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Maintenance Schedule Optimization for Turnaround Hot Gas Path Inspection of Gas Turbine in North Duri Cogeneration Plant Using Impact Method

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ABSTRACT

North Duri Cogeneration Plant (NDC) is once of Chevron asset in IndoAsia Business Unit. The NDC location is in Duri, Province of Riau, Indonesia. The NDC has 3 units gas turbine and each unit has been combined with Heat Recovery Steam Generator (HRSG). An unit gas turbine NDC is produce electricity of 100 MW, and 1 unit of HRSG NDC that is produce steam of 360,000 BCWEPD (Barrel Cool Water Equivalent per Day). Hot gas path inspection (HGPI) is maintenance activities gas turbine, which routine scheduled in NDC every 3 years per unit. Maintenance schedule for turnaround HGPI gas turbine at NDC should be optimizing. By optimized of HGPI maintenance schedule can be maximized work plan, which is comply of 4 Key Performance Indicators there are Safety, Quality, Schedule and Cost through Initiative for Managing PACesetter Turnarounds (IMPACT). The result of optimal electricity production was increased by 13,174 MWh and the steam generated from units in NDC of mass total steam of 126,661 Mlbm and 371,827 BSPD.

KEY WORDS: *Maintenance, NDC, HGPI, IMPACT*

1.0 INTRODUCTION

The North Duri Cogeneration Plant (NDC) is one of the assets belonging to the Chevron IndoAsia Business Unit. The NDC location is in Duri, Province of Riau, Indonesia. Based on data [1] that NDC facility has three units gas turbine and each unit combined with a Heat Recovery Steam Generator (HRSG). 1 unit gas turbine NDC, produces electricity 100 MW. In addition, one unit HRSG NDC produces steam at 360,000 BCWEPD (Barrel Cool Water Equivalent per Day). According to [2] the unit gas turbine NDC is the most efficient with the same capacity than Power Generator and Transmission's (PGT's) PT Chevron Pacific Indonesia gas turbine. NDC and PGT are in different organizations in Chevron IndoAsia business unit. However, the electricity generation is integrating with each other. If a gas turbine unit in NDC to shut down, PGT must operate 3-4 additional gas turbines (GT) to supply the Sumatra Operation (SMO) electricity needs, and PT Chevron Pacific Indonesia (CPI) must use an additional steam generator (SG). Where GT and SG used by PGT and CPI are very inefficient when compared to the GT units in NDC.

Maintenance is needed to keep the performance of unit gas turbine. Programs carried out at NDC for gas turbines for maintenances. Once is the Hot Gas Path Inspection (HGPI) program. Based on the original equipment manufacture (OEM) data, the HGPI at NDC is routinely maintaine every 3 years per unit.

The HGPI program is worked offline units, which the units must be turn off and disconnected from the electricity network. Based the previous HGPI program, it takes an average of 22 days [2]. However, the management was decided for the duration of HGPI program of 18 days. So, it is necessary to improve the program to optimize the duration of the HGPI on the NDC Combustion Turbine (CT) unit 1. By optimizing the HGPI maintenance schedule, it can maximize work planning by fulfilling four aspects of Key Performance Indicators (KPI), namely: Safety, Quality, Schedules and Costs through the Initiative to Manage PACesetter Turnarounds (IMPACT).

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2.0 FUNDAMENTAL THEORY

2.1 Optimization

According to the Big Indonesian Dictionary (KBBI), that optimization comes from the optimal word, which means the best, highest or most beneficial. The optimizing means to be the best or highest. The optimization is the process of optimizing something, in other words the process of making something the best or highest [3]. Therefore, optimization is a process of optimizing something or the process of making something the best. Therefore, optimization means steps/methods to optimize. In the case of this research, it is an effort, step/method used in order to optimize the Gas Turbine Turnaround Hot Gas Path Inspection Schedule in NDC.

2.2 Schedule

According to Paryana Puspaputra and Rahmat Priyo Handono (2013) [4] that effective planning and scheduling greatly contributes to the following:

- Reduce maintenance costs.
- Increase utilization of maintenance personnel by reducing delays and interruptions.
- Improve the quality of maintenance results by applying the best methods and procedures and assigning qualified workers to do the work.
- Minimize the waiting time for maintenance personnel.
- Maximize the efficiency of working time, materials and equipment.
- Maintain equipment operations in meeting production in accordance with delivery schedules and quality.

