Revised Proposal

Attachment 5.13.N.1

ADMS Business Case

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Contents

Glossary

Term	Definition
ADMS	Advanced Distribution Management System is a platform that supports the full suite of distribution network management and optimisation tools to assist distribution businesses to manage the network
Ausgrid Outage Management Cluster	A suite of applications and databases used within Ausgrid to manage the operational works on the network. The outage management cluster Includes DNMS, OMS and several other satellite systems
Contemporised DNMS	An option where the existing DNMS is redeveloped by Ausgrid to modern standards
Current DNMS	An option of the existing DNMS continuing to be maintained by the vender ([redacted] in the medium to long term
DER	Distributed Energy Resources, Generically referring to Medium and Small-scale embedded Energy sources that are increasingly being connected to The distribution network.
DERMS	Distributed Energy Resource Management System – A module of the ADMS that most major vendors are developing to assist with the management of DER
DNMS	Distribution Network Management System is the SCADA and custom built DMS used by Ausgrid
DMS	Distribution Management System is a collection of applications designed to monitor & control the entire distribution network efficiently and reliably. A DMS option has been presented which is the first phase of a full ADMS solution that provides limited key functionality such as switching management
Part ADMS	The second phase of the ADMS project that would include an OMS, field deployment of relevant ADMS functionality (to enable non-verbal communication) and power flow modelling, but it does not have all the advanced applications.
Full ADMS	A full ADMS solution including all the advanced applications available as part of the core package
Like for Like	A solution on a modern platform sourced from a mainstream SCADA/DMS/ or ADMS Vendor to provide the current DNMS functionality
NAR	Network Access Request
OMS	Outage Management System

1 Executive Summary

Ausgrid's Distribution Network Management System (DNMS) is a bespoke Vendor/Ausgrid hybrid which started development in the 1990s. It is a critical part of the Operational Technology (OT) platform that is vital for effectively operating the electricity sub-transmission and distribution networks.

The DNMS was developed with the expectation of it becoming a widely used industry product. However, the anticipated industry adoption was not forthcoming and Ausgrid remains the only user of the system. In the past few years several major weaknesses of the solution have emerged and the severity of their impact continues to increase. These weaknesses include:

- Quality, availability and cost of vendor support;
- Limited functionality compared to modern solutions;
- Shortcoming in cyber security posture and potential for future inability to meet Licence Conditions;
- Safety limitations;
- Lack of OMS and other application integration; and
- Capability that is inconsistent with best industry practice and not aligned with customer's current and future expectations.

Urgent action is needed to overcome these weaknesses. Options were considered for continuing with the current system including re-engaging the vendor for long term support and Ausgrid Contemporising the solution with full control of managing and directing the future Roadmap. However, both these options presented considerable risks. This assessment therefore considered four additional credible options for replacement of the DNMS:

- **Like-for-Like (LFL)** – Replacement of the DNMS using a modern platform sourced from a mainstream SCADA/DMS or ADMS vendor to provide the current DNMS functionality
- **Distribution Management System (DMS)** – This extends the LFL solution and includes key incremental functionality such as switching management
- **Part Advanced Distribution Management System (ADMS) –** This extends the DMS solution adding the outage management system, field deployment of relevant ADMS functionality (enabling non-verbal communication) and improved power flow modelling
- **Full ADMS** – A fully functioned ADMS solution sourced from a mainstream vendor that has advanced tools enabled and applications to manage the network

The table below shows the Net Present Value of the lifecycle costs of all the options for provision of the core and associated support systems. A 15 year assessment period has been selected, which is less than 10 years from commissioning of the full ADMS. Whilst over 30 benefits of the full ADMS were identified the model focussed only on selected large Customer and Ausgrid benefits as this was sufficient to demonstrate the viability of the recommended solution. The same benefits have been assessed for all modelled options.

Cost/Benefits	Current DNMS ($M)	Contemp DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
Costs	$77.9	$102.9	$83.9	$89.7	$96.1	$105.8
Benefits	$-	$-	$6.1	$24.8	$44.3	$50.6
Net Present Cost (incl benefits)	$77.9	$102.9	$77.8	$64.9	$51.8	$55.1
NPV against Base Option	**$-**	**-$24.9**	**$0.1**	**$13.0**	**$26.1**	**$22.8**

Table 1 Discounted Costs and Benefits of Options for a Distribution Management System

The analysis shows that all the DMS/ADMS solutions have a strongly positive NPV compared to the Base Case of continuing with the current DNMS. The two options with the highest NPV were:

- The Part ADMS with an NPV of $26.1m over the assessed project life; and
- The Full ADMS with an NPV of $22.8 m over the assessed project life.

The Full ADMS provides foundational functionality with many benefits that can be realised for customers with other minor network and non-network related investment such as enablement of remotely controllable switches. It is therefore recommended that the Full ADMS is the option selected as this enables Ausgrid to provide the greatest customer benefit in managing the network of the future with increased distributed energy resources whilst providing the network services that customers expect.

2 Background

2.1 Background to DNMS

Ausgrid's Distribution Network Management System (DNMS) is a bespoke vendor/Ausgrid developed hybrid which started development in the 1990's. The DNMS is supported [redacted], and is comprised of two main system components:

- An earlier generation implementation of [redacted] SCADA Master Station; and
- A custom built DMS (Distribution Management System), which is unique to Ausgrid and utilises the [redacted] real-time database to maintain a connectivity model representing Ausgrid's distribution and sub-transmission networks.

The DNMS application forms part of the Ausgrid Outage Management Cluster, a suite of applications and databases in use within Network Services to manage the operational works on the electrical distribution network. The outage management cluster contains over 10 applications, including the DNMS, custom built databases and one-off systems. Many of these applications, including DNMS, are now classified as end of life and are either no longer supported or about to be out of support. The cluster of applications is not fully integrated meaning there is a high overhead of manual administration required to perform standard duties and create reports required to run the business.

The Ausgrid Outage Management Cluster is shown in the diagram below.

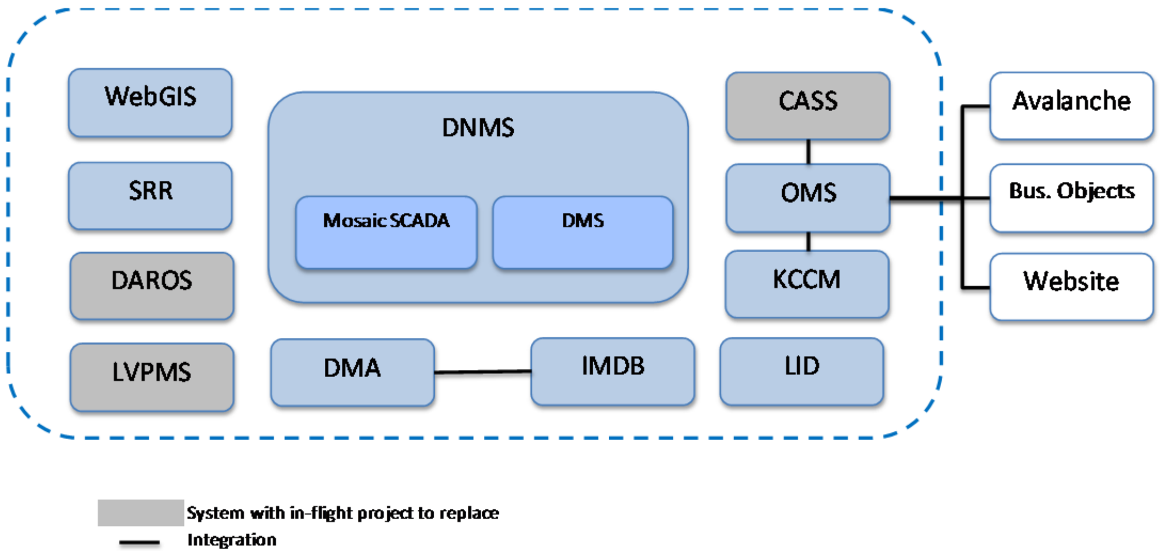

Figure 1 Outage Management Cluster

Aside from the DNMS the outage cluster contains the following applications:

- OMS (Outage Management System) – Provides a centralised view of unplanned outages and integrates with the Computer Aided Service System (CASS). The OMS has additional interfaces to Business Objects (reporting), Avalanche (customer outage messaging on telephony) and Ausgrid's website for outage information, which facilitates outage and hazard reporting by the public.
- DAROS (Disconnect & Reconnect Order System) – This system was built for Ausgrid to manage network access requests and is integrated with the LVPMS. The system is only used by the Sydney Control Room and corresponding depot staff. DAROS is currently being replaced by the Switching Request Register (SRR).
- LVPMS (Low Voltage Parallel Management System) – This ancillary system is integrated with DAROS and was built as an add-on to manage low voltage parallel network configuration and track temporary parallels within the Sydney Control Room. This is currently being replaced by a module of the OMS.
- WebGIS – An internally developed system that is used to manage National Energy Customer Framework (NECF) obligations related to arranging interruptions and notifying customers for planned customer

interruptions. WebGIS is also used to provide an internal view of real-time outage data from OMS on a Google Maps background.

