Business Case – Capital Expenditure

Brooklyn CS upgrade

Business Case Number 204

1 Project Approvals

TABLE 1: BUSINESS CASE – PROJECT APPROVALS

Prepared By	Anthony Jones, *Pipeline and Asset Management Engineer, APA Group*
Reviewed By	Alan Burt, *Engineering Manager Development, APA Group*
Approved By	Mark Fothergill, *General Manager Infrastructure Strategy and Engineering, APA Group*

2 Project Overview

TABLE 2: BUSINESS CASE – PROJECT OVERVIEW

Description of Issue/Project	This project is to upgrade the following aspects of the Brooklyn Compressor Station (BCS): • Safety and Process Control systems • Unit 8, 9, 10, 11 controls • Unit 8, 9, 10, 11 enclosure fans • Unit 8, 9, 10, 11 fuel gas • Unit 8, 9, 10, 11 exhaust stack replacement
Options Considered	The following options have been considered: 1. Option 1: Do Nothing 2. Option 2: Total Replacement 3. Option 3: Station upgrade to ensure life past 2022
Estimated Cost	$10,474,538 (escalated)
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)).
Stakeholder Engagement	The stakeholders effected by this project are: • Australian Energy Market Operator • Energy Safe Victoria

3 Background

The Brooklyn Compressor Station (BCS) has been constructed in multiple stages with each compressor unit installed at different times with various upgrades of equipment.

The strategy employed at Brooklyn is to replace each component of the station as necessary to ensure the life of the units and station past the year 2022. This strategy has commenced with the replacement of the after coolers for units 8, 9, 10 &11.

The replacement of the aftercoolers on units 10 & 11 coincided with a failure on one of the coolers. This occurred when the other cooler was being replaced and thus not available. The effect of both units being out of operation caused considerable problems with the supply to the underground storage system and thus security of supply for winter 2016. This event has demonstrated the need for timely replacement of asset components to avoid prolonged supply interruptions and shortages.

The Australian Standard AS3814-2015 section 1.2.6: *Modification or relocation of an appliance*: "Where an appliance is modified or relocated, it should be upgraded to meet the requirements of this Standard current at the time of the modification or relocation and may need to be re-submitted to the technical regulator for approval". ESV has advised that they expect all equipment in this category to comply with AS3814 applied retrospectively where equipment controls are upgraded. (See Appendix for email from ESV dated 20-Feb-12). The upgrade to the control system triggers this requirement and this means those elements such as the fuel gas systems that were compliant with the standard when installed but do not meet the current standard will also need to be upgraded.

Unit Control Systems:

The control systems on units 8 & 9 were installed in 1982 and are relay based, spare parts are becoming increasingly difficult to source and the package is no longer supported by the equipment manufacturer. These units will require new instrumentation to be installed on the skid to permit new control technology.

The control systems on units 10 & 11 were installed in 1999 utilizes a vendor-supplied programmable control system and is currently obsolete. The upgrade to the latest version of programmable control system from the equipment manufacturer is required.

Station Safety System:

The existing safety system is a programmable electronic control system installed circa 1998, has not been upgraded for some time and includes safety instrumented functions for units that were demolished many years ago. The safety system is due for a major review involving HAZOP, SIL review programming and re-validation to ensure the safety functions meet the current and future safety requirements.

The station safety system does not support Ethernet communications, increasing the difficulty of interfacing with other equipment such as HMIs and RTUs that are undergoing upgrades. The proposal is to replace the communications module and main processors in the station safety system to improve support, speed up the processing speed and reduce safety times during trip incidents.

Primarily the replacement of safety system is to increase the performance of the system. The station safety system controls emergency shutdown processes and other controls to enable safe operation of the entire station.

Station Process Control System:

The station process control system was installed circa 1998 at the same time as the station safety system; the station control system provides controls such as pressure control, load sharing, start / stop logic for the compressors, alarms and diagnostic functions. The process control system has logic installed for equipment that is no longer installed at site.