An important part of planning and scheduling is to know the work in the future and to arrange the balance work loading in all categories. The maintenance management system has the goal of achieving more than 90% of work in planned and scheduled [4]. Planning is the process by which the elements needed to perform the task are determined before starting the work. Scheduling is a process in which work adjusting according to resources and sequences carried out at the specified time. In scheduling agreed upon the time and stages of work planned together with what has done, monitor the work, control the work and report the results of the work. Successful planning requires responses from scheduling.

2.3 Maintenance

Maintenance is a series of organized activities carried out to maintain equipment in the best operating conditions with minimum costs. Maintenance types can be seen in Figure 1.

Maintenance purpose:

- Maximizing production or increasing the availability of facilities at the lowest cost and the best quality and safety standards.
- Reduce breakdowns and emergency shutdowns.
- Optimize resource utilization.
- Reduce downtime.
- Improve control of spare parts stock.
- Increase equipment efficiency and reduce scrap rates.
- Minimize energy use.
- Optimize the use of equipment.
- Provide reliable costs and budget control.
- Identifying and implementing cost reductions.

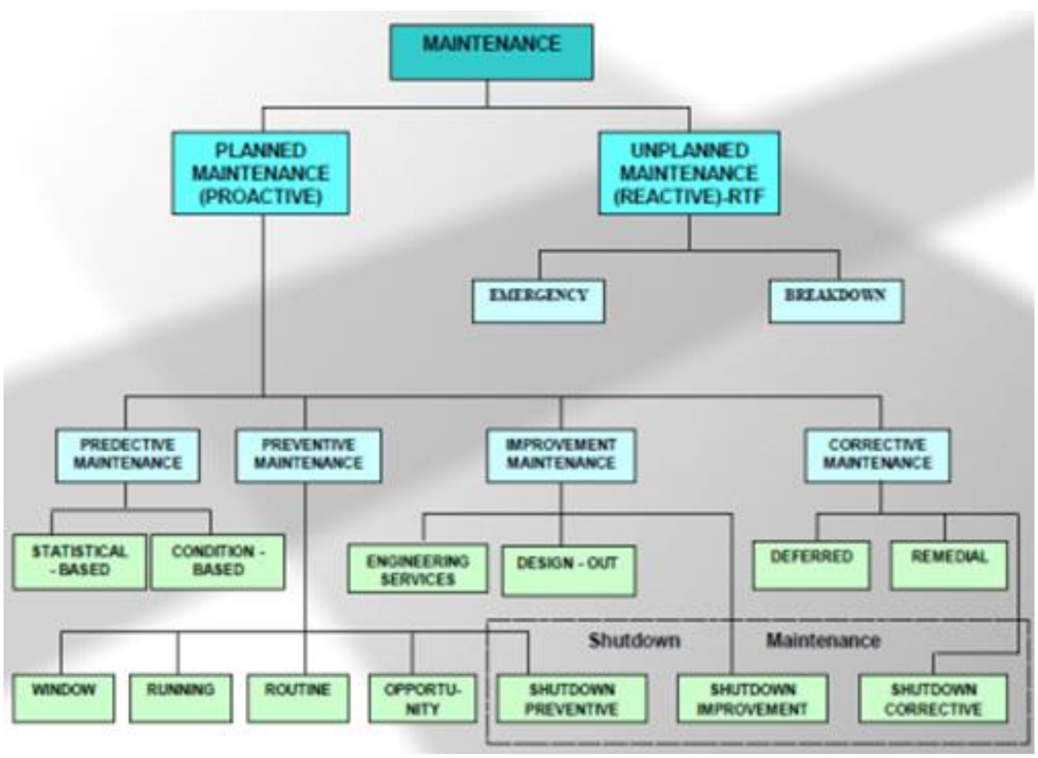

Figure 1: Maintenance Types [4].

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2.4 Turnaround

Based on Chevron's Turnaround management documents, the outage is the period of stopping the plant/engine or the temporary suspension of plant/machine work. In this procedure, turnaround means planned outage while shutdown means unplanned outage.

2.5 Hot Gas Path Inspection

The turbine section (hot gas path) inspection includes a major combustor inspection, plus inspection of the remainder of the turbine hot gas path. Access requires removal of the appropriate cylinder cover and blade rings. In most cases, blades and associated parts are removed from the rotor, cleaned and inspected. Turbine disc blade root serrations are also cleaned and inspected. In units without blade rings, turbine vane diaphragms are removed for cleaning and inspection. Vanes and ring segments are removed from the blade ring as required for cleaning and inspection; and interstage vane seals and baffles are inspected before disassembly. The inspection interval for HGPA depicted in Table 1 [5] and inspection types of a combustion turbine shown in Figure 2 [1].

