708.26, y8/2021 were \$729.51, Y9/2022 is \$ 751.39, Y10/2023 is \$ 872.42, Y11/2024 is \$ 800.11, Y12/2025 is \$ 824.11, Y13/2026 are \$ 848.83, Y14/2027 are \$ 874.3, and Y15/2028 are \$ 1,0015.67.

With owning and operating costs like that, the total costs for y1/2014 are \$1,010.62, y2/2015 is \$967.91, y3/2016 is \$925.73, y4/2017 is \$884.1, y5/2018 is \$1,036.16, y6/2019 is \$801.33, y7/2020 is \$768.61, y8/2021 is \$729.51, y9/2022 is \$751.39, y10/2023 is \$872.42, y11/2024 is \$800.11, y12/2025 is \$824.11, y13/2026 is \$848.83, y14/2027 is \$874.3, and y15/2028 is \$1,0015.67. Total costs experienced a downward trend from y1/2014 to y8/2021. This is because owning costs continue to decrease until the depreciation period ends in the eighth year. After the eighth year or 2021, the total cost trend will increase along with the increase in operating costs which can be seen in Figure 4.10 Total Cost Trend PC1250-8 EX2009. Therefore, PT. XYZ initially planned to scrap the PC1250-8 EX2009 equipment in the eighth year or 2021 because the total cost trend was to increase in the following years.

Table 4. 32 Total Cost PC1250-8 EX2009

Year	y1	y2	y3	y4	y5	y6	y7	y8	y9	y10	y11	y12	y13	y14	y15
Owning Cost	\$ 422.46	\$ 362.11	\$ 301.76	\$ 241.41	\$ 181.05	\$ 120.70	\$ 60.35	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Operating Cost	\$ 588.16	\$ 605.80	\$ 623.98	\$ 642.70	\$ 855.10	\$ 687.63	\$ 708.26	\$ 729.51	\$ 751.39	\$ 872.42	\$ 800.11	\$ 824.11	\$ 848.83	\$ 874.30	\$ 1,015.67
Total Cost	\$ 1,010.62	\$ 967.91	\$ 925.73	\$ 884.10	\$ 1,036.16	\$ 808.33	\$ 768.61	\$ 729.51	\$ 751.39	\$ 872.42	\$ 800.11	\$ 824.11	\$ 848.83	\$ 874.30	\$ 1,015.67

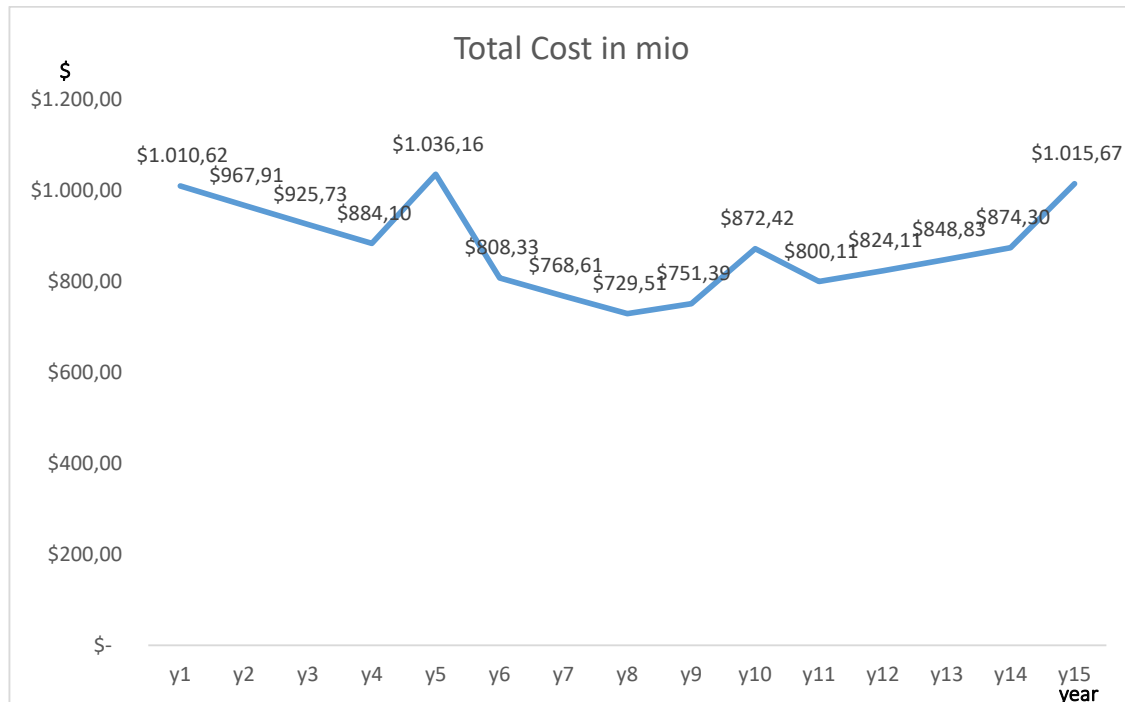


Figure 4. 10 Trend Total Cost PC1250-8 EX2009

4.6 Life cycle Cost analysis

PT. XYZ, especially at the Kalsel job site, is considering scrapping PC1250-8 EX2009 in the eighth year or 2021. This is because in total cost analysis, after the eighth year the costs will increase. As shown in Figure 4.11 LCCA PC1250-8 EX2009, the eighth year marked in red is the planned scrap year. Then the analysis is carried out in more depth by analyzing the impact or influence of GOH which was carried out in the fifth year or in 2018 to find out how far it contributed to the revenue generated.