- SRR– Originally purchased to replace both DAROS and components of LID the system has been deployed for network access requests made to the Wallsend Control Room and is currently being implemented for requests made to the Sydney Control Room.
- DMA (Defective Mains & Apparatus) – Is a Microsoft Access database used in the Sydney Control Room to produce interruption reports for unplanned outages. Additionally, where necessary, a defective mains and apparatus report is created to capture details of defective equipment on the network and sent to the regions to complete repairs.
- LID (Line Impedance Data) – This system is currently used to produce interruption reports in the Wallsend Control Room and also stores line impedance data for the Asset Management Division for the Wallsend/Hunter portion of the network.
- IMDB – A Lotus Notes Interruptions Management Database that is used to capture summary information on outages. Entry is automated from the DMA database for Sydney Control room outages and populated by manual extract from LID for Wallsend Control Room outages.
- KCCM (Key Customer Contact Management) – The system contains additional information for key customers information supplementing the customer database in SAP.
- CASS– A despatching and mobile computing application that controls the issue of customer premise jobs to EmSOs (Emergency Service Operators). Jobs are updated in the field using the CASS mobile client with updates available in OMS via interface. CASS is planned for a tactical replacement in FY19 due to end of life software and hardware issues.

2.2 Existing Functionality

The diagram below provides an overview of the existing functionality of the DNMS and OMS against the functionality that could be available from a contemporary ADMS.

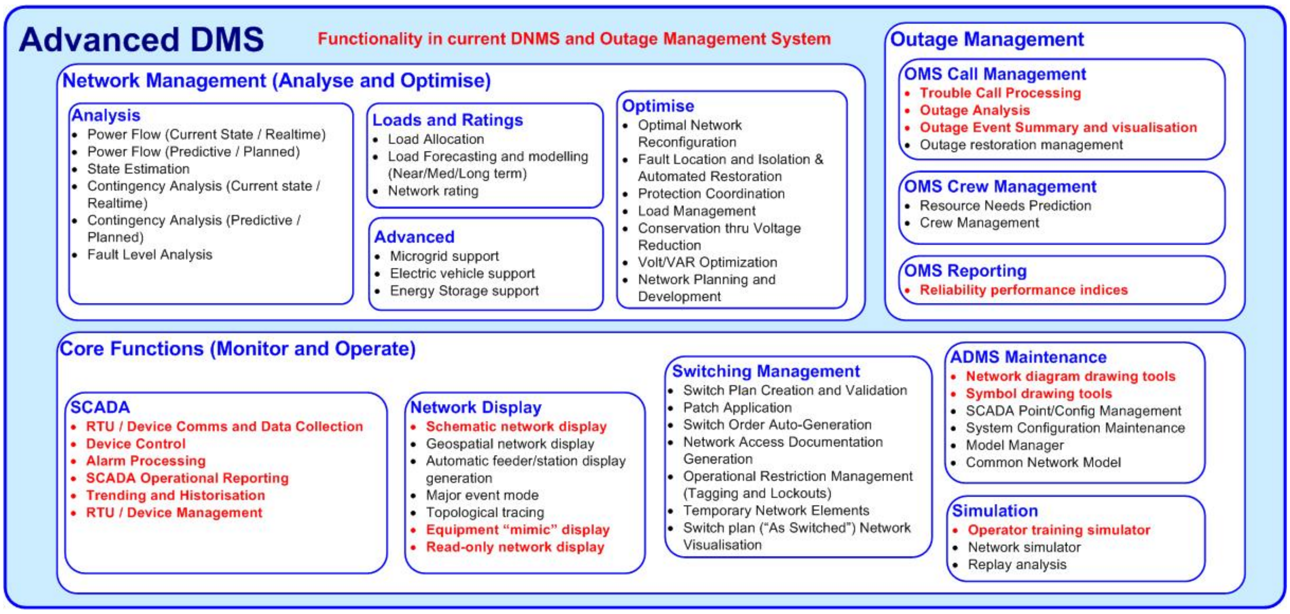

Figure 2 Functionality Available from an ADMS

Key points to note from this diagram are:

- Extremely limited functionality of the DNMS compared to a modern ADMS;
- Lack of Switching Management functionality, which is a core part of many DMS or ADMS implementations;
- Currently OMS & DNMS are not integrated, which contrasts with most modern ADMS solutions that provide both systems on a common model with the benefits of an integrated solution; and

- Wide level of additional network management and operational support applications that are standard ADMS functionality.

2.3 Purpose of this Document

A DNMS replacement pre-implementation project has been established to pursue options and solutions to modernise and replace Ausgrid's DNMS. This project is delivering a long term strategic initiative to transform and simplify the control environment, systems, processes and technologies to enable Ausgrid to continue to be reliable and reduce operational risks to an acceptable level.

The purpose of this document is to provide a high-level assessment of the options for a replacement DNMS and their compatibility with the National Electricity Rules. It breaks down as follows:

- Section 3 – Reviews the current DNMS considering cost, risk and compliance with Ausgrid's Licence Conditions
- Section 4 – Considers the option for Continuing with the current or a Contemporised DNMS
- Section 5 – Presents four credible options for DNMS replacement
    - Like-for-Like replacement
    - DMS
    - Part ADMS
    - Full ADMS
- Section 6 – Provides a comparison of the costs of all options
- Section 7 – Reviews the benefits delivered by the options on modern platforms
- Section 8 – Delivers an assessment of the recommended solution based on the costs and benefits of all options.

3 Need for a Replacement DNMS

3.1 Approach

This section reviews the current challenges faced with continued operation of the DNMS. It highlights several issues that collectively illustrate that this is a high cost system that does not allow Ausgrid to meet its operating requirements. In addition, in a period of disruptive technologies, it is inflexible and unable to assist with the opportunities and challenges from Distributed Energy Resources (DER).

The issues have been broken down into the following sections:

- Vendor Product Support;
- Limited Functionality Deployed in the DNMS;
- DNMS Reliability and Network Performance;
- Capacity Issues;
- Cyber Security Risks;
- Cost of Maintaining DNMS;
- Safety Limitations;
- Integrated DMS/OMS and Regulatory Reporting;
- Best Industry Practice; and
- Meeting Customers' DER Management Expectations.

3.2 Vendor Product Support

The DNMS is a bespoke system that is unique to Ausgrid. The vendor [redacted] has advised Ausgrid that they regard the DNMS as a beta legacy system and have no future roadmap for the solution. The current support arrangements are due to expire in 2020 with the possibility of two extensions for a year. Beyond this period ongoing sustainable and cost-effective support is unlikely, and [redacted] appear to be focused on the end of the contract with no expansion of the resource pool capable of system maintenance. This approach extends a recognised risk of very limited key vendor resources able to restore/restart the system in the event of an issue occurring.

At this stage it is not clear whether the vendor would offer support after the contract expires. However, there are three key risks to consider if this was offered:

1) **Inability for the vendor to be able to provide support** – Any proposed support agreement would be dependent on the key resources who are at, or nearing, retirement age and hence likely to retire in the short term. If these remaining key resources were to leave [redacted] then there would be no capability to provide any support, even assuming an agreement could be made on the commercial terms.

2) **Lack of Product Development** – [redacted] has no plans to further develop this legacy system. It will consequently continue to fall further behind the level of functionality available in leading ADMS solutions which may be required to deal with increased DER and other network challenges. This compares to alternative products with detailed roadmaps and product development plans that can share the risk of new product development between many users.

3) **Cost of Product Enhancements –** If the DNMS is to be an ongoing solution it needs several major upgrades and re-architecture to enable continued compliance with Ausgrid's Licence requirements. In addition, it will need to be enhanced over time as new requirements emerge. If Ausgrid were to remain on DNMS they would have to pay 100% of any extended functionality as they are the only user on the system with [redacted] having no reasonable prospect of growing the user base. This compares to alternative solutions that will see development costs shared across many users and where vendors are keen to expand capability to assist in future sales of the products.