Table 1: Recommended Inspection Interval [5]

EBHtotal and ES		INSPECTION
TOTAL EQUIVALENT BASE HOURS (EBHtotal)	TOTAL EQUIVALENT STARTS (ES)	INSPECTION TYPE RECOMMENDED
(1)	(1)	COMBUSTOR (MINOR)
8,000	400	COMBUSTOR (MAJOR)
24,000	800	TURBINE (HOT PATH)
48,000 96,000 (3)	1,600 (2) See Appendix B (3)	MAJOR * Rotor Inspection

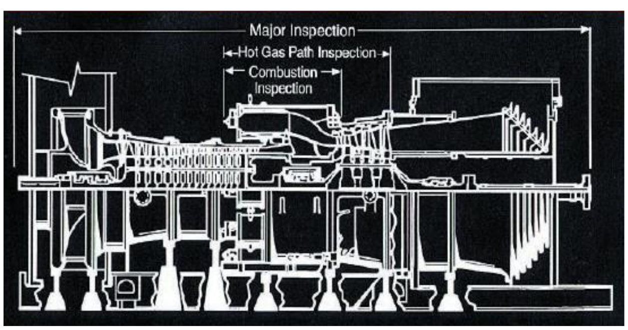

Figure 2: Inspection Types W501D5A Combustion Turbine [1]

2.6 Gas Turbine

The gas turbine used at NDC is made by SIEMENS Westinghouse type 501D5A (Figure 3) which consists of a 19-stages high-efficiency axial compressor, a combustion chamber equipped with 14 combustors arranged in a circle around the engine axis, and a 4-stage reaction type turbine. Turbine turns clockwise when viewed from the inlet.

Air from the atmosphere sucked through the inlet manifold and the inlet casing into the compressor. The air compressed and enters to the combustion chamber and combustors with a steady flow. Fuel is flowed into combustors, burned, increasing the temperature of the mixture of air and combustion products. A mixture of compressed and heated gas flows through turbine, the pressure and temperature converted to heat energy. The absorbed converted into mechanical work in the form of a rotation. Some of the power generated from the turbines used to turn generators and exciter. Gas discharged through the axial exhaust diffuser and exhaust manifold in the exhaust system (Figure 4). To ensure good initial characteristics, interstage bleeds are installed at stages 6, 11 and 14 of the compressor. They will open at the start of the starting cycle and close when the turbine reaches near synchronous rotation. Alignment of the turbine to the generator is maintained by rigid compressor end support and flexible turbine end support. Flexible turbine end support allows for variations in heat.

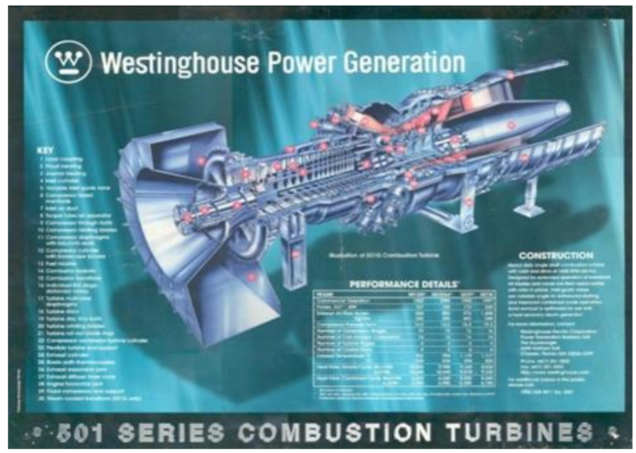

Figure 3: 501 Series Combustion Turbines [6]

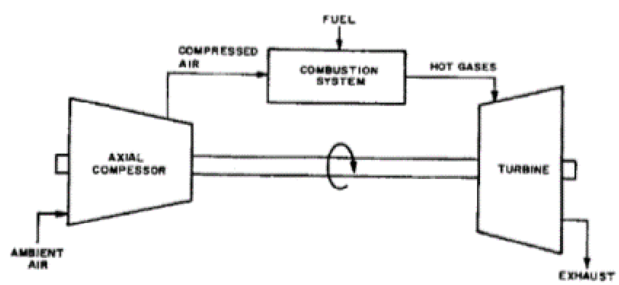

Figure 4: Hot Gas Path [6]

2.7 North Duri Cogeneration Plant

North Duri Cogeneration Plant (NDC) is one of Chevron's assets in the IndoAsia Business Unit. NDC is located in Duri, Province of Riau, Indonesia. Based on data [1] the NDC facility has three units gas turbine and each unit is combined with a Heat Recovery Steam Generator (HRSG). One unit of NDC gas turbine produces electricity 100 MW. In addition, one unit of HRSG NDC produces steam 360,000 BCWEPD (Barrel Cool Water Equivalent per Day).