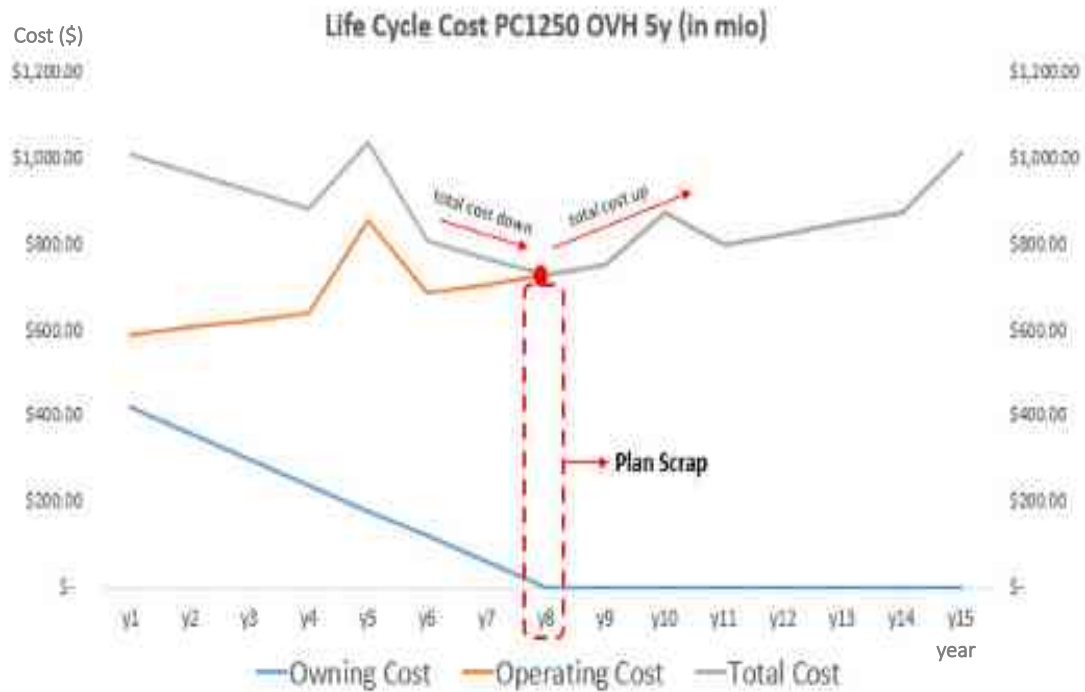


Figure 4. 11 LCCA PC1250-8 EX2009

The General Overhaul which was carried out in the fifth year, namely in 2018 on PC1250-8 EX2009, was initiated because the trend in physical availability (PA) performance had decreased since the second year in 2015. PA in y2/2015 was 95%, y3/2016 was 90%, y4 /2017 was 91%, and in y5/2018 it was 88%. In the year where equipment availability fell the most in the fifth year or 2018, the Management of PT. XYZ decided to carry out GOH for the PC1250-8 EX2009 with the aim of returning the equipment 's performance to its previous performance. The targeted PA performance is PA 91%.

4.6.1 Impact PA to UA after GOH

After carrying out GOH in year y5/2018, the performance of the equipment experienced an increase in PA until the ninth year or 2022. PA after GOH, in year y6/2019 was 92%, y7/2020 was 91%, y8/2021 was 92%, and y9/2022 is 92%. Utility availability (UA) also increased after the implementation of GOH. Before the GOH was carried out, the UA PC1250-8 EX2009 was at 60 percent, which is more than the target of 60% and above. UA after the GOH was carried out experienced an increase in the following four years, namely UA in y6/2019 was 66%, y7/2020 was 65%, y8/2021 was 66%, and y9/2022 was 66%. Visualization of PA performance

after GOH on PC1250-8 EX2009 is shown in Figure 4.12 Impact of PA to UA after GOH and Table 4.33 PA & UA after GOH. In the tenth year or in 2023, it appears that PA performance has decreased to 82% and is also followed by UA performance at 59%. This happens because there have been many unscheduled breakdowns which have been discussed in the performance data sub-chapter. The Klasel Plant jobsite team has also evaluated PT's management and improvement action plans. PT. XYZ has decided to carry out GOH again right in the tenth year in 2023 to return to better performance at the PA target of 92%.

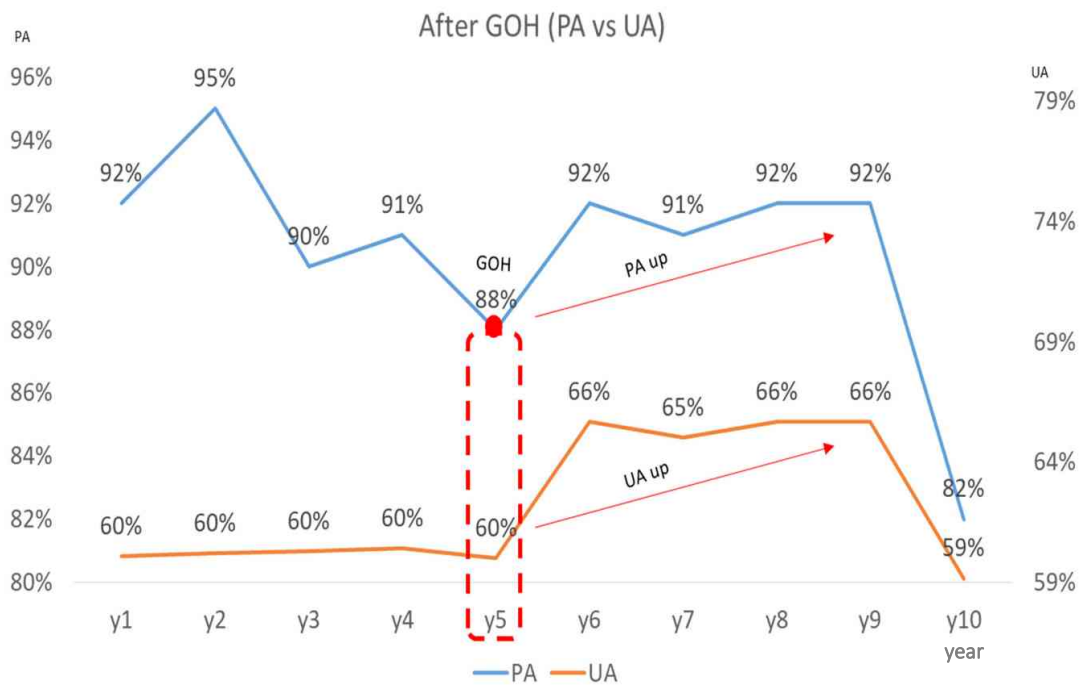


Figure 4. 12 Impact PA to UA after GOH

Table 4. 33 PA & UA after GOH

	PA	UA
y1	92%	60%
y2	95%	60%
y3	90%	60%
y4	91%	60%
y5	88%	60%
y6	92%	66%
y7	91%	65%