3.3 Limited Functionality Deployed in the DNMS

One of the issues with the DNMS is that there is limited functionality available in the system and successfully deployed by Ausgrid. This limited functionality presents a missed opportunity for capex and opex efficiency as well as safety advances that a contemporary system would be able to deliver. Two key examples are:

1) **Capex Improvements – Avoided Augmentation** – A combination of power flow analysis tools, a short-term forecasting solution and dynamic ratings would provide information to the operator to assist them in managing the network. The availability of this functionality would give operators greater confidence on peak load conditions and would provide the potential to delay network upgrades and augmentations.

2) **Opex/Safety Improvements – Efficiency and Accuracy of Writing/Checking Switching Management Instructions** – The switching management module of the ADMS will reduce the time needed to write and check the switching instructions as well as improving the accuracy of the checks to ensure there are no safety rules or network operating violations. This would have efficiency, safety and reliability implications and is a key feature of many contemporary systems.

These standard modules of an ADMS have not been implemented with the DNMS and represent a missed opportunity to operate the business more efficiently.

3.4 DNMS Reliability and Network Performance

The DNMS is still considered a development project by the vendor, which is reflected in the application's 'Beta DNMS' title. The system continues to have many software and functional failures with the table below showing a list of incidents over approximately the last 12 months. The impact of these failures has ranged from the loss of productive time, to the complete loss of control and monitoring availability at multiple substations.

Impact	Incident Type
System outage	Simultaneous crash of SCADA master station servers at different locations. No cause identified by vendor.
System Outage	System requires shutdown to change database size – During shutdown emergency XGUI failed to start increasing outage time.
System Outage	AEMO unintentionally sent additional (valid) ICCP data which caused the system to crash.
System Outage	Sydney production 'keeper' failure which caused entire system outage. Sydney DR site failure to operate.
Loss of Redundancy	UPS power issue – system fail-over did not function as designed.
Loss of Redundancy	Routine check of Wallsend DR site found system in crashed state and unable to start.
Loss of Redundancy	Test of Sydney DR site found system entered infinite crash reboot cycle and unable to start.
Loss of Redundancy	System disaster recovery processes were unable to be executed due to use of old protocols. Manual (currently undocumented) workaround processes required.
Loss of Visibility of network state	Several hardware failures including two causing impact to visibility
Loss of Visibility of network state	Transaction server crashed requiring restart – Unknown cause with no fault found by the vendor.
Loss of visibility of network state	Multiple protocol stack crashes (loss of visibility of groups of devices until restart) – Unknown cause no fault found by vendor.
Workstation Outages	Workstation crashes and irregular performance experienced with increased use of existing DNMS functionality – e.g. tagging
Loss of Visibility of network state	DNMS workstation froze without indication and no alarms were presented to the Operator for approximately two hours. Potential for missed or delayed observation of a network event with potential impact to network reliability

Table 2 DNMS Incidents in the last 12 months

Alongside these specific incidents there are concerns that older issues were not resolved and could reoccur. This includes:

- Spontaneous database desynchronization;
- System destabilisation due to network conditions (already re-occurring). This was the cause of the longest system outage which led to a significant remediation project and is currently compensated for through manual intervention; and
- Data corruption and issues - partly compensated for by increased manual data checking.

With the increasing obsolescence of the DNMS and declining or removed vendor support it is likely that the level of availability of the DNMS will continue to decrease. This will impact on the visibility and control that Operators have of the network, which feeds through to network reliability, safety and performance. Section 4 of Ausgrid's Licence provides specific requirements relating to reliability standards including:

'4.1 A *Licence Holder* must not, when *excluded interruptions* are disregarded, exceed in a *financial year* the *SAIDI average standards* that apply to its *feeder types*.

Any increase in the level or durations of interruptions of the control system could impact the ability to meet this Licence Condition.

3.5 Capacity Issues

The DNMS has reached the capacity limit for its database size which is impacting the ability for Ausgrid to commission substations, points equipment and telemetry for the Sydney region. The vendor has recommended several changes to the core of the DNMS to resolve this capacity limit. These recommended actions are:

- DNMS core code change – preliminary review indicates the DNMS code change required is significant, impacting the core DNMS code base, requiring code recompilation as references to tables used by the DNMS are hardcoded.
- Addition of a new database table and associated configuration adjustments to handle additional substations, points equipment and telemetry.
- Additional data concentrators required as all points within one data concentrator need to be on the same database table.

In consideration of the vendors recommended actions to resolving the capacity issue, the following issues have been identified and are being risk assessed:

- The timeframe to complete this proposed code fix and add in the new required tables and associated configuration changes required to the DNMS and then test and deploy to production is not yet known,
- There is a vendor experience risk as current [redacted] support staff have not previously undertaken this type of change end to end covering the full processes and changes required in creating the new table and the associated DNMS code and configuration changes for Ausgrid's bespoke DNMS solution.
- The resource effort to thoroughly test the code changes to mitigate the risk and have confidence in the change is expected to be significant.
- Significant parts of the DNMS complied code in production are not positively traceable to the original uncompiled source code and development environments. The recommended DNMS source code changes to resolve the capacity limit are based on uncompiled source code that cannot be positively confirmed as being the same as used in the production DNMS. This source control issue presents a high risk to Ausgrid undertaking code changes to the DNMS source code as Ausgrid is unable to demonstrate that a secure development process has been followed to manage dependent risks. Making changes to the system that cannot be traced is mis-aligned with a secure development process[1] and is not consistent with Licence Condition requirements to manage the operation and control of its distribution system using industry best practice.
- The risk mitigation effectiveness provided by undertaking testing of the code changes is reduced significantly due to gap in traceability issue and secure development processes.

Due to these considerations Ausgrid are reviewing an approach to tactically remove less critical SCADA points from the DNMS to accommodate SCADA points for new substations, points equipment and telemetry being commissioned.

[1] Electricity Subsector - Cybersecurity Capability Maturity Model (Es-C2m2) Version 1.1 - February 2014 Section 7.8 Supply Chain And External Dependencies Management (Https://Www.Energy.Gov/Sites/Prod/Files/2014/02/F7/Es-C2m2-V1-1-Feb2014.Pdf)

3.6 Cyber Security Risks

Ausgrid's distribution network is part of the National Critical Infrastructure list defined by the Australian Government[2]. As part of these requirements Ausgrid needs to maintain its infrastructure so that it remains safe from security risks. Alongside this Federal Government requirement there is also a specific Licence Condition for Ausgrid related to Critical Infrastructure, which states:

9.2 Except to the extent that the Licence Holder is undertaking steps in accordance with, and for the duration of, a Protocol agreed with the Commonwealth Representative, the Licence Holder.

(a) must, by using ***best industry practice*** *for electricity network control systems, ensure that operation and control of its distribution system, including all associated ICT infrastructure, can be accessed, operated and controlled only from within Australia, and that its distribution system is not connected to any other infrastructure or network which could enable it to be controlled or operated by persons outside Australia;*

The Licence Condition also has clear roles including the senior officer responsible for operational technology who is responsible for:

Developing and implementing strategies to manage cyber security and other threats affecting the network operational technology environment;

[redacted]

Whilst best practices provide some transitionary ability for legacy systems, over time these standards are refreshed, and the transitionary arrangements become non-compliances. Given the age there would be a high cost of changing the DNMS to make it consistent with the Licence requirement to use best industry practice for access controls.

3.7 Cost of Maintaining DNMS

There is a high cost for Ausgrid to continue operating using the DNMS.

The average vendor support cost for the DNMS over the last few years is [redacted]. This compares with the expected vendor support costs for an ADMS (including the OMS) of around [redacted] per annum and represents a significant on-going annual saving to Ausgrid. Supporting the DNMS also requires Ausgrid to maintain the [redacted] computing platform which is specialised hardware that is not core Ausgrid technology. [redacted] is discontinuing the [redacted] platforms and ongoing support for this infrastructure and the Operating System (OS) will become unavailable in future. This will require the DNMS application to be ported to a different technology and OS.

The high cost of vendor support for the DNMS is exacerbated by the need to maintain satellite systems (e.g. SRR, OMS, LV Parallel Management System, Defective Mains and Apparatus, etc.) as this functionality is not provided by the DNMS. Most modern ADMS solutions incorporate this functionality directly in the system and therefore avoid this cost.