2.8 IMPACT (Initiative for Managing PACesetter Turnarounds)

IMPACT is part of SERIP stage 3 about management of turnaround and shutdown. IMPACT is the best practice process approved by Chevron to be used to manage turnaround. IMPACT

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is a process that is driven by operations and operations plans. Supporting organizations and projects that will have an impact on operating facility downtime is expected to follow IMPACT rules; including economic down time in determining the rate of return (ROR) and return on capital employed (ROCE) for the project.

Within the Chevron OE Management System (Element 5.5, Reliability and Efficiency Expectations), the organization is expected to have a process consisting of "a structure, project planning approach for facility turnarounds and maintenance projects that are important to reduce down time and ensure efficient use of resources." Among the most important maintenance performed by the company is related to facility turnarounds, this procedure provides Global Upstream's standards for doing the work.

The SERIP Turnaround and Shutdown management procedure is Global Upstream's official use of the Chevron Initiative for Managing PACesetter Turnarounds (IMPACT) process, which has been used as the best practice for all Chevron companies to work on turnarounds. The procedure provides a systematic approach to do turnaround work to ensure production down time is minimized and target availability is achieved

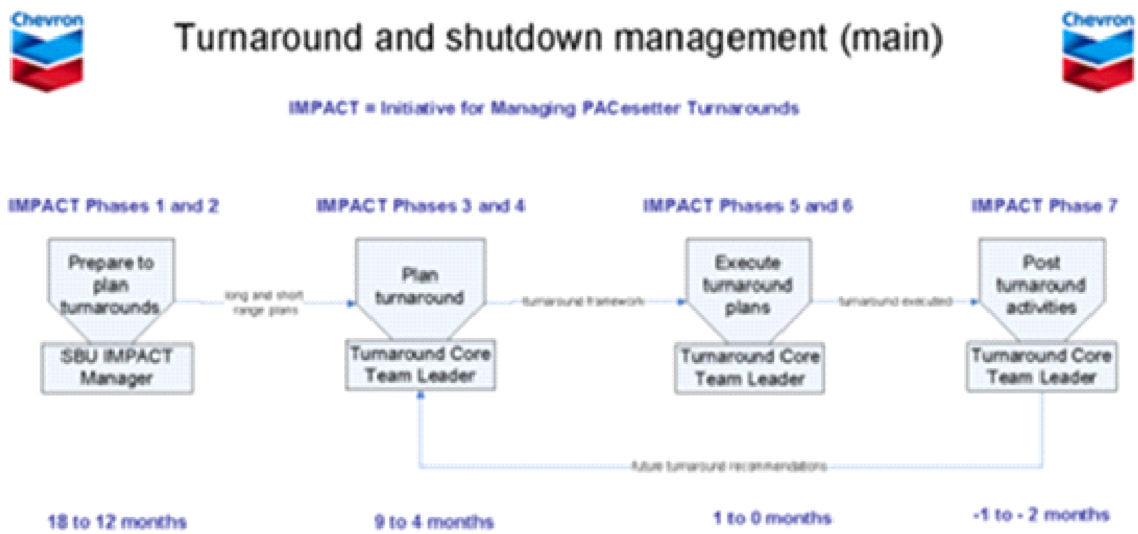

Figure 5: Turnaround and shutdown management (main) [8]

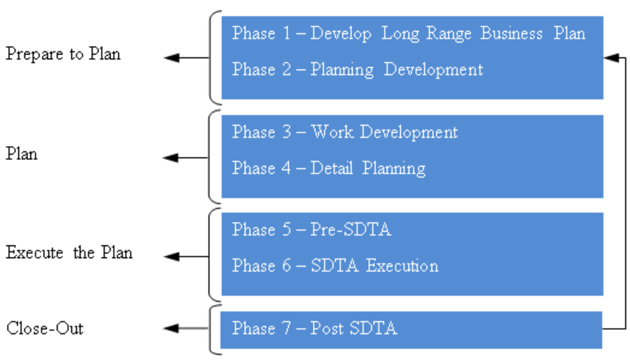

Figure 6: IMPACT Process Overview [9]

3.0 METHODOLOGY

The research flowchart can be seen in Figure 7. The stages of method as following:

a. Study literature

Study literature is a stage of understanding the theory of the research to be carried out. This study literature is taken from several company procedures, books, journals and the internet regarding previous research aimed at learning theories and maximizing the writer's understanding of existing data sources.