	PA	UA
y8	92%	66%
y9	92%	66%
y10	82%	59%

4.6.2 Impact PA to Productivity after GOH

In Figure 4.13 Impact of PA to Productivity after GOH, it is found that there is no significant impact between PA and the productivity of the PC1250-8 EX2009 after GOH. This is as discussed previously because greater productivity is influenced by several factors such as operator skill, type of loading material and loading area. The operator's skill greatly influences productivity, starting from the length of flying hours, whether he is senior or junior, it can have an impact on how much productivity he gets. Loading material and loading area also influence excavator productivity. The overburden loading material has a different character from the sludge material so the productivity is also different. Also, a loading area that is less than standard will correct productivity, such as a bucket level that is too close or too far from the dump truck vessel, or a front loading width that is less than standard.

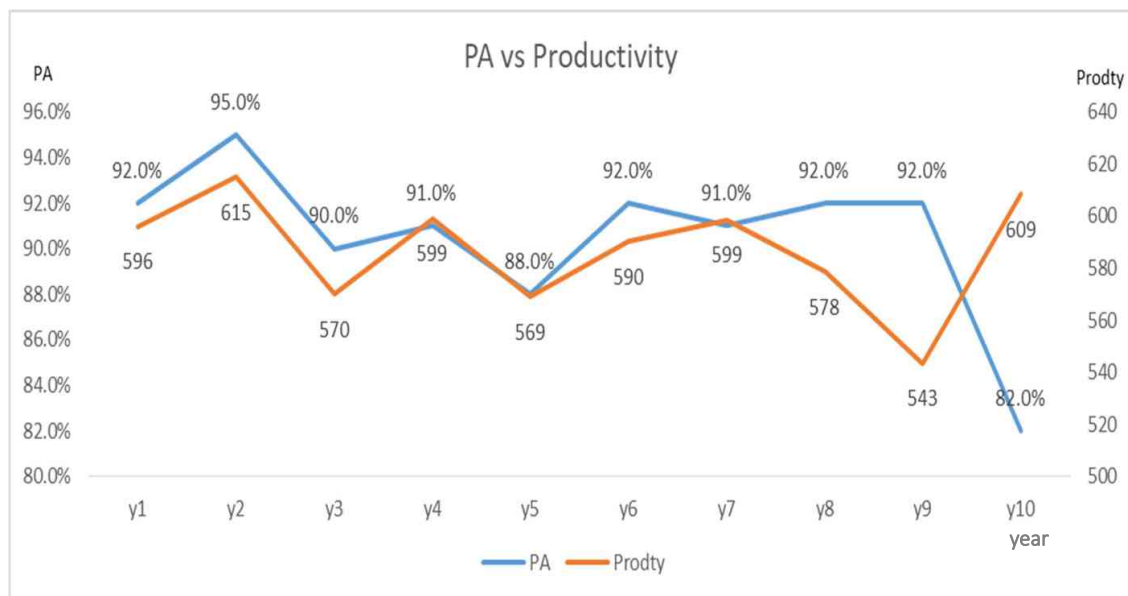


Figure 4. 13 Impact PA to Productivity after GOH

4.6.3 Impact PA to Revenue Analysis

After GOH in y5 or 2018 the contribution to revenue was positive. The contribution to this revenue is the calculation between the target revenue generated by the PC1250-8 EX2009 with the target parameters PA 91%, UA 60% and productivity 553 BCM so that the annual production target is 2,644,976.88 BCM by comparing the production results after GOH.

It was found that the revenue contribution after GOH PC1250-8 EX2009 was carried out in y6/2019 was 18%, y7/2020 was 17%, y8/2021 was 16%, and y9/2022 was 9%. This means that the impact of GOH has had a positive contribution to revenue for four consecutive years. In Y10 or 2023, the contribution to revenue will decrease to -2%, which is due to the decline in PA and UA performance as previously explained. Furthermore, due to the impact of the decline in PA performance, the management of PT. XYZ decided to continue GOH in 2023. The next year after 2023 is the projection. PA is forecasted using empirical data from the previous year, namely from 2014 to 2023 so that PA is obtained until 2028 as in Figure 4. 14 Forecast PA by Microsoft Excel Analysis. Forecast PA upper confidence level bound was chosen in this study to project future analysis because it is at a more optimistic level of confidence than the estimated forecast. The upper confidence level bound was chosen because it also has similarities with the historical PA that occurred after the GOH was carried out. In the PA forecast it will be 0.92 (92%) in y11/2024, 0.93 (93%) in y12/2025, 0.92 (92%) in y13/2026 and 0.91 (91%) in y14/2027. Specifically for the year Y15/2028, researchers chose a forecast estimate (PA) of 0.847 or a percentage of 85%. In y15/2028, we use forecast estimates because based on historical events that occur every five years, the PA trend experiences a decline, which is then continued with the GOH program to improve performance. The PA, which is a forecast based on calculations from empirical data, can of course be achieved by carrying out a quality maintenance program such as carrying out periodic service according to the schedule, implementing equipment cleanliness programs, carrying out periodic inspections that are integrated with backlog management, maintaining working temperature and oil pressure. and others through conditioning monitoring indices that comply with standards and other maintenance activities. Next, for UA using regression parameters and productivity using parameters by Plan.