3.8 Safety Limitations

Licence Condition 9.3 (b) of Ausgrid's Licence places obligations on the senior officer responsible for operational technology including delivering the SCADA capability required to safely and reliability operate the NSW Distribution System.

The adoption of a modern ADMS using some of its expanded capability would allow for several safety improvements to be adopted by Ausgrid, which would reinforce compliance with this responsibility. This includes:

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[2] On 21 February 2017, the Critical Infrastructure Centre released a discussion paper outlining the complex and evolving national security risks of sabotage, espionage and coercion to our critical infrastructure.

[3] [redacted]

- **Electronic Permit monitoring for HV/LV** – The system will show the Operator in real time where crews have a permit to work on the network. The system would also automatically lock out operation of remotely operable switchgear that conflicted with the permits issued to work on the network. This reduces the chances of inadvertently creating a safety incident.
- **Step by step instructions for HV/LV** – The system could verify all switching instructions prior to operation to confirm they comply with all safety requirements. It also provides an audit record of all actions performed should any future investigation be required.
- **Non-verbal communications to Field Operators/Crews** (through field deployment of relevant ADMS functionality) – Less opportunity for misinterpretation of communications. There is also a clear audit record of all non-verbal communications.
- **Real time view of the network for Field Operators/Crews** – Field crews will have the same real time view of the network as the Operator. Field crews will know if any part of the network is energised and can avoid safety issues that may emerge.

An example of the significance of this issue can be seen by the average of 16[4] switching errors observed in the control rooms in the last 2 years, many of which have a potential safety implication. The combination of the move to detailed switching and the switching management/non-verbal communication modules in ADMS should greatly reduce the number of incidents and provide greater confidence that the SCADA capability is being used to safely and reliability operate the distribution system.

3.9 Integrated DMS/OMS and Regulatory Reporting

The original concept for the DNMS was that a trouble call facility and other OMS functions would be included. However, due to regulatory requirements Ausgrid removed this requirement and implemented [redacted] Network Management System ([redacted] A DNMS/OMS data link was purchased, but data alignment and integration issues meant this was unable to be deployed into production. The absence of a link between the 2 systems means that the responsibility for keeping the DNMS in synch with the OMS is a manual task for the control room during outages and the switched state of the network between systems is unsynchronised. This creates several issues including:

- Duplication of data entry which is both inefficient and creates the potential for errors;
- Potential misalignment of DNMS/OMS data in real time resulting in the Customer Services representative not being able to provide the latest outage information to customers;
- Reliance on manual data entry creating risks that regulatory reports may not be up to date and could contain errors; and
- Customer facing web portal not having up-to-date information, particularly during storms or major network events.

3.10 Best Industry Practice

An ADMS is now a standard toolset for distribution network operators, and with the emergence of disruptive technologies, is likely to become more important. This is demonstrated in recent reports including:

- The Department of Energy (DoE) in the United States released a report that summarised the experience of utilities in the country in terms of implementing ADMS systems. The report advised that Utilities are investing in the ADMS technology because they believe the capabilities it enables are essential to the future of their business. Utilities that are investing in ADMS view it as necessary to stay relevant in the changing electricity business[5].

- The ENA roadmap[6] notes that the next decade is likely to see a step change in the rapid adoption of new energy technologies, driven by falling costs and global carbon abatement measures. This decade provides a limited window of opportunity to reposition Australia's electricity system to deliver efficient outcomes to customers.

  The roadmap anticipated that by 2027 the power system would need to support an expanding range of new energy solutions requested by customers, while meeting expectations for reliability, cost and customer experience. This would require advanced network planning and operation with new technological capabilities developed, trialled and

[4] Switching Instruction Review, March 2017 – Cutler-Merz report for Ausgrid
[5] https://energy.gov/sites/prod/files/2015/02/f19/Voices%20of%20Experience%20-%20Advanced%20Distribution%20Management%20Systems%20February%202015.pdf
[6] ENA Transformation Roadmap Report 2017

validated in Australia to enable progressive implementation of advanced network optimisation delivering the distribution system balancing that will be required.

Clearly meeting these requirements necessitates a range of models, tools and techniques with enhanced monitoring and control, and this can only build on the capabilities of a modern ADMS. These solutions will need to develop as the system complexities develop and it would be advantageous if utilities can share these development costs using common systems.

All other Australian mainland distribution networks, with the exception of Power and Water Corporation (NT), either operate, or are implementing, an ADMS or DMS from one of the major vendors (GE, Schneider, OSI, Oracle, ABB). All these vendors feature on the Gartner Magic Quadrant (trusted IT research and analysis of industry providers) and the Gartner Hype Cycle for the Utilities industry (review of new, emerging and maturing technologies).

Ausgrid stands out as an exception being the one major distribution utility relying on an old, bespoke DMS from a vendor that doesn't have the functionality, support or roadmap that the other solutions provide. Given the growth of the likely requirement of an ADMS, the current solution is clearly no longer best practice and unlikely to meet the demands of the evolving network. The timeframe to implement an ADMS makes it essential that rapid progress is made on this replacement program.

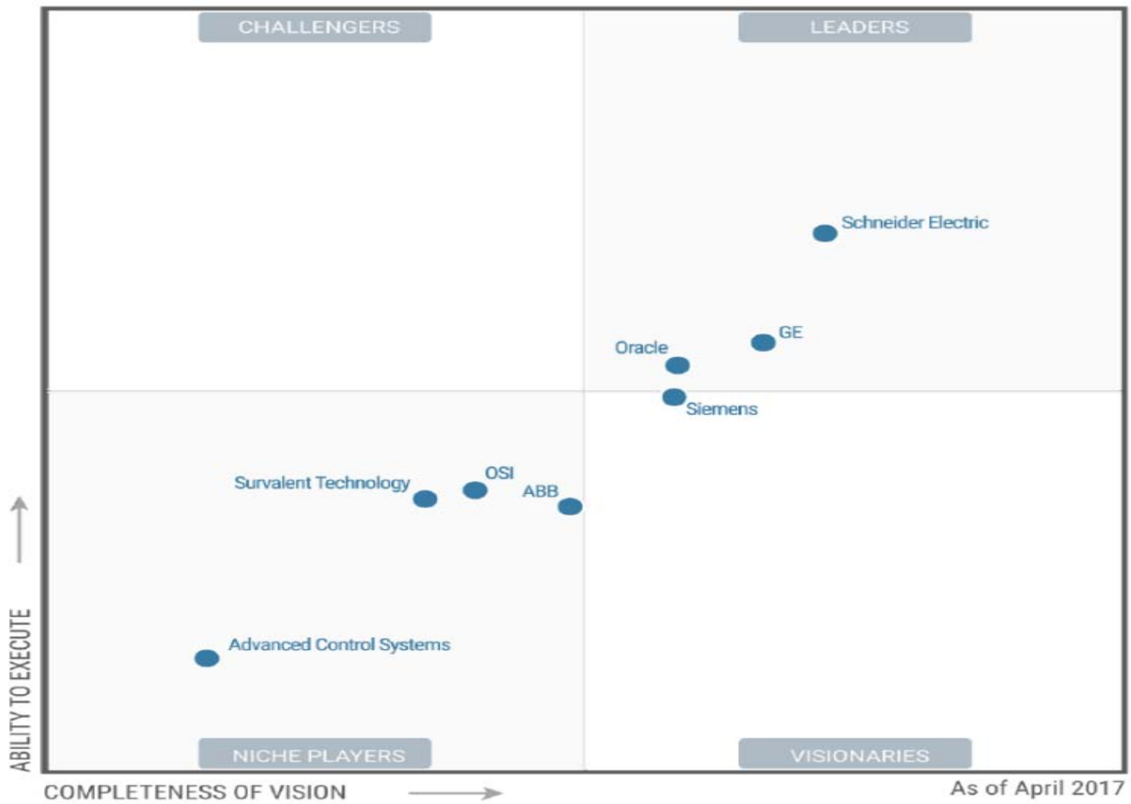

Figure 3 Gartner Magic Quadrant for ADMS Solutions

3.11 Meeting Customers DER Management Expectations

Ausgrid expects to see strong growth in the level of renewables that customers wish to deploy on their network over the next 2 regulatory periods. This is shown in the diagram below from Ausgrid's Stakeholder Consultation [7].