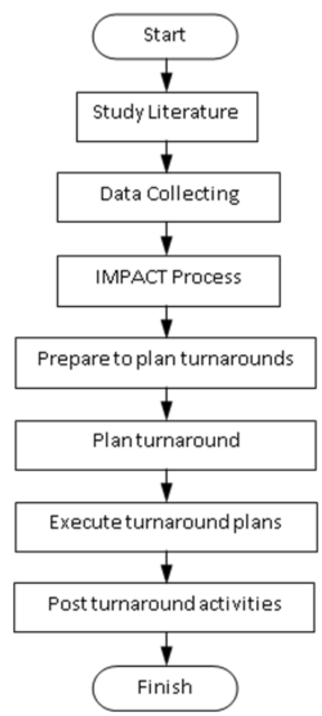

Figure 7: Research Flow Chart

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b. Data Collecting

In this stage, the researcher collected the data from several periods of the HGPI turnaround program from units 1, 2 and 3, which had implemented in NDC. Also collected several related reference documents used for this research.

c. IMPACT Process

Conceptualizing the IMPACT process for HGPI in NDC based on turnaround and shutdown management procedures. In this paper adopted the seven stages IMPACT Process that is depicted in Figure 6. It is carried out starting from preparing to plan turnarounds, plan turnaround, executing turnaround plans and post turnaround activities.

4.0 RESULT AND DISCUSSION

As the basis of this study is a collection of duration data from several periods of HGPI turnaround implementation from units 1, 2 and 3 as shown in Table 2.

Table 2: HGPI Duration CT1, 2 and 3 from 2008 to 2015

No.	Date and Time	Power Plant	Remarks	Duration (day(s))
1	28-04-2015 00:00	NORTH DURI POWER PLANT	00:00 Off line NDC-CT #2, then unit shutdown for S/B. (Start HGPI program) JDE Number = 123	28
	25-05-2015 11:50	NORTH DURI POWER PLANT	11:50 Start Up NDC-CT #2, then On-Line on 12:35. (After HGPI program) JDE Number = 123	
2	18-05-2011 01:30	NORTH DURI POWER PLANT	Off line NDC-CT #3, then unit shutdown for NSB. (Start HGPI program).	21
	06-08-2011 08:30	NORTH DURI POWER PLANT	08:30 Start Up NDC-CT #3, then unit on-line on 09:01. 09:02 Closed 230KV No. Duri GCB #33.	
3	14-03-2010 22:08	NORTH DURI POWER PLANT	22:08 Off line NDC-CT #1, then unit shutdown for NSB on 22:11 (Start HGPI program)	18
	01-04-2010 17:25	NORTH DURI POWER PLANT	Start Up NDC-CT#1, then unit on-line on 18:52.	
4	10-08-2008 23:59	NORTH DURI POWER PLANT	Off Line NDC-CT #3, then unit shutdown for NSB. (Start HGPI program)	22
	01-10-2008 21:09	NORTH DURI POWER PLANT	Start Up NDC-CT #3, then unit on-line on 22:00.	
			Average	22