The process control system is due for a major review involving CHAZOP, programming and re-validation to ensure the control system program is up to date and redundant logic is removed.

As with the safety system, the station control system does not support Ethernet communications, increasing the difficulty of interfacing with other equipment such as HMIs and RTUs that are undergoing upgrades. The proposal is to replace the communications module and main processors in the station control system to improve support and improve the processing speed.

Fuel Gas:

The fuel gas system does not comply with the Type B appliance requirements of AS 3814 and needs to be upgraded, this work includes:

- Fuel gas vent valve arrangement and relocation outside the compressor building
- AGA certified isolation valves
- Logic changes to the start sequence
- Fuel hose upgrade
- Design calculations

The fuel gas modification involves installation of a replacement fuel control module by the equipment manufacturer and requires the upgrading of the unit control system as described above.

Ventilation System:

The enclosure ventilation system does not meet performance requirements on the hottest days in summer. The unit safety system will shut down the unit when maximum allowable temperature is reached. This has occurred on a number of occasions in the past. Thus the capacity of the station and VTS are reduced on hot days.

The enclosure and ventilation fans must be modified or replaced to provide sufficient cooling capacity for continued operation on hot days without reducing VTS capacity.

Exhaust Stack, Units 8, 9, 10 and 11:

The exhaust stacks are in poor condition and are the most common item of corrosion and failure across the APA fleet of turbomachinery. This is due to the high temperatures and thermal cycling during service. The exhaust stacks penetrate the roof the buildings that house the units and the roofs have asbestos lining that will need to be replaced when exhaust stack replacement occurs.

Inlet Filters, Units 8, 9, 10 and 11:

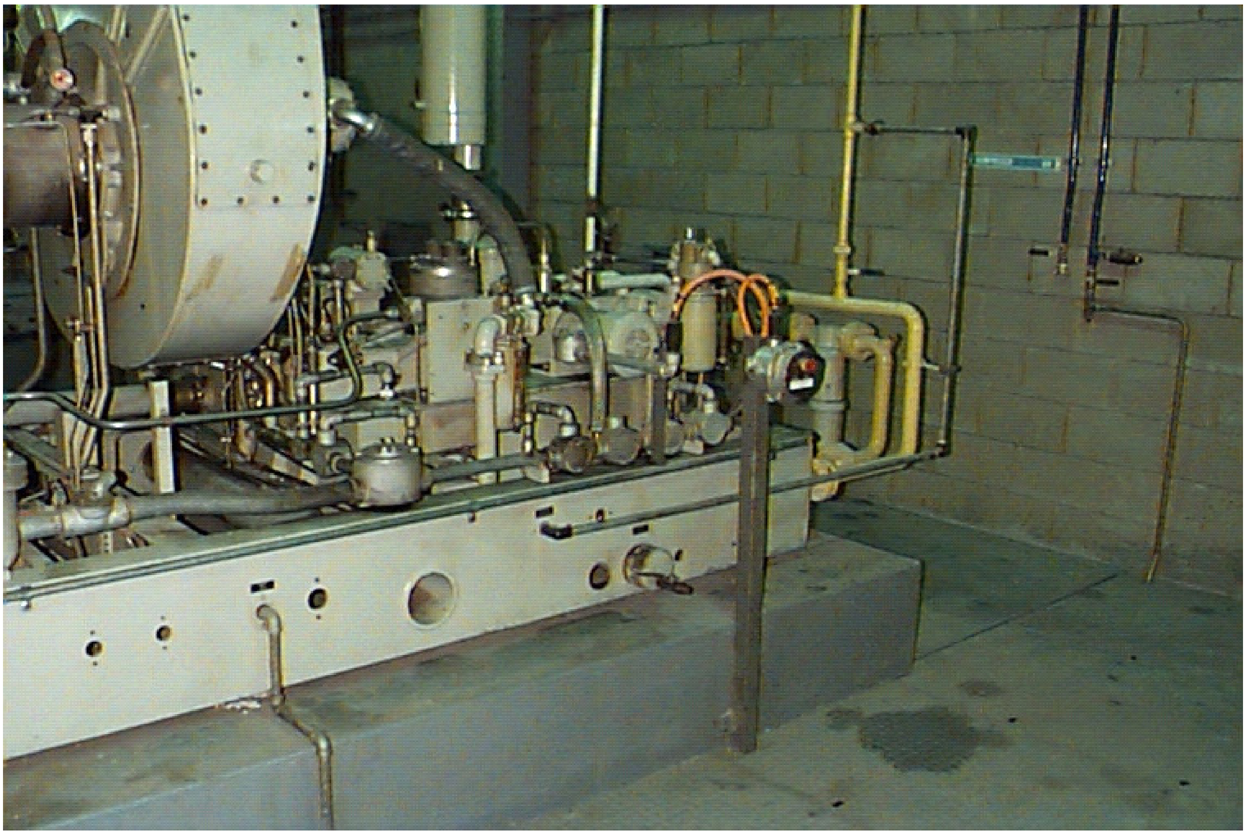
The process air inlet housing and filters have reached end of life and are suffering corrosion with through wall penetrations. The holes created by corrosion bypass the filtration system that is required for turbine integrity.