[7] Ausgrid, Stakeholder Consultation Document, 2019-2024 Proposal

Figure 4 Customers with Small Scale Solar and Battery Systems - Ausgrid Stakeholder Consultation

The ENA Roadmap[8] aligns with these expectations for growing distributed renewable sources and promotes several milestones to manage this growth. The key milestones for the Grid Transformation Project include agreement by 2020 on an integrated suite of advanced network operation mechanisms for the safe, reliable and efficient operation of a high-DER distribution system. It is expected that by 2022 that a full suite of Advanced Network Optimisation (ANO) tools should have been trialled and validated across a diversity of Australian network topologies and DER 'scenarios.

The trialling of ANO tools aligns with Ausgrid's Stakeholder Consultation, which notes that the investment in a modern ADMS would provide the ability to operate the grid safely, reliably and effectively as more and more customers adopt distributed energy resources. This would enable the system to meet customer expectations in allowing more renewables into the grid, providing customers the option of choosing green energy or generating their own power from solar panels, as well as facilitating their participation in peer-to-peer trading.

The ability to quickly adapt systems to cope with high levels of DER is not available with the current DNMS. This would restrict Ausgrid's ability to support customers' demands to connect to the network as well as more efficiently integrate the demand and generation on the system. Action should be taken now to prepare Ausgrid to deliver the facility to connect DER.

3.12 Conclusions

The option of continuing with the DNMS will present many risks to the business and could place Ausgrid in conflict with Licence Conditions. In addition, the system will restrict Ausgrid's ability to operate the grid safely, reliably and effectively as more customers adopt distributed energy resources and choose to engage in demand management.

This broad set of challenges and system limitations demonstrates that continuing with the current DNMS is not a viable option and the assessment therefore needs to focus on options for its replacement.

[8] Electricity Network Transformation Roadmap, Final Report, April 2017

4 DNMS Options

4.1 Options Considered

The review considered two options to allow Ausgrid to base its control room operations on the DNMS:

1) Option 1 - Continuing with Current DNMS
2) Option 2 - Contemporising the DNMS

A review of both options is provided below. As Option 1 is the current BAU position it is adopted as a Base Case for review against all other options.

4.2 Option 1 – Continuing with the Current DNMS

Under this option it would be necessary for Ausgrid to re-negotiate [redacted] to reach agreement for them to continue supporting the product in the longer term. This will require [redacted] to train additional resources in the bespoke Ausgrid DNMS solution and this investment will be reflected in the cost (directly passed through to Ausgrid as the sole customer for this product solution).

The product will also need to be remediated to overcome the most significant weaknesses and ensure that Ausgrid do not risk breaching their Licence Conditions. The modelling has assumed no 'non-essential' improvements or deployment of any additional system functionality, but just the minimum to allow it to continuing operating with existing functionality. These developments include:

- Implementation of additional user privilege security controls at an application level to supplement a tactical solution currently being implemented at an operating system level;
- Implementation of application level monitoring capability to provide notification and alarming if the application or workstations are not operating correctly, e.g. frozen;
- Update and refresh the operator and support staff workstations from Windows 7 to windows 10 compatible PC's to ensure that workstations have a current supported operating system;
- Migration from the [redacted] platform. [redacted] are no longer planning to continue to develop or support [redacted] in the longer term and this will require a technology platform and Operating System change in the near future ;
- Remediation of the ICCP communications to AEMO for the DNMS to resolve current issues related to lack of link redundancy and resilience to "data flooding';
- Improve the resilience of DNMS to degraded or intermittent network and communications links; and
- Resolution of issues that continue to arise with use of system functionality. As an example, the recent increased use of tagging in DNMS has resulted in a number of issues such as workstation crashes, performance issues, disappearing tags and tag database size constraints. Each of these issues requires separate investigation and resolution.

All satellite systems and the overall functional landscape are retained without improvements. This option does not deliver any material changes to functionality or any additional integration between the various satellite systems and existing OT technologies. Even with all these remediations many of the weaknesses and justification for moving away from the current solution will remain.

The risks and challenges associated with this option have been reviewed in section 3 of the report.

4.3 Option 2 -Contemporised DNMS Option

Ausgrid recently reached an agreement with [redacted] that enabled them to take over responsibility for the support of the system. This action reflected concerns Ausgrid had on the risks associated with the system as well as the performance of the vendor and their capability to cost effectively undertake support once the current contract expires. Given the agreement, it was decided to investigate the option of Ausgrid taking over responsibility for modernisation and remediation of the system, which was termed "contemporised DNMS". This option is included to demonstrate that Ausgrid have considered all alternatives, but it does present significant risks and limitations.

The approach would separate out the two core components of the DNMS, namely the [redacted] SCADA platform, and the DMS applications. The [redacted] platform, although being highly customised and hence divergent from [redacted] current [redacted] baseline product, would continue to be supported [redacted] and hence this would not be remediated by Ausgrid as part of this option. Ausgrid would take over responsibility for all DMS applications.

Ideally under this option the complete system would be available by the end of 2022, when the current support agreement including the possible extension expires. However, a review of the activities required has resulted in an estimate of 5 years from project commencement. The key issues that are addressed by approach are limited to:

- Meeting the Licence Condition for best practice cyber security requirements for access and control;
- Updating the system to deal with some of the issues creating reliability problems with the system; and
- Bringing the system up to standards that would make it portable across platforms. The system would move to Linux, rather than compiling on the [redacted] operating system.

The existing DNMS would continue to operate and be maintained [redacted] until the new system was available. Once the system was updated, Ausgrid would take over responsibility for maintaining the contemporised DMS applications and delivering any upgrades that may be required. [redacted] would remain responsible for supporting and maintaining the underlying [redacted] platform.

All satellite systems and the overall functional landscape are retained without improvements. This option does not deliver any material changes to functionality or any additional integration between the various satellite systems and existing OT technologies.

4.3.1 Specific Risks with the Contemporised DNMS Option

There are several material risks with the contemporised DNMS options that should be considered alongside the financial comparison. These are:

- Ausgrid has no experience in the software development of complex, real-time systems. This would require the recruitment of a team with expertise in this area and the creation of software development and quality control processes. These are processes that any large software business would have already established to apply across all their products. This risk creates a significant probability of both a time and a cost overrun against the proposed schedule.
- For the Contemporised option Ausgrid would need to create and manage a team of software support staff to maintain the system. This would need enough coverage to provide 24 hours by 7 days a week support with all resources dedicated to the project.
- There is a risk that by remediating the software, bugs could be introduced creating unintended availability issues with the system. This risk is increased by utilising a solution that was not originally developed by Ausgrid. Comprehensive end-to-end testing would help to mitigate this would also add considerable commensurate costs and require any new issues to be resolved.
- Maintaining the [redacted] solution will still retain [redacted] risks associated with this part of the product
- There would be a downside risk with two parties looking after different parts of the solution (i.e. [redacted] SCADA, and the DMS applications) in that in the event of faults emerging between the two components, there would be potential contention over the responsibility for resolving the errors.
- There is a risk that Ausgrid may be viewed as non-compliant with their cyber security and reliability requirements for the duration of the period needed to develop the software. These issues could be resolved much more quickly with the alternative options where a solution (sufficient to allow the decommissioning of the DNMS) could go live in just over 2 years.
- The option fails to address several of the key constraints identified in the review of the current DNMS including:
    - As the sole user of the system, Ausgrid will continue to be responsible for 100% of funding for all upgrades and bug fixes;
    - Remaining inconsistent with best industry practice of using a recognised product from a major vendor;
    - Not delivering the safety improvements identified as possible with the ADMS;
    - No assistance with DER Management or provision of the additional functionality that modules such as Switching Management and Power Flow analysis could deliver.

In summary the options of maintaining or taking an end of life software product with just one bespoke implementation (Ausgrid) and using it as a platform for the next 10 years of critical operation in a rapidly evolving power system and energy market environment with heightened cyber security risks is highly imprudent.