Table 3: SDTA IMPACT Roadmap

	PREPARE TO PLAN		PLAN		EXECUTE THE PLAN		CLOSE-OUT
	Phase 1 **Long Range Business Plan**	**Phase 2** **Conceptual Development**	**Phase 3** **Work Development**	**Phase 4** **Detail Planning**	**Phase 5** **Pre-SDTA**	**Phase 6** **SDTA Execution**	**Phase 7** **Post-SDTA**
Deliverables	**SDTA Long Range Schedule** • 5 years schedule of Major Overhaul, Hot Gas Path Inspection and Combustion Inspection • Integrated for Salak, NDC and Darajat **Capital Plan for SDTA** **Regulatory Work for SDTA** **Long Lead Material Identification & Order** **Communication** • Decision Team & Execution Team phase gate meeting • Execution Team and DRB occasional communication • Execution Team regular coordination meeting	**SDTA Overview** • Background • Purpose • Objective • Definition of success • Business driver • Stakeholder and concern **SDTA Scope** **Worklist Criteria** **SDTA Project Team, Timeline and Key Deliverable** **Cost Estimation (±30%)** **Control Plan** • Schedule of IMPACT phases for each key deliverable • Frozen for routine progress tracking purpose **Last SDTA & Lessons Learned Review** **Communication** • Decision Team & Execution Team phase gate meeting • Execution Team and DRB occasional communication • Execution Team regular coordination meeting	**Work Breakdown Structure (WBS) & Frozen Work List** • List of overhaul works structurized as WBS • PIC of work • Equipment requirement • Material requirement • Manpower requirement • Contracting requirement **Approved AFE** • Cost allocation • AFE structure **Contracting Management** • Contracting strategy • Contracting plan • Contract SOW & request • Contracting process **Material Management** • Material plan (identification of material requirement vs warehouse stock to identify materials to procure) • Material specification & request • Material purchasing process **Risk Assessment & Mitigation** **OE-HES Plan** **Quality Plan** **Communication** • Decision Team & Execution Team	**Work Package** • Work package content include work order, work permit, SOP, QA/QC document, JSA, drawings, material list, equipment list, manpower list **Contracting Management** • Contracting process • Contract award & sign-off **Material Management** • Material purchasing process • Material delivery **Detail Schedule** • Resource levelling • Shutdown & startup schedule • Detail work schedule **Risk Mitigation** **OE-HES Program** • Detail program of the OE-HES Plan **Supports** • Communication plan • Laydown/ work area plan • Documentation system • Security program • General Services program transportation, catering, accommodation, meals, office space, IT support)	**Pre-Work** • Work package distribution • Construction of scaffolding • Material & equipment mobilization to the work place **Contractor Mobilization** **OE-HES Program Implementation** **Pre-SDTA Plant Performance Test** **Communication** • Decision Team & Execution Team phase gate meeting • Execution Team and DRB occasional communication • Execution Team regular coordination meeting • Kick-off meeting • Coordination and technical meetings with contractors	**Execution as the plan** **Daily Coordination Meetings** **Daily Reports** **OE-HES Program Implementation** **QA/QC Implementation**	**Final report** **Post-SDTA Plant Performance Test** **Lessons learned** **Close-out meeting** **Resolving of excess materials** **De-mobilization of contractors** **Mobilization of parts repair** **AFE closure**

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			phase gate meeting • Execution Team and DRB occasional communication • Execution Team regular coordination meeting	**Communication** • Decision Team & Execution Team phase gate meeting • Execution Team and DRB occasional communication • Execution Team regular coordination meeting			
Target Date	Started 18 months prior to outage for 4 months	Started 14 months prior to outage for 2 months	Started 12 months prior to outage for 5 months	Started 7 months prior to outage for 5 months	Started 2 months prior to outage for 2 months		Started when SDTA completed for 2 months
Decision Team	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager	**Endorser** • GM Operation **Decision Executive** • Asset Manager **Decision Review Board** • Operations Manager • O&M Advisor • FE Manager
Execution Team	**Lead** • TM Maintenance **Member** • Maintenance Planner • TM Facilities Engineering • Shutdown Coordinator	**Lead** • TM Maintenance **Member** • Maintenance Planner • TM Facilities Engineering • Shutdown Coordinator	**Lead** • SDTA Manager **Member** • Asset Team (Mtce, Ops, FE, HES, SSG, Mtce Planner) • Shutdown Coordinator	**Lead** • SDTA Manager **Member** • Asset Team (Mtce, Ops, FE, HES, SSG, Mtce Planner) • Shutdown Coordinator	**Lead** • SDTA Manager **Member** • Asset Team (Mtce, Ops, FE, HES, SSG, Mtce Planner) • Shutdown Coordinator	**Lead** • SDTA Manager **Member** • Asset Team (Mtce, Ops, FE, HES, SSG, Mtce Planner) • Shutdown Coordinator	**Lead** • SDTA Manager **Member** • Asset Team (Mtce, Ops, FE, HES, SSG, Mtce Planner) • Shutdown Coordinator

In the Table 2, the average duration of HGPI is 22 days. With a maximum duration of 28 days that occurred in 2015 and the fastest time was 18 days that occurred in 2010. Therefore, the target for the duration of HGPI is 18 days. The SDTA IMPACT roadmap can be seen in Table 3.

The HES program devided of lagging indicator (Table 4) and leading indicator (Table 5). The lagging indicator is consisting of:

a. Injury/Illness
   - Medical Treatment Case (MTC)
   - Restricted Work Activity Case (RWAC)
   - Day Away From Work (DAFW)
   - Fatality Case
b. Property Damage
c. Motor Vehicle Crash (MVC)
d. Fire
e. Environmental

Table 4: HES lagging indicator

Type of Incident	PM	Actual	Status
Injury/Illness			
❖ Medical Treatment Case (MTC)	0	0	●
❖ Restricted Work Activity Case (RWAC)	0	0	●
❖ Day Away From Work (DAFW)	0	0	●
❖ Fatality Case	0	0	●
Property Damage	0	0	●
Motor Vehicle Crash (MVC)	0	0	●
Fire	0	0	●
Environmental	0	0	●
Total	**0**	**0**	

