Business Case – Capital Expenditure

Turbine Overhaul and Minor Upgrades

Business Case Number BC235 CY23-27

1 Project Approvals

TABLE 1: BUSINESS CASE – PROJECT APPROVALS

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2 Project Overview

TABLE 2: BUSINESS CASE – PROJECT OVERVIEW

Description of Issue/Project	This objective of this project is to continue the ongoing program of gas turbine overhauls. The turbines that are due for overhaul in the 2023-2027 period are: Gooding Unit 3 and Unit 2 – These T4002 gas turbines are expected to reach overhaul runtime during the 2023-2027 period. Springhurst Unit 1 – The T6102 gas turbine engine is expected to reach overhaul runtime during the 2023-2027 period (assuming flows south increase post WORM). The overhaul of a gas turbine is a routine process that permits another 30,000 hours of turbine operation. Overhauls are conducted on a run hour threshold basis, annual internal inspections are also performed to ensure intervention if issues are identified. In addition to the gas turbine overhauls, small upgrades are completed to incorporate original equipment manufacturer service bulletins to improve reliability or address safety concerns.
Options Considered	The following options have been considered: Option 1: Do Nothing Option 2: Complete Overhaul at Recommended Life Option 3: Overhaul Based at Recommended Life with Condition Monitoring (Preferred option)
Estimated Cost	$5,000,000
Relevant Standards	APA has a Service Envelope Agreement with AEMO wherein APA as owner and maintainer of the asset are required to use “good practice”.
Consistency with the National Gas Rules (NGR)	The replacement of these assets complies with the new capital expenditure criteria in Rule 79 of the NGR because: • it is necessary to maintain and improve the safety of services and maintain the integrity of services (Rules 79(2)(c)(i) and (ii)); and • it is such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of providing services (Rule 79(1)(a)).
Key Stakeholders	The turbine engine provides power and thus capacity to the VTS. The stakeholders affected are: • Australian Energy Market Operator • Original Equipment Manufacturer.

Benefits to Customers and Consumers	The benefits to customers and consumers on condition-based turbine overhauls is maintaining reliability and security of supply.

3 Background and Project Need

APA utilises Solar Turbines gas turbine compressor packages located at numerous sites on the VTS. Gas turbines are used to drive centrifugal gas compressors which enable pipelines to store and flow much larger volumes to the market. They are operated by AEMO as the independent system operator of the VTS and maintained by APA. Table 3 provides a summary of the VTS gas compressors.

TABLE 3: VTS COMPRESSOR UNITS

Compressor Station	Model	Quantity
Gooding	Centaur 40	4
Brooklyn	Centaur 40	3
	Saturn 10	2
Wollert	Centaur 50	2
	Saturn 10	3
Springhurst	Centaur 50	1
Euroa	Centaur 50	1
Winchelsea	Taurus 60	1
Total		17

Turbine Overhauls and Starts

Gas turbines require overhauls on a run hour basis. Original Equipment Manufacturer (OEM), Solar Turbines, recommendations are for a major overhaul at 30,000 hours.

Many of the VTS gas compressors are only operated during peak demand periods so they have a high numbers of starts for the number of hours online. It is not uncommon to see engines in the VTS complete more than 1,500 starts over a 30,000 hour operating period. This operating pattern can be understood by monitoring the start to run hour ratio, for VTS the average hours per start of has reduced from 23 to 21 since 2010. Due to the incremental thermal stress damage that turbines experience during each start sequence APA also conducts annual internal inspections to monitor for issues that require overhaul prior to the run hour threshold.

Exchange Turbine Option

APA has an Alliance Agreement with the OEM (Solar Turbines Australia) which provides for reduced costs for overhaul of engines provided the assessment (performed by the OEM) indicates failure is not imminent. APA's policy is therefore to utilise periodic internal inspections of the machines and to utilise their observed condition to extend the overhaul intervals where possible or intervene to prevent premature failure.

An overhauled engine, power turbine and auxiliary gearbox are returned in zero-hour condition, equivalent to new condition (turbine blades and wear parts such as discs, seals and shafts are re-worked or replaced as required). To reduce downtime, APA generally exchanges turbines rather than sending for overhaul as this service is available at the similar cost whilst reducing downtime.