The air inlet filters for units 10 and 11 are located on the process piping side of the building. Therefore there is a risk of gas ingestion into operating units in the event of a gas leak in the area resulting in potential total loss of the affected units and adjacent facilities.

Electric Start, Units 8, 9, 10 and 11:

The existing starting system installed uses power gas and pneumatic motors. This results in direct gas emissions to the environment on each occasion that a turbine starts or attempts to start. The pneumatic starter systems are no longer supplied on new turbines installed for APA Group, electric starting is the preferred option.

As the compressor packages are located in a common hall with pressurised piping to skid edge, this also presents a leak and explosion threat in the building. Current design demands that this is treated as a station Emergency Shutdown. Removal of pneumatic piping including fuel gas supply will reduce the potential of station ESD and consequent risks arising from the station vent system.



Above photograph of onskid pressure piping within building

Conversion to electric starting requires the upgrade of the unit control system as described above.

Seal gas motors, Units 8, 9, and 10:

The existing seal gas system installed on these wet-seal compressor packages uses power gas and pneumatic motors as described above. This also results in direct gas emissions to the environment on each occasion that a turbine starts or stops. Electric drives for the seal-oil system are proposed which will eliminate the gas leakage risk as described above.

4 Risk Assessment

The following failure modes expected from the current condition of the units:

- Control system failure leading to inability to operate for an extended period
- Failure of exhaust stack and other balance of plant leading to inability to operate for an extended period
- Failure to apply current standards to heavily modified equipment
- Automatic shutdowns that reduce capacity for compression due to insufficient cooling of enclosures
- Direct emissions from power gas system for turbine starts
- Automatic station shutdowns that prevent compression due to gas leaks from the gas start piping.

TABLE 3: RISK RATING

Risk Area	Risk Level
Health and Safety	**Moderate**
Environment	**Low**
Operational	**Moderate**
Customers	**Moderate**
Reputation	**Moderate**
Compliance	**Moderate**
Financial	**Moderate**
Final Untreated Risk Rating	**Moderate**

5 Options Considered

5.1 Option 1 – Do Nothing

- The Do Nothing option is to permit the station units to degrade until their failure or until detected and emergency replacement is undertaken.

- Either outcome will result in the station being taken out of service on short notice and repairs undertaken under in a manner that is not consistent with prudent and efficient practice. In the event of a failure there will be long delays until plant can be reinstated and this has a significant risk of causing capacity shortfalls in the Victorian Transmission System.