Table 5: HES Leading Indicator

Leading Indicators	PM	Total	Status
Safety Induction & Orientation	All workforces	291	●
BBS Observation Report	17 reports/day*	283	●
Hazards Observation Report	4 reports/day	64	●
Management Safety Walk (NDC Leaders and Business Partner's Management) – use form	2x/week	6	●
Safety Officer Meeting	6/week	13	●
Safety Campaign	4 banners	4 banners	●
Tool box/Pre-Job Safety Meeting	1x/day/company (total 5 company)	72	●
Stop Work Authority (SWA)	As necessary	12	●
Random blood pressure test	12 persons/day	193	●
CHESM field inspection	5 contractors	5	●

Leading indicator consist of:

a. Safety Induction & Orientation
b. BBS Observation Report
c. Hazards Observation Report
d. Management Safety Walk (NDC Leaders and Business Partner's Management)
e. Safety Officer Meeting
f. Safety Campaign

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g. Tool box/Pre-Job Safety Meeting
h. Stop Work Authority (SWA)
i. Random blood pressure test
j. CHESM field inspection

The duration of the actual implementation of CT unit 1 HGPI was 15 days 18 hours 54 minutes. Table 6 shown shutdown unit 1 on April 4, 2016 at 05:06 pm and start-up unit 1 on April 20, 2016 at 12:00 pm. The HRSG unit 1 it starts to be activated on April 21, 2016 at 04:00 pm.

Table 6: Monthly Average of Operation Data for Load Unit 1 during April 2016

Date	NDC UNIT	CONV CAPABILITY	AVERAGE LOAD	RH. BY GAS	RH. BY OIL	GEN-GAS	GEN-OIL	FUEL CRUDE	FUEL DIST.	STATUS
01/04/2016	NDC-1	89.1	90.74	24	0	2,177.7	0	0	0	R
02/04/2016	NDC-1	91.7	91.08	24	0	2,186	0	0	0	R
03/04/2016	NDC-1	90.7	91.83	24	0	2,204	0	0	0	R
04/04/2016	NDC-1	89.4	85.19	17.1	0	1,456.7	0	0	0	S
05/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	S
06/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
07/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
08/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
09/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
10/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
11/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
12/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
13/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
14/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
15/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
16/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
17/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
18/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
19/04/2016	NDC-1	89.4	0	0	0	0	0	0	0	N
20/04/2016	NDC-1	89.4	69.84	12	0	838.1	0	0	0	S
21/04/2016	NDC-1	89.4	81.14	17.15	0	1,391.6	0	0	0	R
22/04/2016	NDC-1	92.3	89.08	24	0	2,137.9	0	0	0	R
23/04/2016	NDC-1	92.3	85.28	24	0	2,046.7	0	0	0	R
24/04/2016	NDC-1	91.9	92.73	24	0	2,225.6	0	0	0	R
25/04/2016	NDC-1	91.5	94.78	24	0	2,274.6	0	0	0	R
26/04/2016	NDC-1	91.1	94.13	24	0	2,259	0	0	0	R
27/04/2016	NDC-1	92	94.3	24	0	2,263.2	0	0	0	R
28/04/2016	NDC-1	91.6	94.2	24	0	2,260.9	0	0	0	R
29/04/2016	NDC-1	91.6	93.83	24	0	2,252	0	0	0	R
30/04/2016	NDC-1	91.5	94.33	24	0	2,263.9	0	0	0	R

AFB1 : early power delivery to customer
AFB1 = MWh x $/kWh x 1000

AFB2 : fuel cost reduction due to early power delivery
AFB2 = MWh x (MMBtu/MWhCPI - MMBtu/MWhNDC) x $/MMBtu

AFB3 : early steam delivery to customer
AFB3 = Mlbm x $/Mlbm

AFB4 : fuel cost reduction due to early steam delivery
AFB4 = BSPD x $/BSPD

Based on these data from the acceleration of the HGPI program from about 22 days the result is accelerate to 15 days, the total electricity production obtained was 13,174 MWh, the savings from comparison of using HRSG NDC with steam generators owned by PGT totaling 43,749 MMBtu/MWh, the mass of total steam is 126,661 Mlbm and 371,827 BSPD.