Minor Upgrades

As part of the normal business OEMs release service bulletins and product information letters advising customers of modifications and improvements that can be made to machines to improve reliability and safety. Sometimes they are critical to be implemented immediately but more often they are small improvements to be implemented at next overhaul or during next available opportunity which is usually the overhaul of the engine. Some examples of recommended improvements from Solar Turbines that have been released to customers applicable to Centaur 40, 50 and Taurus 60 Gas Turbine compressor packages are shown in the following table.

Upgrade/Modification	Description	Benefit
Addition of Separation Gas Shut Off Valves	Shut off of instrument air to separation seals when unit is not running	Numerous VTS units don't operate constantly, however the separation gas (instrument air) is continuously supplied to the seals leading to unnecessary wear and tear on the air compressors and unit compressor seals. Adding instrument air isolation reduces the likelihood of the related reliability issues.
Upgraded Seal Gas Monitoring System	Latest design of seal gas monitoring system includes additional transmitters to measure flow in and out of each separation seal on the gas compressors.	More reliable and earlier detection of dry gas seal (process gas seal) failures or degradation of the separation gas (lube oil seals) seals which can lead to dry gas seal failure if they fail.

4 Risk Assessment

The scenario considered is that a turbine is operated until failure with the failure mode that could have been prevented with condition monitoring. In terms of consequence, turbine failures generally cause significant mechanical damage but rarely with consequence escalation as they are designed to fail safely. However, turbine failures can sometimes experience a loss of containment of rotating parts and could involve damage to the fuel gas system which has fire and safety implications particularly if personnel are present. For all scenarios the turbine will be inoperable for a significant period of time and will cost substantially more restore to operational if compared overhaul before failure. The scenario considers the worst consequence in terms of capacity impact and this is reflected in the risk assessment provided in table 5.

TABLE 4: RISK RATING

Risk Area	Consequence	Likelihood	Residual	Target
Health and Safety	Fatality or life threatening injuries or illness or permanent total disability of employees and contractors or members of the public	Rare [every 50yrs]	Low	Low
Environment	One or a combination of the following consequences: - onsite and impacting < 1 ha - no remediation needed - impact continues for < 1 wk	Remote [every 20yrs]	Negligible	Low
Operational Capability	An interruption of ≥ 1 month but < 1 year to the delivery of firm services	Remote [every 20yrs]	Moderate	Moderate
People	Some impact on team or site engagement / minor site level complaints or breaches	Remote [every 20yrs]	Negligible	Low
Compliance	Non-compliance with a contractual/legal obligation(s) - results in litigation	Remote [every 20yrs]	Low	Low
Reputation & Customer	Some decline in customer satisfaction recoverable in >12 months	Remote [every 20yrs]	Negligible	Low
Financial	$1M-$5M (asset remediation cost)	Remote [every 20yrs]	Negligible	Low
Residual Risk Rating			Moderate	

5 Identification and Assessment of Options

1.1 Identification of Options

Option 1 – Do Nothing

The Do nothing option would be to operate until failure (run to failure operating regime). This approach would ignore the condition monitoring assessments. Due to the severity of the untreated risks including catastrophic failure this option is not a viable alternative.

Option 2 – Complete Overhaul at Recommended Life

This option would be to operate until reaching 30,000 hours, regardless of the condition monitoring. The operating conditions are controlled by AEMO and not APA. The high number of starts compared to run hours is likely to produce issues with the need to overhaul before 30,000 hours.

Option 3: Overhaul Based at Recommended Life with Condition Monitoring (Preferred option)

The proposed solution is to continue the routine annual inspection regime to monitor the health of the gas turbine and provide any information that would require the engine overhaul to be completed sooner than OEM recommendations. Option 3 involves overhaul of Gooding Compressor Station Units 2 and 3 and the Springhurst Compressor Station Unit 1 with minor upgrades also included.

1.2 Assessment of Options

TABLE 5: SUMMARY

Option	Description	Costs
Option 1	Do Nothing	Indeterminate
Option 2	Complete Overhaul at Recommended Life	Greater than **$5,000,000**
Option 3	Condition Monitor and Overhaul at Recommended Life with addition of Minor Upgrades (Preferred options)	**$5,000,000**

Option 1 Do nothing ignores the condition monitoring assessments and is a run to failure approach. The potential untreated risks of Option 1 include catastrophic failure. Under these circumstances personnel safety would be jeopardised and the turbine would be off-line affecting pipeline deliverability. “Disposition repair” of turbines may be possible for turbine engines which may fail prematurely despite preventative maintenance program. Option 1 is not considered viable due to the potential for catastrophic failure.