- The plant failure has other risks that are difficult to quantify however the consequences of a lack of security of supply would be unacceptable at any time of year with few exceptions. APA does not operate compressor stations or their significant components to failure.

5.1.1 Cost/Benefit Analysis

- The benefits of this option are to delay the inevitable capital replacement. There will be additional costs if the replacements are not planned (as a result of failure). These additional costs are the costs to expedite a solution; this usually requires paying a premium for components and resources including labour, in addition to the cost of the supply shortfall.

- There are efficiencies in delivering this package of work with one effort. All of the work requires shutdown of each unit and synergies are gained during shutdowns with project management, procurement, supervision, equipment hire and engineering management.

5.2 Option 2 – Replace all four units with three new compressors

- The expectation is eventually every aspect of each unit (8, 9, 10 &11) will be replaced as necessary. Currently the turbine engines are in serviceable condition however the Balance of Plant (BoP) discussed previously will require replacement by 2022.

- An alternative approach is to completely replace the compressor units with new units. This approach will remove the additional costs of design and construction associated with existing plant and will achieve reduced operational cost, risk and capital expenditure profile for at least 15 years.

- While the exact cost of this option would depend on more detailed design including considerations of connections into the Brooklyn-Lara Pipeline, alterations to the building, interstage headers and large bore valves are likely to require redesign, creating significant cost changes. The lowest expected cost of Option #2 is approximately $45m, based on recent experience.

5.2.1 Cost/Benefit Analysis

- The benefits of this option are
  - The new compressors can operate to full Class 600 pressure (ie Brooklyn Lara Pipeline) with headers that can accept this pressure. Currently the station configuration prevents optimum availability of compressors.
  - The new compressors can be staged correctly for future flow and pressure requirements leading to more efficient use of these assets
  - The new compressors will be dry seal, reducing the undesirable amount of oil that is currently injected into pipeline system

The risks of this option are an overall reduction in power capability, turndown and ability to have backup compressors to permit station maintenance. The cost of design and construction in a brown field environment usually costs 15-20% more than similar equipment in a green field environment.

5.3 Summary of Cost/Benefit Analysis

The section should include a general overview of how the options compare and identify any options are not technically feasible.

TABLE 4: SUMMARY OF COST/BENEFIT ANALYSIS

Option	Benefits (Risk Reduction)	Costs
Option 1	Do Nothing	indeterminate
Option 2	Replace four units with three new units	$ 45,000 k
Option 3	Replace balance of plant and control system	$ 10,474 k

5.4 Proposed Solution

5.4.1 Replace Selected Balance of Plant and Control System

The units 8, 9, 10 & 11 require replacement of the following major components:

- control system,
- air inlet housing,
- exhaust stack,
- fuel gas,
- process safety system and control system software.

5.4.2 Why are we proposing this solution?

This solution is to implement the long term strategy of the Brooklyn Compressor strategy by ensuring the safety, reliability, availability of each compressor unit for at least 20 years. The Gas Safety (Gas Installations) Regulations 2008, Part 5 s35;

“A person who is the owner of a complex gas installation must;

(b) keep any Type B appliance contained in the complex gas installation in a safe condition and in a proper state of repair”

In order to achieve compliance with the above stated regulation, the following details each aspect of the replacement project:

- The fuel gas system physical positioning can create a circumstance where leakage of gas could enter the compressor common building (causing station ESD) or air intake for the turbine (causing upset conditions). The Australian Standards AS3814 for Industrial and Commercial Gas Fired Appliances and AS21789 Turbomachinery have simple diagrams and requirements for fuel gas. The installed turbines do not comply and do not vent fuel gas during an emergency shutdown. Energy Safe Victoria have written to APA (Appendix B) in the past about upgrading gas fired appliances to today’s standard and the requirement to implement risk management processes.