It was found that in the projection years 2024, 2025, 2026 and 2027, the post-GOH revenue contribution made in 2023 was still positive but the trend was decreasing when compared to

the previous post-GOH contribution, namely y11/2024 with a contribution of 12%, y12/2025 with a contribution of 13 %, y13/2026 at 14% contribution, y13/2027 at 8% contribution and y15/2028 at -5% contribution. The impact of PA after GOH has been carried out on revenue contribution can be seen in Table 4.34 Impact of PA to Revenue Analysis..

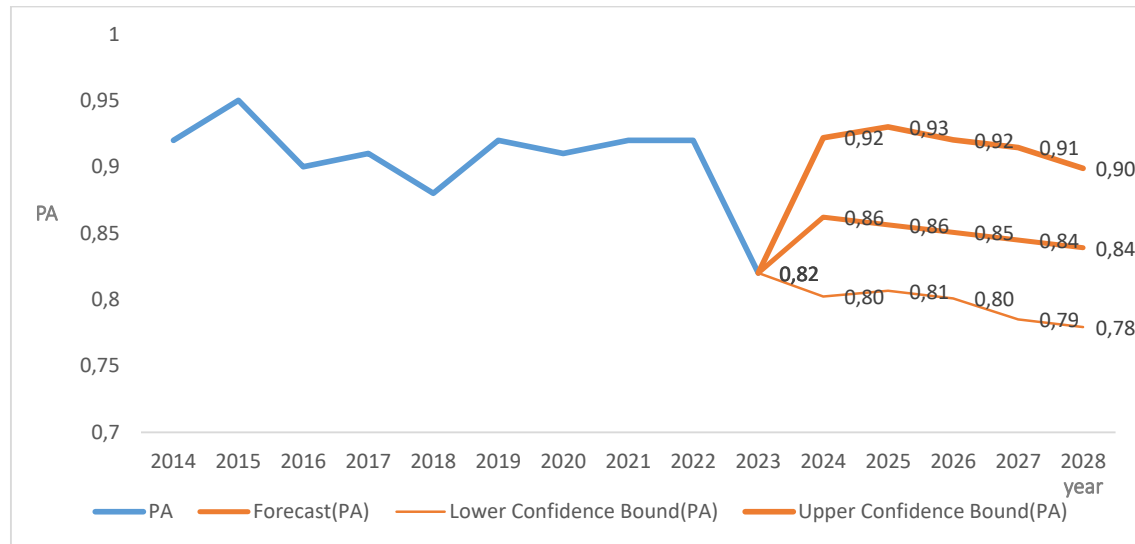


Figure 4. 14 Forecast PA by Microsoft Excel Analysis

Table 4. 34 Impact PA to Revenue Analysis

	Year	PA	UA	Productivity (BCM/h)	MoHH	Produksi (BCM)	Rate	Revenue (ml)	Contribution Revenue	Remark
2014	y1	92%	60%	596	8760	2,881,969.92	\$1.50	\$4,322.95	10%	-
2015	y2	95%	60%	615	8760	3,070,818.00	\$1.50	\$4,606.23	17%	-
2016	y3	90%	60%	570	8760	2,696,328.00	\$1.50	\$4,044.49	3%	-
2017	y4	91%	60%	599	8760	2,864,993.04	\$1.50	\$4,297.49	10%	-
2018	y5	88%	60%	569	8760	2,631,784.32	\$1.50	\$3,947.68	0%	OVH
2019	y6	92%	66%	590	8760	3,125,026.73	\$1.50	\$4,687.54	18%	-
2020	y7	91%	65%	599	8760	3,103,352.34	\$1.50	\$4,655.03	17%	-
2021	y8	92%	66%	578	8760	3,062,303.06	\$1.50	\$4,593.45	16%	-
2022	y9	92%	66%	543	8760	2,876,676.71	\$1.50	\$4,315.02	9%	-
2023	y10	82%	59%	609	8760	2,586,062.33	\$1.50	\$3,879.09	-2%	OVH
2024	y11	92%	66%	553	8760	2,927,363.53	\$1.50	\$4,391.05	11%	-
2025	y12	93%	66%	553	8760	2,988,556.47	\$1.50	\$4,482.83	13%	-
2026	y13	92%	66%	553	8760	2,927,363.53	\$1.50	\$4,391.05	11%	-
2027	y14	91%	65%	553	8760	2,866,802.27	\$1.50	\$4,300.20	8%	-
2028	y15	85%	61%	553	8760	2,516,700.35	\$1.50	\$3,775.05	-5%	-

4.6.4 Cost of Revenue Analysis

Cost of revenue is obtained from the total costs incurred by the PC1250-8 EX2009 divided by the total revenue generated. In the previous discussion, the total cost that occurred from y1/2014 to y15/2028, the trend was to form a U curve. Total costs trended down from y1/2014 to y8/2021, then trended up again from y9/2022 to y15/2028. In Table 4.35 Cost of Revenue Year to Year, it is found that after GOH in y5/2018, the Cost of revenue (CoR) PC1250-8 EX2009 has decreased from the previous year's CoR of above 20% to below 20%. Namely CoR in y6/2019 was 17.24%, y7/2020 was 16.51%, y8/2021 was 15.88%, and y9/2022 was 17.41%.

This means that CoR becomes smaller after GOH is carried out on PC1250-8 EX2009. Furthermore, in year y10 or 2023, a GOH will be carried out which will correct the CoR to 22.49%, it is projected that there will be a decrease in CoR after that in y11/2024 it is 18.22%, y12/2025 is 18.38%, y13/2026 is 19.33%, and y14/2027 is 20.33% . However, in terms of the trend seen in Figure 4.15 Cost of Revenue Trends, CoR tends to increase from year to year. In connection with the total costs that occur, especially operating costs, which include an increase in operator wages, an average increase of 3-6% each year, an increase in the price of parts, oil and components, an average increase of 3-4% each year, and an increase in The average increase in fuel prices is 6% every year, which has an impact on the higher CoR PC1250-8 EX2009.