Option 2 is not preferred because turbine failure maybe occur earlier than 30,000 hours and thus introducing risks similar to the Do Nothing option. This risk is greater due to the way AEMO operates the compressor stations with a high number of starts. This creates greater wear and tear and increased risk of premature failure.

Option 3 is the preferred option. Monitoring the condition turbines taking into account the extra wear and tear from frequent starts and condition-based overhauls reduces the risk of failure of the turbines. The overhauls will permit another 30,000 hours of engine life.

1.2.1 Why are we proposing this solution?

Rotating plant require maintenance to ensure they continue to operate reliably. Gas turbine engines operate at high temperatures and speed with very close machine tolerances with internal components moving at high speeds subject to wear due to the large air volumes and thermal fatigue due to the internal operating temperatures. This leads to the necessity to remove the turbines for manufacturer rebuild to ensure reliability and performance is maintained.

OEM recommendations are for major rebuilds at intervals associated with the running hours and whilst APA does extend this period, it requires performance monitoring and internal inspections to monitor the engine condition. The overhaul cannot be ignored as performance would degrade with additional running hours and ultimately component failure would result in catastrophic damage.

OEMs often make recommendations to improve reliability and safety based on their observations and feedback from customers across industry operating the same engines. Often these are small expenditures that are logical to execute as minor upgrades during an extended outage window such as an engine overhaul.

APA has a Service Envelope Agreement with AEMO wherein APA as owner and maintainer of the asset are required to use “good practice”.

6 Consistency with the National Gas Rules

Consistent with the requirements of Rule 79 of the National Gas Rules, APA considers that the capital expenditure is:

- Prudent – The expenditure is necessary in order to maintain and improve the safety of plant and personnel. Condition-based overhaul for such critical assets that are subject to extra wear and tear resulting from AEMO's operations is of a nature that a prudent service provider would incur.
- Efficient – The overhaul work will be carried out by the equipment manufacturer. There is no viable alternative to the manufacturers overhaul. The expenditure can therefore be considered consistent with the expenditure that a prudent service provider acting efficiently would incur. All expenditure is undertaken in conformance with the APA procurement policy.
- Consistent with accepted and good industry practice – Condition monitoring turbines is an accepted industry practice and consistent with as low as practicably possible principle.

7 Forecast Cost Breakdown

The costs associated with turbine overhaul are the following:

- Removal
- Exchange or overhaul of gas turbine with OEM
- Reinstallation and testing
- Installation and testing of minor upgrades

The cost estimate provided in table 5 is based on equipment vendor quotations and actual costs of recent similar projects.

TABLE 6: PROJECT COST ESTIMATE

	Qty	Rate	Total
Internal Labour	3	$200,000	$600,000
Materials			
Centaur 40	2	$1,000,000	$2,000,000
Centaur 50	1	$1,200,000	$1,200,000
Contracted Labour	3	$200,000	$600,000
Other Costs (Minor upgrades)	3	$200,000	$600,000
Total			**$5,000,000**

Note:
If utilisation continues at current levels for the Brooklyn compressor station, Unit 11 and 12 Centaur (T4002) turbines will both require overhaul towards the end of the 2023-2027 period. However, completion of the WORM project is anticipated to reduce Unit 11 and Unit 12 utilisation so they have been excluded from this business case.

8 Acronyms

Acronym	Definition/Description
AEMO	Australian Energy Market Operator
AGA	Australian gas association – Type B compliance governing body
API	American Petroleum Institute – publisher of standards
CHAZOP	Control system HAZOP – study of the control system functions to identify logic vulnerabilities
ESD	Emergency shutdown – control system-initiated shutdown designed to prevent incident escalation if operating parameters are breached
ESV	Energy Safe Victoria
HAZOP	Hazard and operability study
HMI	Human machine interface
ILI	Inline inspection – pipeline internal inspection
OEM	Original Equipment Manufacturer
RA	Risk Assessment
RBI	Risk Based Inspection – a process used to prioritise maintenance or inspection activities based on risk of failure.
SIL	Safety Integrity Level – an assessment used to rank control systems by their ability to fail safely
SMS	Safety Management Study
VTS	Victorian Transmission System