- Similarly, the power gas supply for engine starters and seal gas pumps can create a circumstance where leakage of gas could enter the compressor building, for which station ESD is implemented upon detection of gas. Conversion to electric start reduces routine gas emissions, emergency station venting and the associated risk to public, personnel and property.

- The unit control systems are obsolete, difficult to maintain and spare parts are no longer supported. Without replacement of control system and instruments, a significant failure of the control system will lead to a prolonged loss of availability. In addition, the latest control systems create a safer platform for process safety control. In accordance with the Gas Safety Regulations (Gas Installations) s35(b), APA must maintain Type B appliances in a safe condition and in a proper state of repair.

- The safety process and control system is software coding that integrates operation of the station. This software customisation is out dated and will not serve functional purpose when the unit control systems are upgraded. This would leave the station control system substantially inferior in performance than required.

- Ongoing support for HMI and SCADA equipment requires upgrade of communication hardware in station safety and control systems. The upgrade also requires upgrade of the main processors. This will extend the life of the equipment and improve speed of response of the equipment.

- The anti-surge and fast stop systems prevent upset turbine conditions to reach disastrous consequences. When the unit control system is replaced, the most advanced anti-surge system can be installed.

- The inlet air and exhaust stacks have reached end of life and are in need of replacement. These simple housings are not expected to remain fit for purpose after 2020.

5.4.3 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 services and maintain the integrity of services to customers and personnel and is of a nature that a prudent service provider would incur.
- Efficient – The field work will be carried out by the external contractors who have demonstrated specific expertise in completing the installation of similar facilities in a safe and cost effective manner. The expenditure can therefore be considered consistent with the expenditure that a

prudent service provider acting efficiently would incur. All expenditure is undertaken consistent with the APA procurement guidelines.

- Consistent with accepted and good industry practice – Addressing the process safety risks and upgrading systems to Australian Standards whenever performing major works, as well as replacing components that have reached the end of their useful life is accepted as good industry practice. In addition the reduction of risk to as low as reasonably practicable in a manner that balances cost and risk is consistent with Australian Standard AS2885 and Energy Safe Victoria directives (Appendix B)
- To achieve the lowest sustainable cost of delivering pipeline services – The sustainable delivery of services includes reducing risks to as low as reasonably practicable and maintaining reliability of supply.

5.4.4 Forecast Cost Breakdown

The cost estimate for station safety system and control system is based on experience of the APA personnel that will complete the works having completed several systems within APA Group, eg Winchelsea CS, Euroa CS, Gooding CS.

Upgrading of the unit control systems is based on recent project at Gooding CS to upgrade 4 Centaur C40 compressors as required for units 10 and 11 at Brooklyn CS. The estimate for units 8 and 9 are based on recent quotations for upgrade of similar Saturn compressors at Wollert CS.

The estimate for replacement of exhaust silencers is based on the costs from the Gooding CS upgrade where new exhaust stacks were installed on four Centaur C40 compressors. This has also been used to estimate cost of exhaust silencers for the Saturn compressors.

The entire scope for this project is unique, and whilst efforts have been made to utilize similar system upgrades on other plant, they are not the same. The variation is cost for this project is expected to be significant as the equipment manufacturer quotes in US dollars, discounts are given for multiple identical units and these discounts are difficult to estimate. Recent experience with projects at Brooklyn has demonstrated the time constraints applied by the Australian Energy Market Operator can effect project delivery costs.