4.4 Compliance with Capex Objectives and Criteria

4.4.1 Capital Expenditure Objective

The compliance of these solutions against the capital expenditure objectives is shown below:

Mapping to the relevant "Capital expenditure objective(s)" (Chapter 6, National Electricity Rules) The forecasted capital expenditure is considered necessary to achieve:	
Objective	**Review**
6.5.7 (a) (1) meet or manage the expected demand for standard control services over that period	Over the next ten years it is anticipated that there will be a large increase in the amount of DER that will connect to Ausgrid's network as part of a standard control service. Facilitating this DER will require Ausgrid to develop solutions that provide visibility and allow control of the DER to avoid the need for unnecessary augmentation. The current/contemporised DNMS will not provide the facility to manage this expected demand for DER. Under either of these options it may be necessary for Ausgrid or the vendor to undertake system development on the DNMS to assist in management of DER with the minimum option likely to be power flow applications. Ausgrid does not have experience of this form of software development and there would be a risk of delay and cost overruns as well as the quality of the product as all established vendors will have strict control methods for production of software. If this was undertaken by the vendor, for just one customer, then this type of development is likely to be expensive compared to a product where costs are shared amongst many customers.
6.5.7(a)(3) maintain the quality, reliability and security of supply of standard control services	The current/contemporised DNMS has risks related to reliability and cyber security that translate into an Ausgrid risk on its ability to maintain quality, reliability and security of supply. If these options were successful in ensuring the robustness of the DNMS, particularly regarding cyber security and DNMS reliability, then it meets this objective. However, the level of internal support should a problem emerge, would need to be consistent with the resources other vendors with multiple users could apply to resolve any reliability issues.
6.5.7(a)(4) maintain the safety of the distribution system through the supply of standard control services.	This risk in this area relates to unreliability of the DNMS to avoid a deterioration in safety requirements. The impacts on the ability to meet this objective are therefore the same as 6.5.7(a)(3).

Table 3 DNMS Options Against the Capital Expenditure Objectives

4.4.2 Capital Expenditure Criteria

Mapping to "Capital expenditure criteria" (Chapter 6, National Electricity Rules) The forecasted capital expenditure reasonably reflects each of the following:	
Criteria	**Review**
6.5.7(c)(1) the efficient costs of achieving the capital expenditure objectives; **6.5.7(c)(2)** the costs that a prudent operator would require to achieve the	These two criteria have been assessed together as a prudent operator would consider both costs as well as risks in comparison to other options. A financial assessment of the 2 options has been provided in sections 6 to 8 of this report.

capital expenditure objectives; and	It should be noted that these are higher risk options than procuring a modern solution as it requires Ausgrid to take on several activities (product development and product maintenance) for which it has no experience, or to contract with a vendor as the sole user of the product. This creates an enhanced risk of cost and time overruns. Additionally, either option provides no path to provide the functionality that may be required to cope with managing the network in the next 10-15 years and could result in higher development costs (100% funded by Ausgrid), or stranded assets as a replacement ADMS would ultimately be required to meet Licence Conditions. The risk associated with these options does not align with these capital expenditure criteria.
6.5.7(c)(3) a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives.	Cost inputs used for the assessment were derived from previous operating experience with the system with the costs socialised with the key users.

Table 4 DNMS Options Against the Capital Expenditure Criteria

4.5 Conclusions

A review of the risks of continuing with or contemporising the DNMS against a modern system indicates that these are much higher risk options for Ausgrid to pursue. There is also a risk with these options of failure to comply with the Capital Expenditure Objective and Capital Expenditure Criteria.

The high level of risk means continuing with either DNMS option is not viewed as credible. However, financial assessment has continued to assess whether either option would be prudent and efficient if the risks were ignored.

5 Alternative Options for DNMS Replacement

5.1 Options Considered

The previous sections illustrated that continuing to operate with the current [redacted] supported DNMS, or Ausgrid contemporising the DNMS, are high risk options. This section outlines four alternative options that were considered for replacement, these being:

- **Like-for-Like** - A Like-for-Like (LFL) replacement using a modern platform sourced from a mainstream SCADA/DMS or ADMS vendor to provide the current DNMS functionality;
- **DMS** – This is first phase of an ADMS solution including key functionality such as Switching Management;
- **Part ADMS** – This solution builds on the DMS and includes an integrated OMS as part of the ADMS solution and represents the first 2 phases of the ADMS Project; and
- **Full ADMS solution** – This solution builds on the Part ADMS and completes the ADMS by enabling the advanced applications within the solution

All options are based on delivery of Commercial Off The Shelf (COTS) software.

A modern ADMS solution provides functionality that that is fundamentally embedded in the unified product suite. Consequently, ADMS options were not developed on the basis of the incremental implementation of specific functionality but on the basis of the phases in Ausgrid's implementation plan which provides some logical breakpoints.

5.2 Option 3 - Like-for-Like Replacement

This option is a replacement of the DNMS with a modern product offering only the same functionality. As a feature of all modern systems, the solution would support the latest cyber security features and would be expected to be more reliable. It would also have on-going support from the system vendor with the capability for enhancements with additional modules of the product. This includes the ability to develop DER solutions which could be implemented by Ausgrid once the level of DER penetration requires additional visibility and control.

The project scope would not include enhancements available in the ADMS and the solution maintains the same functionality in the satellite systems with no material changes to their functionality. The Like-for-Like is assumed to be commissioned in early 2021.

5.3 Option 4 – DMS (ADMS Phase 1 Only)

This extends the LFL solution and includes key incremental functionality such as Control Room switching management to deliver additional benefits to customers and to Ausgrid.

The first phase covers replacement of DNMS and limited key functionality offering major benefits to Ausgrid. As well as the core monitoring and control functionality, it delivers:

- Integrated Switching Management and support for the broader switch planning process;
- Digital drafting and execution of switching instructions; and
- Sub-transmission network modelling and thus the ability to perform real-time network security analysis.

The solution would also provide a platform for subsequent expansion of the ADMS, albeit the cost of restarting the project would be higher. The DMS is assumed to be commissioned in early 2021.

5.4 Option 5 – Part ADMS (ADMS Phase 1 and 2 Only)

The key addition for this phase of the project is replacement of the OMS using the embedded OMS extensions within the ADMS. Major developments in this phase include:

- Fully-integrated outage management;
- Embedded digitalisation of the processes used in requesting access to the network for planned work;
- Run-time network security analysis undertaken by operators;
- Non-verbal communications from field deployment of relevant ADMS functionality between control room operators and field operators; and
- Automatic National Energy Customer Framework (NECF) breach detection.

Both the OMS and the power flow analysis tools available in this phase of the modelling will provide material benefits to Customers and Ausgrid. The Part ADMS is assumed to be commissioned in late 2022.

5.5 Option 6 – Full ADMS (ADMS Phases 1, 2 and 3)

This final phase provides the advanced applications required to support network optimisation. Major deliverables in this phase include:

- Automated fault detection, isolation and restoration capability;
- Dynamic loads and ratings enabling more efficient utilisation of the network;
- Advanced applications to enhance optimisation of the network (such as Volt/Var Control, Open-point Optimisation, advanced Load Forecasting); and
- Enhanced Training Environment (Operator Training Simulator).

The Full ADMS with the complete system should be operational in early 2024.

5.6 Compliance with Capex Objectives and Criteria

5.6.1 Capital Expenditure Objective

The compliance of these options against the capital expenditure objectives is shown below:

Mapping to the relevant "Capital expenditure objective(s)" (Chapter 6, National Electricity Rules) The forecasted capital expenditure is considered necessary to achieve:	
Objective	**Review**
6.5.7(a)(1) meet or manage the expected demand for standard control services over that period	Over the next ten years it is anticipated that there will be a large increase in the amount of DER that will connect to Ausgrid's network. Facilitating this DER will require Ausgrid to develop solutions that provide visibility and allow control or provision of signals to the market for DER to avoid the need for unnecessary network augmentation. The current DNMS (Options 1 & 2) and Like-for-Like (Option 3) will not provide this capability. Option 4 would be a relatively low cost to expand to this capability. Option 5 and 6 will provide a full power flow analysis solution enabling assessment and management of DER impacts on the network. All major ADMS vendors are in the process of developing modules to facilitate better control of DER and these should be available with a shared development approach in the next couple of years. This functionality is not currently included in the replacement project as it is still in development and hence the costs/benefits cannot be definitively established. As the need to manage DER increases either of these options (5 or 6) could be adapted to meet the evolving requirements. However, the costs will be lower under the ADMS options, which offer much of the core functionality immediately.
6.5.7(a)(3) maintain the quality, reliability and security of supply of standard control services	Options 3, 4, 5 and 6 would implement a modern system which would be expected to provide a secure and reliable distribution management system with the appropriate cyber security provisions. These would be supported on an on-going basis by the respective vendor. As such all these options would be expected to comply with the objective for maintenance of the quality, reliability and security of supply for standard control services.
6.5.7(a)(4) maintain the safety of the distribution system through the supply of standard control services.	A modern control system is required to maintain system reliability to avoid a deterioration in management of safety impacts. All credible options would provide a secure and reliable distribution management system with the appropriate cyber security provisions and would therefore meet this objective.