Table 4. 35 Cost of Revenue Year to Year

	Year	Total Cost	Revenue	COR
2014	y1	\$ 1,010.62	\$ 4,322.95	23.378%
2015	y2	\$ 967.91	\$ 4,606.23	21.013%
2016	y3	\$ 925.73	\$ 4,044.49	22.889%
2017	y4	\$ 884.10	\$ 4,297.49	20.573%
2018	y5	\$ 1,036.16	\$ 3,947.68	26.247%
2019	y6	\$ 808.33	\$ 4,687.54	17.244%
2020	y7	\$ 768.61	\$ 4,655.03	16.511%
2021	y8	\$ 729.51	\$ 4,593.45	15.881%
2022	y9	\$ 751.39	\$ 4,315.02	17.413%
2023	y10	\$ 872.42	\$ 3,879.09	22.490%
2024	y11	\$ 800.11	\$ 4,391.05	18.221%
2025	y12	\$ 824.11	\$ 4,482.83	18.384%
2026	y13	\$ 848.83	\$ 4,391.05	19.331%
2027	y14	\$ 874.30	\$ 4,300.20	20.332%
2028	y15	\$ 1,015.67	\$ 3,775.05	26.905%

Figure. 39 Cost of Revenue Year to Year

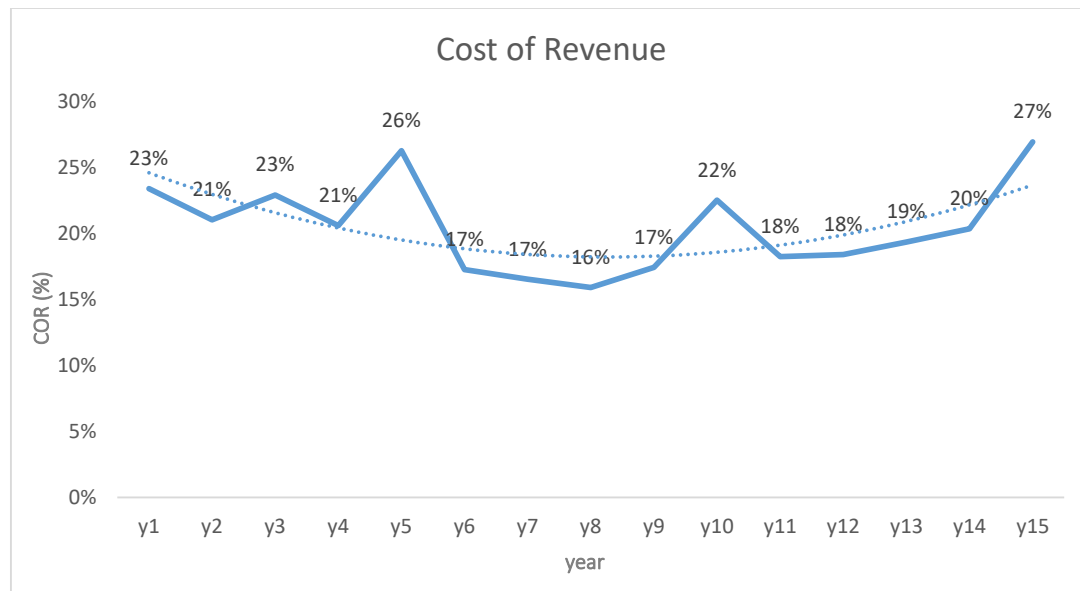


Figure 4. 15 Trend Cost of Revenue

4.6.5 Revenue Sensitivity Analysis

Revenue sensitivity analysis is carried out by simulating the main parameters, namely PA, UA and productivity. The main reference is the size of production targeted by PT. XYZ, namely

for 1x PC1250-8 EX2009, it must produce production of 2,644,976.88 BCM with Revenue of \$3,945,942 per year with the derivative parameters being PA 91%, UA 60% and productivity 553 BCM. In Figure 4.16 Revenue Sensitivity Analysis (PA & UA), a positive contribution to revenue is found at a PA value of 91% and UA 60% with a fixed productivity parameter of 553 BCM.

The PA and UA configuration with a fixed productivity parameter of 553 BCMA to produce a positive contribution to revenue is PA 89% with a minimum UA of 62%, PA 90% with a minimum UA of 61% will produce a positive contribution to revenue of >1%, PA 91% with a minimum UA 61% will produce a positive contribution to revenue of >2%, PA 92% with a minimum UA of 60% will produce a positive contribution to revenue of >1%, PA 93% with a minimum UA of 60% will produce a positive contribution to revenue of >2 %. The higher the PA and UA produced, the more positive the revenue contribution will be.

Revenue Sensivity Analysis (PA & UA)

		PA							PA				
		89%	90%	91%	92%	93%			89%	90%	91%	92%	93%
UA	58%	\$3,730,577.40	\$3,772,494.00	\$3,814,410.60	\$3,856,327.20	\$3,898,243.80	UA	58%	-5%	-4%	-3%	-2%	-1%
	59%	\$3,794,897.70	\$3,837,537.00	\$3,880,176.30	\$3,922,815.60	\$3,965,454.90		59%	-4%	-3%	-2%	-1%	0%
	60%	\$3,859,218.00	\$3,902,580.00	\$3,945,942.00	\$3,989,304.00	\$4,032,666.00		60%	-2%	-1%	0%	1%	2%
	61%	\$3,923,538.30	\$3,967,623.00	\$4,011,707.70	\$4,055,792.40	\$4,099,877.10		61%	-1%	1%	2%	3%	4%
	62%	\$3,987,858.60	\$4,032,666.00	\$4,077,473.40	\$4,122,280.80	\$4,167,088.20		62%	1%	2%	3%	4%	6%

Figure 4. 16 Revenue Sensivity Analysis (PA & UA)

In Figure 4.17 Revenue Sensitivity Analysis (PA & Productivity) PA and Productivity configuration with fixed parameters UA 60% to produce a positive contribution to revenue is PA 89% with a minimum Productivity of 570 BCM will produce a positive contribution to revenue of >1%, PA 90% with a minimum Productivity of 560 BCM will produce a positive contribution to revenue of >1%, PA 91% with a minimum Productivity of 560 BCM will produce a positive contribution to revenue of >2%, PA 92% with a minimum Productivity of 550 BCM will produce a positive contribution to revenue of >1%, PA 93% with a minimum Productivity of 550 BCM will produce a positive contribution to revenue of >2%. The higher the PA and Productivity produced, the more positive the revenue contribution will be.