TABLE 5: PROJECT COST ESTIMATE, ESCALATED

	Total
BCS Safety and Process Control System	**$327,883**
BCS Unit 10 & 11 controls upgrade	**$2,855,096**
BCS Unit enclosure fans augmentation	**$185,733**
BCS Unit 8 & 9 controls upgrade	**$2,423,343**
BCS Unit 8,9,10,11 exhaust stack replacement	**$1,329,866**
BCS Unit 8,9,10,11 electric start conversion	**$1,513,223**
BCS Unit 8,9,10 Seal Gas Motor Upgrade	**$669,699**

BCS Unit 8,9,10,11 Fuel Gas Modification	**$1,169,695**
Total	**$10,474,538**

Appendix B – Energy Safe Victoria Correspondence

Alan,

One of our inspectors, Peter Ryan has had a good look at the ISO 21789 standard and has commented as below:

"ISO 21789 appears to be a very comprehensive standard addressing many aspects of turbine safety not covered by AS 3814. It appears to be non- prescriptive and based on risk assessment procedures. AS 3814 section 5.8 Stationary gas engines and turbines is very similar to ISO 21789 clause 5.10.5.1 under the heading "gas fuel systems."

AS 3814 clause 5.8.1 General in part states" Gas fired turbines that comply with the requirements of ISO 21789 may be deemed by a technical regulator to meet the intent of this standard".

ISO 21789 does not appear to comply with the requirements of AS 3814 clause 2.26.3, Requirements for a programmable electronic system (PES).

I believe that any turbine installed in Victoria which complies with the requirements of ISO 21789 should also comply with the relevant sections of AS 3814, being mindful that much of the valve train, flame proving and flame failure requirements appear to be identical.

Any turbine being installed in Victoria should be submitted in accordance with schedule 9 of the Gas Safety (Gas Installation) Regulations2008.
The requirements set out in AS 3814 clause 2.26.3 should form part of the submission.

AS 3814 and ISO 21789 appear to complement each other however ISO 21789 does not appear to be appropriate as a standalone standard in regard to gas safety".

Peter has said you can contact him to have a further discussion if required, see attached contact. Hope this clarifies the situation.

Regards

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From:	Bill Holden
To:	Burt, Alan
Cc:	Graeme Cook; Darren TILLEY; Ignazio Cannizzo; Bonar, Craig; Callar, Geoff
Subject:	RE: AS3814 - Modification to Type B appliances
Date:	Monday, 20 February 2012 8:15:55 AM

Dear Alan,

Thank you for your response below.

Any plant change is a critical activity from both safety and operability viewpoints and it is important that as per your Safety Case, risk management process is applied to this particular project to assist with specific decisions or to manage recognised risk areas in order to achieve risk being reduced to ALARP.

You quite correctly point out that "*GSA s44 would seem to permit the field equipment to remain at the existing level of risk, whereas AS3814 ambiguously requires the appliance to be upgraded ...... ISO21789 unambiguously sets out the requirements for the fail-safe design of the complete package*." and as I stated in my email (also below), AS 3814 Clause 5.8.1 states that the requirements of ISO 21789 may be deemed by ESV to meet the intent of AS 3184.

To clarify, while GSA s44 reads that field equipment can remain at the existing level of risk, this does not negate APA's risk management obligation to achieve risk being reduced to ALARP. Consequently, it is not simply an issue of there being a compliance trigger as distinct from a change management risk assessment trigger.

From a Safety Case perspective as well, it is not ESV's intention to deem that the requirements of ISO 21789 meet the intent of AS 3184 or not.

ESV would rather see that APA has considered all of the requirements of both standards as relevant to their proposed scope of work and that they have determined whether the work as proposed will ensure that once completed, risk remains at ALARP.

As mentioned in my earlier email, it is my belief that this is most easily determined by adopting a compliance matrix, identifying gaps and then making sure that these are picked up and addressed in a formal HAZOP. However, as APA has articulated how it deals with risk management in its Safety Case, I only offer this as a suggestion.

I note your timing of 24 Feb and am conscious of the fact that this issue needs to progress quickly. Hopefully, you now have sufficient clarification in order to do so.

However, should you feel that you would still like to meet to discuss this further, then please let either Graeme or myself know a.s.a.p. and we will see what we can arrange at the earliest opportunity to accommodate all.

With regards,

W. Holden
Manager Gas Infrastructure Safety

energysafe VICTORIA

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