Table 5 Modern System Replacement Options Against Capital Expenditure Objectives

5.6.2 Capital Expenditure Criteria

The compliance of these options against the Capital Expenditure Criteria is shown in the table below.

Mapping to "Capital expenditure criteria" (Chapter 6, National Electricity Rules) *The forecasted capital expenditure reasonably reflects each of the following:*	
Criteria	**Review**
6.5.7(c)(1) the efficient costs of achieving the capital expenditure objectives; **6.5.7(c)(2)** the costs that a prudent operator would require to achieve the capital expenditure objectives; and	The results of the cost benefit analysis demonstrate that the implementation of a Part ADMS or Full ADMS provide an efficient investment for the long term interest of customers. In considering the total benefits (both quantified and qualitative) the Full ADMS provides the least cost to customers in the longer term. The most efficient option has been assessed following the cost benefit review that demonstrates the net impact of the different solutions. Ausgrid has taken several steps to ensure that the selected option is efficient. This includes: • Selecting the software vendor through a transparent and comprehensive sourcing exercise. An overview of this process is provided as Appendix A. • Ensuring a proven, on-going product is selected to share the costs of future developments and support amongst a large installed base. • Decision to implement a standard product, minimising customisations and hence future costs.
6.5.7(c)(3) a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives.	Cost inputs used are based on reasonable estimates with the process followed described in Appendix 1. A breakdown of the costs is provided in section 6.

Table 6 Modern System Replacement Options Against Capital Expenditure Criteria

5.7 Conclusions

All options largely meet the Capital Expenditure Objectives. However, the greater capability of the Full/Part ADMS means it would be better positioned to deal with evolving customer requirements of the network. The compliance again the efficiency and prudency criteria should only be made on the basis of a cost benefit assessment. This assessment is provided in sections 6, 7 and 8 of this report.

6 Costs of Alternative Options

6.1 Approach

The approach compares the cost of all options to provide the functionality currently delivered by the Outage Management Cluster described in Section 2. It includes the costs of development, operation, maintenance and upgrades for the options as well as any satellite systems such as the OMS and SRR.

The costs are broken down into several consistent categories covering:

- Project Cost;
- Onshoring Costs;
- Capex cost of system operation; and
- Opex cost of system operation.

The costs are assessed over a 15-year period, which is less than 10 years after the Full ADMS goes live. The ADMS will be refreshed during this commissioning period so the 10-year operating life for the system is relatively conservative. The hardware cost is excluded as this is budgeted separately. However, an internal review indicated this is likely to be a similar cost between options given the hardware requirements of OMS and the satellite systems.

The modelling for all options excludes company overhead in line with normal regulatory reporting requirements. The analysis does indicate that the inclusion of a labour overhead on both cost and benefits would have a positive impact on the ADMS, due primarily to the efficiency savings delivered by this option relative to the other options. However, this impact is not included in the numbers presented within this report.

Contingency has been allocated according to the level of risk. The LFL/DMS Options have contingency capped at 7.5% to reflect the level of certainty established during the Initial Solution Design work. The Part ADMS has contingency increasing to 10% with the Full ADMS having contingency of up to 15% in the later stage of the project. This results in an average 10% contingency applied across the Full ADMS project. A 15% contingency was applied to the DNMS options, which were viewed as higher risk with the small budget for base DNMS having the potential for a significant cost overrun should any additional changes be required.

The ADMS costs have been built up with the ADMS Pre-implementation Team and are based on vendor quotations and a detailed build-up of project costs. The Like-for-Like replacement project is based on the ADMS Phase 1 cost, but with some costs reduced to recognise lower functionality. The allocation of costs between Opex and Capex is based on estimates provided by Ausgrid.

Costs for contemporising and maintaining the DNMS were estimated with the current support team.

All figures shown below are the NPV based on a 4.2% real discount rate.

6.2 Project Cost

The project costs (in NPV) for the six options are shown in the table below.

Cost Element	Current DNMS ($M)	Contemp DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
[redacted]						
Total	**$6.9**	**$32.3**	**$31.5**	**$34.3**	**$51.9**	**$57.5**

Table 7 Project Costs of the DNMS Replacement Options

As expected, the Full ADMS has the largest overall cost partly due to the project cost that extends over a 5-year period from FY 2019. However, Ausgrid recognise that the enhanced functionality of the Full ADMS option is likely to deliver material benefits in unquantified productivity and reliability improvements. It has therefore taken a decision to self-fund all external costs of the project from Financial Year 2024. The impact of this decision is highlighted as a negative cost in the table above as it reduces the level of capex Ausgrid will ask customers to fund for this project[9].

The incremental project cost from DMS to Part ADMS is nearly $18m with a less than $6m increase in moving from Part ADMS to Full ADMS given Ausgrid's decision to self-fund part of the project cost.

The Vendor Implementation Cost for the contemporised DNMS is the cost for the Ausgrid Developers to modify the system.

6.3 Data Onshoring Project Costs

Ausgrid has had continued engagement with Federal Government departments responsible for critical infrastructure in order to seek final approval for a request for dispensation from part of their Critical Infrastructure Licence Conditions that restrict off-shore access to critical data. As this final approval was not forthcoming, Ausgrid has adopted a technical and implementation approach that conforms to stringent Data Security Constraints and ensures that none of Ausgrid's critical data can be stored anywhere other than on Ausgrid's premises nor can it be accessed from anywhere other than Ausgrid's premises. These are referred to as the Data Onshoring requirements.

Costs that apply to these Data Onshoring requirements apply to all options that implement a modern platform and they represent the incremental project costs of retaining Ausgrid specific data on Ausgrid premises. The costs below reflect the changes to the vendor costs with some additional costs impacting the Ausgrid project costs identified above.

Cost Element	Current DNMS ($M)	Contemp DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
Vendor Onshoring Cost	$-	$-	$5.5	$5.5	$8.2	$10.9
Total Onshoring Cost	**$-**	**$-**	**$5.5**	**$5.5**	**$8.2**	**$10.9**

Table 8 Vendor Onshoring Project Cost

6.4 Capex Cost of System Operation

These are the on-going capex costs (in NPV) for the solutions and are provided in the table below

Cost Element	Current DNMS ($M)	Contemp DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
[redacted]						
Total	**$26.3**	**$20.5**	**$15.1**	**$16.6**	**$13.1**	**$14.5**

Table 9 Capex Cost of System Operation

The DNMS is based on the long run average cost of enhancements and starts from 2019 with the cost reflecting the fact that no other company uses the product. The internal support costs include additional resources to deal with cyber security and other enhancements within the system. The relatively high support cost for Full ADMS reflect additional personnel required to look after more functionality in the solution. The higher costs of support are offset by reduced cost of OMS Support and Upgrade. These OMS costs only apply until October 2022 for the ADMS as the OMS is replaced at this point.

[9] There are alternative ways that the expected additional reliability/productivity improvements could have been captured, including within the benefits assessment. However, as the self-funding is reducing the level of funding customers are expected to contribute the remaining benefits are all well-defined it was decided to retain this as a negative cost. The choice of where this self-funded element was presented should not have any material impact on the business case.

6.5 Opex Cost of System Operation

The table below shows the Opex costs (in NPV) for the solutions

Cost Element	Current DNMS ($M)	Contemp DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
[redacted]						
Total	**$44.8**	**$50.1**	**$31.9**	**$33.4**	**$22.8**	**$22.9**

Table 10 Opex Cost of System Operation

The main cost differential relates to the support costs for the DNMS. These are based on historic figures and reflect the high costs of retaining a solution with a single user rather than an extended customer base.

6.6 Summary

A summary of the costs of all options (in NPV) is shown in the table below:

Cost Element	Current DNMS ($M)	Contemp DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
[redacted]						
Total	**$77.9**	**$102.9**	**$83.9**	**$89.7**	**$96.1**	**$105.8**

Table 11 Summary of Costs

The Net Present Cost of the ADMS providing the Outage Management Cluster over the 15-year assessment period is $27.9m higher than the Base Case of the Current DNMS. The higher cost of the ADMS should be reviewed in light of the additional benefits it delivers. These are described in Section 7.

7 Benefits for the ADMS Option

7.1 Benefits Identified from the ADMS

An assessment has been made of the incremental benefits of moving from a DNMS to a system on a modern platform. The process started by identifying many benefits and grouping them into categories covering:

- Safety;
- Efficiency;
- Customer Benefits;
- Reliability;
- Regulatory Reporting/Audit; and
- Avoided Capital Investment.