Revenue Sensivity Analysis (PA & Productivity)

		PA							PA				
		89%	90%	91%	92%	93%			89%	90%	91%	92%	93%
Productivity	530	\$3,718,882.80	\$3,760,668.00	\$3,802,453.20	\$3,844,238.40	\$3,886,023.60	Productivity	530	-6%	-5%	-4%	-3%	-2%
	540	\$3,789,050.40	\$3,831,624.00	\$3,874,197.60	\$3,916,771.20	\$3,959,344.80		540	-4%	-3%	-2%	-1%	0%
	550	\$3,859,218.00	\$3,902,580.00	\$3,945,942.00	\$3,989,304.00	\$4,032,666.00		550	-2%	-1%	0%	1%	2%
	560	\$3,929,385.60	\$3,973,536.00	\$4,017,686.40	\$4,061,836.80	\$4,105,987.20		560	0%	1%	2%	3%	4%
	570	\$3,999,553.20	\$4,044,492.00	\$4,089,430.80	\$4,134,369.60	\$4,179,308.40		570	1%	2%	4%	5%	6%

Figure 4. 17 Revenue Sensivity Analysis (PA & Productivity)

In Figure 4.18 Revenue Sensivity Analysis (UA & Productivity) UA and Productivity configuration with fixed parameter PA 91% to produce a positive contribution to revenue is UA 59% with a minimum Productivity of 570 BCM will produce a positive contribution to revenue of >2%, UA 60% with a minimum Productivity of 560 BCM will produce a positive contribution to revenue of >2%, UA 61% with a minimum Productivity of 550 BCM will produce a positive contribution to revenue of >2%, PA 62% with a minimum Productivity of 540 BCM will produce a positive contribution to revenue of >1. The higher the UA and Productivity generated, the more positive the revenue contribution will be.

Revenue Sensivity Analysis (UA & Productivity)

		UA							UA				
		58%	59%	60%	61%	62%			58%	59%	60%	61%	62%
Productivity	530	\$3,675,704.76	\$3,739,078.98	\$3,802,453.20	\$3,865,827.42	\$3,929,201.64	Productivity	530	-7%	-5%	-4%	-2%	0%
	540	\$3,745,057.68	\$3,809,627.64	\$3,874,197.60	\$3,938,767.56	\$4,003,337.52		540	-5%	-3%	-2%	0%	1%
	550	\$3,814,410.60	\$3,880,176.30	\$3,945,942.00	\$4,011,707.70	\$4,077,473.40		550	-3%	-2%	0%	2%	3%
	560	\$3,883,763.52	\$3,950,724.96	\$4,017,686.40	\$4,084,647.84	\$4,151,609.28		560	-2%	0%	2%	4%	5%
	570	\$3,953,116.44	\$4,021,273.62	\$4,089,430.80	\$4,157,587.98	\$4,225,745.16		570	0%	2%	4%	5%	7%

Figure 4. 18 Revenue Sensivity Analysis (UA & Productivity)

From this sensitivity analysis, it can be interpreted that to maintain or have a positive impact on revenue, PT. XYZ needs to pay attention to the configuration of its parameters. Under the parameters outlined above, the contribution to revenue will be minus or the company could

suffer losses. In this research regarding the PC1250-8 EX2009 carried out by GOH, its availability performance can be maintained according to the sensitivity analysis of the contribution to positive revenue with PA >90% in four consecutive years after GOH. Collaboration between departments together with Operations and Engineering is needed to be able to maintain and even improve parameters other than PA, namely UA and Productivity, to contribute positively to company revenue.

4.6.6 LCCA GOH PC1250-8 EX2009 Impact Analysis

From several analyzes that have been carried out on the PC1250-8 EX2009 in the form of impacts after carrying out GOH, then proceed to analyze the overall life cycle costs of the unit. Can be seen in Figure. 4.20 LCCA GOH PC1250-8 EX2009 Impact Analysis and Table 4.36 Projected Contribution of PA After GOH 2023 to Revenue, starting from the first unit obtained, namely in y1/2014 to y5/2018, the performance contribution of PC1250-8 EX2009 to revenue is positive but the trend is decreasing. Its contribution to revenue in that period was 10% in y1/2014, 17.4% in y2/2015, 3.1% in y3/2016, 9.5% in y4/2017 and -0.5% in y5/2018. In this period, the total costs also decreased due to the decrease in owning costs from year to year even though operating costs continued to increase. Only in y5/2018 did the total cost experience an upward trend, this is because in that year GOH was carried out.

In y5/2018 PC1250-8 EX2009 GOH was carried out which had a positive contribution impact on revenue four years later, namely in y6/2019 it was 18%, y7/2020 was 17%, y8/2021 was 16%, and y9/2022 was 9 %. In this period, total costs continued to fall from y1/2014 but stopped in y8/2021. Y8/2021 is the year the unit plan was scrapped because after Y8/2021 and above the total cost will increase. By looking at the year the unit plan was written, the contribution in that year still contributed positively to the revenue impact of the GOH carried out, so the Management of PT. XYZ decided to postpone the disposal of the unit, which in the following years after GOH still contributed positively to revenue.

The contribution to revenue decreased very drastically in the year y10/2023 to a contribution of -2.2% which was due to the performance availability or PA PC1250-8 EX2009 experiencing a decrease in PA of 82%. In that year, Management PT. XYZ decided GOH to boost PA's performance again so that it can make a positive contribution to revenue. As shown in Figure 4.19 PA PC1250-8 EX2009 in 2023, the PA performance of PC1250-8 EX2009 after GOH

was carried out in September in 2023, PA experienced an increase again until this research was written to PA 90%.