Table 7: Monthly Steam Delivery Report for Unit 1 During April 2016

	Feed Water Inlet		NDC #1			
Date	Pressure	W Ave Temp	Steam Delivery		W Ave Temp	W Ave Qlty
	PSIG	F	Mlbm	BCWE	F	%
1	106	171	31,116.5	91,168.2	494	71.2
2	106	168	31,160.0	91,199.1	495	70.7
3	106	170	31,284.5	91,629.2	495	71.0
4	105	170	13,148.5	38,510.6	483	67.9
5	106	169	0.0	0.0	0	0.0
6	105	172	0.0	0.0	0	0.0
7	106	174	0.0	0.0	0	0.0
8	106	174	0.0	0.0	0	0.0
9	106	173	0.0	0.0	0	0.0
10	106	176	0.0	0.0	0	0.0
11	106	175	0.0	0.0	0	0.0
12	106	176	0.0	0.0	0	0.0
13	106	174	0.0	0.0	0	0.0
14	106	176	0.0	0.0	0	0.0
15	106	171	0.0	0.0	0	0.0
16	106	174	0.0	0.0	0	0.0
17	106	169	0.0	0.0	0	0.0
18	106	177	0.0	0.0	0	0.0
19	106	177	0.0	0.0	0	0.0
20	106	178	0.0	0.0	0	0.0
21	106	181	7,789.0	22,899.7	487	66.6
22	105	177	23,443.0	68,826.3	490	71.1
23	106	177	23,145.5	67,952.9	482	70.1
24	105	179	24,266.0	71,293.5	489	71.1
25	105	177	24,064.0	70,649.5	490	72.3
26	106	172	23,953.5	70,205.3	488	70.1
27	106	167	24,047.5	70,358.2	485	70.0
28	105	170	24,095.5	70,573.3	485	69.5
29	105	171	24,072.0	70,528.6	485	70.1
30	105	172	24,017.0	70,391.4	486	70.2
Total	106	173	329,602.5	966,185.8	488	70.1

Table 8 explains the selling price of electricity from DC to PGT/CPI, the purchase price of gas by NDC from CPI, the selling price of steam from NDC to HCT/CPI, the average baseline of PGT/CPI's gas turbine heat. The financial benefit calculation is shown in Table 9.

Table 8: Baseline, Electricity Delivery Prices, Gas Purchase Prices, April Steam Prices, Average CPI Gas Turbine Heat Baseline, Average NDC Gas Turbine Heat Baseline, ∆ Average Heat and Steam Prices [1]

Description	Value	Unit
Baseline	6,530	MWh
Power delivery fee	0.0298	$/kWh
Gas procurement price	3.24	$/MMBtu
April steam price	1.14	$/BSPD
Baseline heat rate of PGT's gas turbine	16.03	MMBtu/MWh
Baseline heat rate of NDC's gas turbine	12.7	MMBtu/MWh
∆ Heat rate	3.3	MMBtu/MWh
Steam fee	4.5	$/Mlbm

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Table 9: Financial Benefit Calculation

Date	MWh	AFB1	Δ MMBtu	AFB 2	Steam (Mlbm)	AFB 3	Steam (BSPD)	AFB 4	AFB1+2+3+4	Cum. AFB
4/20/2016	838	24,975	2,783	9,018	-	-		-	33,993	33,993
4/21/2016	1,392	41,470	4,622	14,974	7,789	35,286	22,900	26,106	117,835	151,828
4/22/2016	2,138	63,709	7,100	23,004	23,443	106,203	68,826	78,462	271,378	423,206
4/23/2016	2,047	60,992	6,797	22,023	23,146	104,855	67,953	77,466	265,335	688,542
4/24/2016	2,226	66,323	7,391	23,948	24,266	109,931	71,294	81,275	281,476	970,018
4/25/2016	2,275	67,783	7,554	24,475	24,064	109,016	70,649	80,540	281,814	1,251,832
4/26/2016	2,259	67,318	7,502	24,307	23,954	108,515	70,205	80,034	280,175	**1,532,007**

5.0 CONCLUSION

From the IMPACT method used to optimize the duration of the HGPI on a gas turbine in NDC, the SDTA IMPACT roadmap contains types of activities that can standardized as an HGPI program. The fulfilling of four aspects of Key Performance Indicator (KPI) of safety, namely lagging and leading indicators meet the program. The indicator of quality revealed no re-work and successful in commissioning. The schedule obtained the duration of the HGPI CT1 maintenance program for 15 days 18 hours 54 minutes faster than the target duration of 18 days and this provides a financial benefit for the company of US$1,532,007.-. It compared to the average duration of the HGPI maintenance program, which was 22 days. Therefore, the lost production opportunities were reduced and the company's profits increased. This also has a positive impact on employees with the appreciation given by the company. From the cost of all employments were still within a predetermined budget. The providing of optimal production results, by shortening the duration of the HGPI, it increased electricity production by 13,174 MWh and the steam generated from units in NDC that was the mass total steam of 126,661 Mlbm and 371,827 BSPD.

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