Figure 4. 19 PA PC1250-8 EX2009 in 2023

month

By carrying out the five-year GOH again in y10/2023 and through the previous analysis that has been discussed regarding the impact of the GOH carried out, it can be projected that in the following years the contribution of PC1250-8 EX2009 will make a positive contribution, namely in y11/2024 it will be 10.7%, y12 /2025 is 13%, y13/2026 is 10.7%, and y14/2027 is 8.4%. However, in y15/2028 the contribution is projected to fall to -4.8% due to PA in that year decreasing to 85% and UA to 61% which can be seen in Figure. 4.36 PA After GOH 2023 Contribution Projections to Revenue.

Table 4. 36 PA After GOH 2023 Contribution Projection to Revenue

	2023	2024	2025	2026	2027	2028
	y10 (GOH)	y11	y12	y13	y14	y15
Plan Produksi (BCM)	2,644,976.88	2,644,976.88	2,644,976.88	2,644,976.88	2,644,976.88	2,644,976.88
Plan Revenue (\$ in mio)	\$ 3,967.47	\$ 3,967.47	\$ 3,967.47	\$ 3,967.47	\$ 3,967.47	\$ 3,967.47
Projection						
PA	82%	92%	93%	92%	91%	85%
UA	59%	66%	66%	66%	65%	61%

Productivity (BCM/h)	608.5	553	553	553	553	553
MoHH (h)	8760	8760	8760	8760	8760	8760
Produk (BCM)i	2,586,062.33	2,927,363.53	2,988,556.47	2,927,363.53	2,866,802.27	2,516,700.35
Rate (\$)	1.5	1.5	1.5	1.5	1.5	1.5
Revenue (\$ in mio)	3,879.09	4,391.05	4,482.83	4,391.05	4,300.20	3,775.05
Contribution Revenue	-2.2%	10.7%	13.0%	10.7%	8.4%	-4.8%

So from the analytical considerations above, starting in year 14/2027 Management PT. XYZ is considering the PC1250-8 EX2009 unit for scrap. This consideration is because the total cost or cost of revenue is getting higher so that revenue and profitability are decreasing as shown in Figure 4.20 LCCA GOH PC1250-8 EX2009 Impact Analysis. In y14/2027 PT. XYZ must also prepare a new replacement unit so that readiness for replacement does not cause delays in production activities which could further erode revenue.

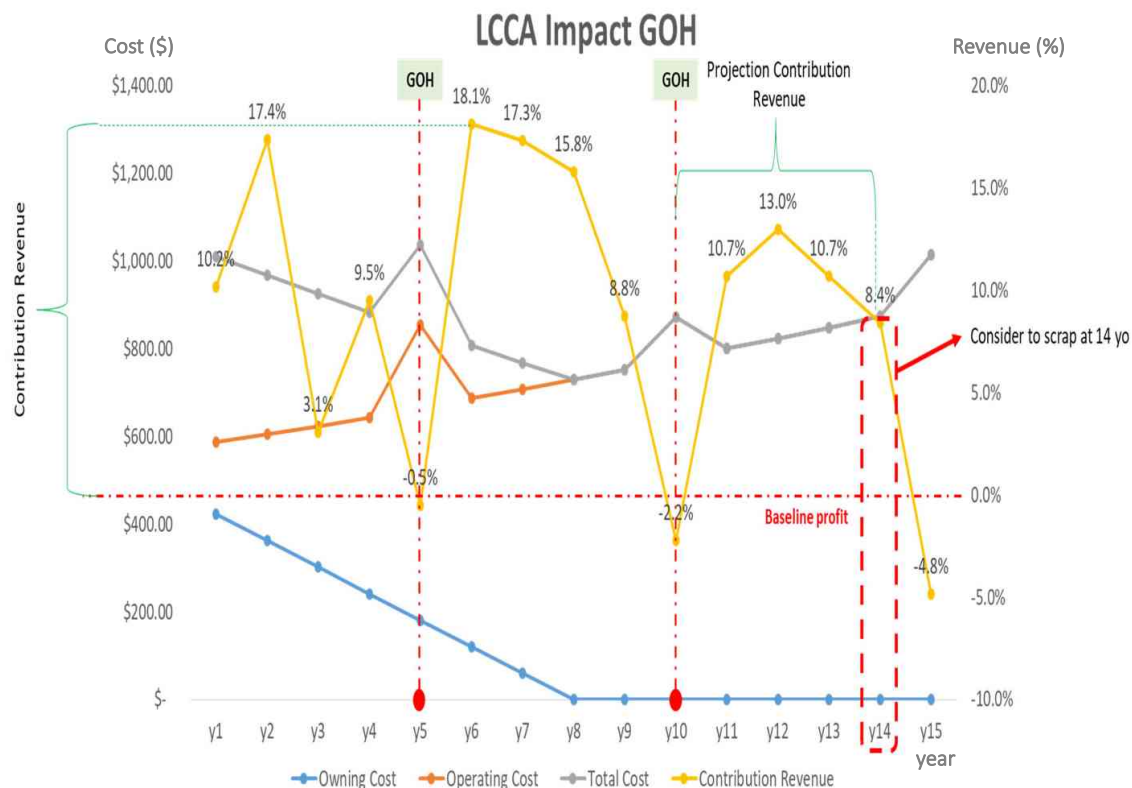


Figure 4. 20 LCCA GOH PC1250-8 EX2009 Impact Analysis

From the results of the LCCA PC1250-8 EX2009 analysis calculations carried out by GOH, Management PT. XYZ, which previously planned scrap in y8/2021 or eight years of service life (40,000 hours), until now y10/2023 or service life (50,000 hours) is still used for production and its economic life can still be optimized to make a positive contribution to revenue until y14/2027.

Several things were of course done by PT. XYZ as an effort to maintain PA performance apart from carrying out GOH. Some of these things are by carrying out intense and periodic monitoring of the life of each component (Figure 4.21 Dashboard Lifetime Component & Parts), carrying out extra ordinary quality maintenance programs during service and backlog, integrating integrated technical parameter data through machine learning which is currently is being developed by the team so that it can provide fast, precise and accurate recommendations and decisions, evaluate every maintenance activity which is carried out intensively in stages starting from mechanic, group leader, planner, plant engineer, Section Head to plant Dept Head.

By carrying out the activities above, PA will be more likely to be maintained on target. This was also explained by Maryono, Ena & Dena (2020) that to find out the root of technical problems, a quality review or evaluation is needed to get a quality report, so that the recommendations or decisions taken are right on target. Through the use of digital technology, technical analysis will be easier and faster. The machine learning development carried out is a step forward to improve the quality of monitoring and evaluation.

In Figure 4. 22 Dashboard Lifetime Components & Parts as a consideration to find out the optimal lifespan of each component and part in detail. Main components and their derivative parts are informed about the average age in real time from the dashboard. Apart from that, you can also analyze the cost per hour of each component and part.

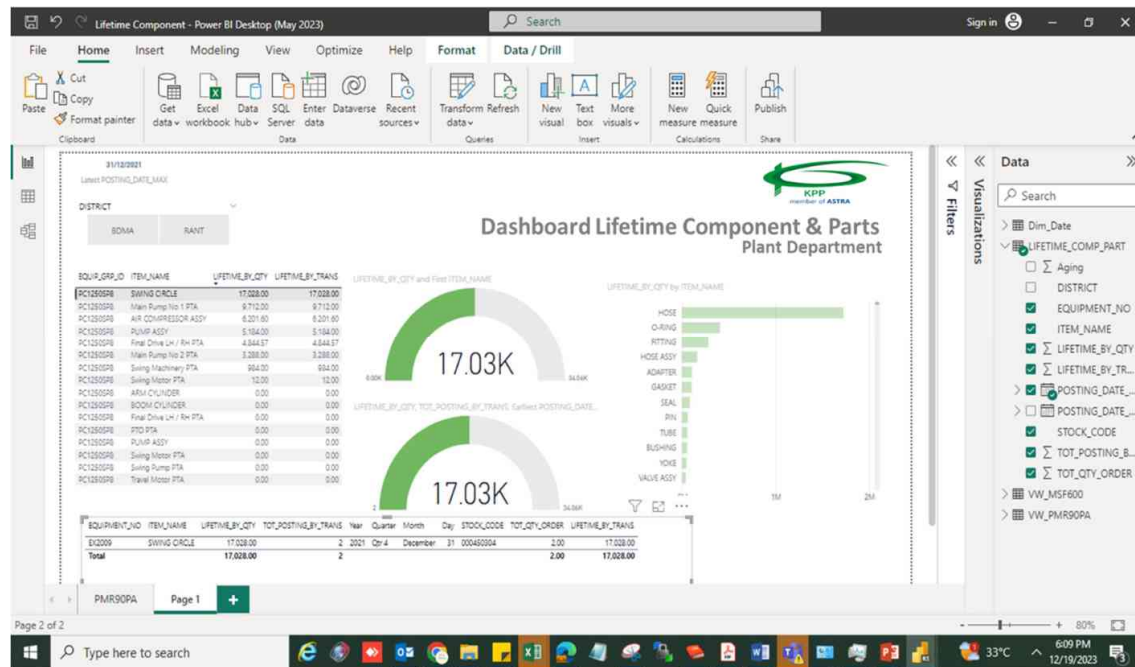


Figure 4. 21 Dashboard Lifetime Component & Parts

In Figure 4.22 Plant Machine Learning Architecture PT. XYZ is a form of effort to integrate all technical parameters of heavy equipment which is carried out to speed up analysis with recommendations so as to produce fast, precise and accurate action or execution decisions that can maintain and even improve PA performance in providing a positive contribution to revenue such as analysis. has been done before.

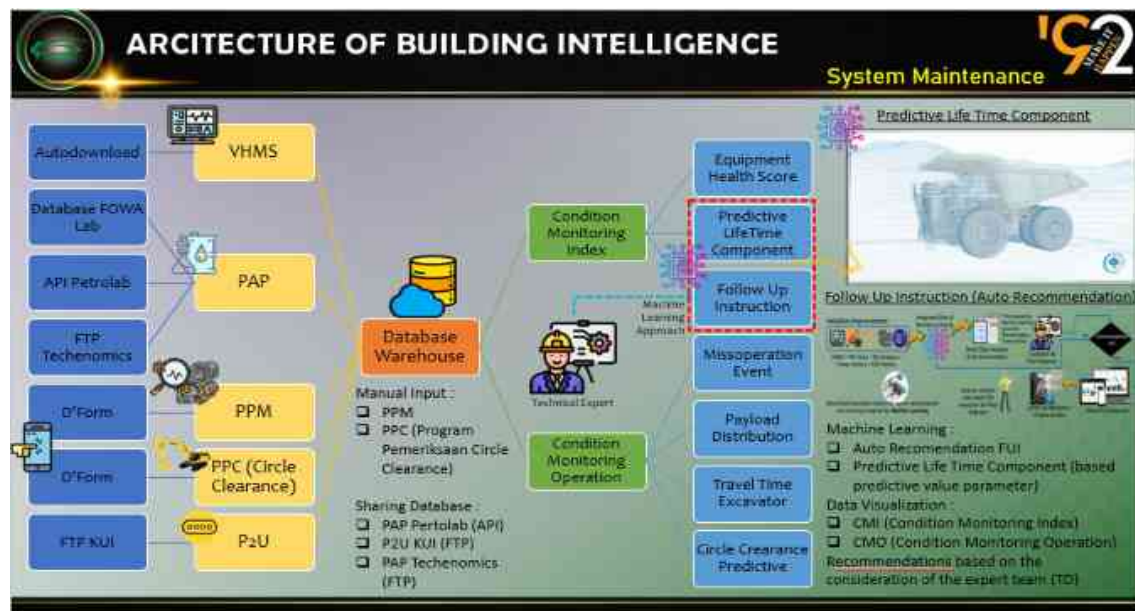


Figure 4. 22 Plant Machine Learning Architecture