An initial high-level review was undertaken to assess the benefit by size. A list of the expected number in each category is shown in the table below.

Benefit Category	Large (Greater than $250k pa)	Medium ($100-$250k pa)	Small (<$100k pa)
Safety	1	2	2
Efficiency	5	3	5
Customer Benefits	1	2	3
Retailer Benefits	2		
Reliability	3	1	1
Regulatory Reporting/Audit			2
Network Augmentation	2	1	

Table 12 Count of Benefits by category for ADMS

The following sections provide further details on the 'large' efficiency, reliability and network augmentation benefits, with Appendix B providing a full list of all the benefits. At this stage the safety benefits have not been quantified as this can involving subjective judgements on probability and the value of life or injury. The retailer benefits relate to reduced losses and require further research on the input data to robustly quantify the benefits. However, given evidence from Smart Grid Smart City Project and internal assessment, they are both expected to be material.

No value has been ascribed to the foundation platform that ADMS provides to deliver additional solutions that are likely to evolve over the assessment period for the project. Given the level of disruption in the industry, these are also expected to be material.

7.2 Overview of Quantified Benefits

The table below provides an overview of the key quantified benefits. Some of the benefits will have both reliability and efficiency benefits and have been described under the area of the largest benefit, but the benefit components have been separately allocated in later sections.

Benefit	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
Time Saving in Writing/Checking Switching Instructions		$10.0	$10.0	$10.0
Grouping NARs and Reducing Job Cancellations		$2.4	$2.4	$3.3
Time Saving from use of a Single Data Model	$6.1	$6.1	$8.4	$8.4
Reduced Augmentation Capex Costs			$2.5	$4.7
Reduced Customer Cost of Connections			$3.6	$6.9
Faster Resolution of Complex Unplanned Outages		$3.0	$10.9	$10.9
Faster Resolution in a Storm of Complex Unplanned Outages		$1.5	$4.8	$4.8
Reduction in Number of Switching Errors		$1.8	$1.8	$1.8
Total	**$6.1**	**$24.8**	**$44.3**	**$50.6**

Table 13 Value of Benefits for ADMS

Benefits vary depending on the option selected. In the diagrams below the columns are used to indicate the maximum benefit with Full ADMS with the cumulative benefits shown depending on the DMS option selected.

7.3 Efficiency Benefits

7.3.1 Overview of Efficiency Benefits

The main efficiency benefits predicted for the ADMS are shown in the chart below with a cumulative value of more than $22m for the Full ADMS over the project assessment period. The project assessment finishes in December 2034, which is why the benefits are lower in the 2034 financial year. Further detail on each benefit is provided below.

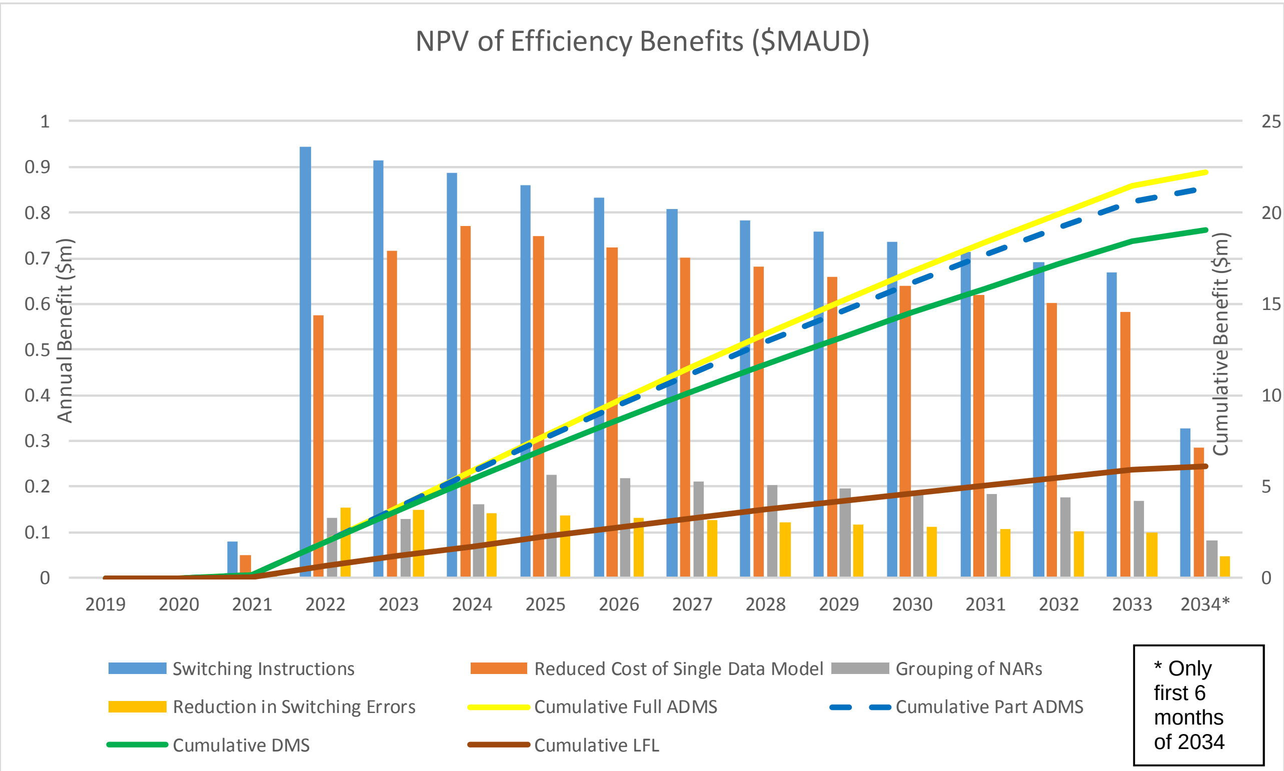

Figure 5 NPV of Efficiency Benefits

7.3.2 Efficiency in Switching Instructions

The assessment of this benefit is based on the adoption of detailed switching instructions in the Sydney Control Room. This change is required for safety and efficiency purposes and would be undertaken independent of the replacement of the DNMS.

This benefit is the time saving in writing and checking detailed switching instructions compared to the business as usual option of continuing with SRR. The SRR solution can assist with scheduling switching jobs and provide templates/archived examples. However, it doesn't incorporate (or integrate with) a network model and hence it cannot provide the point-and-click functionality available with an ADMS, nor the same point-and-click ability to rapidly check proposed switching instructions against validation rules. The ADMS can also automatically suggest optimum switching, which can be used as a basis for drafting the switching instructions.

The benefit has been worked up from the number of people expected to be involved in writing/checking of switching instructions once the Sydney Control room has moved to detailed switching instructions with an assumption of a 25% saving from the functionality provided by the ADMS. This results in an annual benefit of over $1m.

7.3.3 Retirement of Satellite Systems

These savings primarily cover the legacy SRR and OMS systems. These systems will have vendor support and upgrade costs as well as internal support resources. The remaining systems identified as part of the Outage Management Cluster are internally maintained with only a very small amount of resources required to support them.

Whilst these savings are significant, they are reflected in the lifecycle costs of running the Outage Management Cluster and have therefore not been recorded separately as a benefit.

7.3.4 Reduced Costs of Single Data Model

Currently Ausgrid operates three independent vendor systems, which all use a version of Ausgrid's network connectivity model. The OMS model is mastered from the GIS, but the DNMS model is mastered independently within the DNMS itself and is the most operationally critical. The DNMS model requires a team of people to maintain using the embedded DNMS configuration tools. Sources of other network data are dispersed in multiple systems.

Under all modern systems the GIS data will become the master for all network models used in the new operational system. This delivers efficiency benefits in not having to maintain duplicate systems, and it allows ADMS/OMS to operate using the same network model. This will lead to additional efficiencies and safety benefits that have not yet been quantified.

The quantified benefit claimed is the efficiency benefit of needing fewer Drawing Editors and load rating personnel. There is an expectation that the resourcing for this activity can be reduced by 50% for the Part/Full ADMS and 35% for the Like-for-Like/DMS solution, which still has to update the data in the OMS. The Full/Part ADMS is expected to result in an annual benefit of over $900k.

7.3.5 Improved Grouping of Network Access Requests and Reduced Cancelllations

The ADMS can be set up to include assessment of the potential for grouping of NARs (as well as for detecting potential clashes). Ausgrid already has processes in place to group NARs, so these are the incremental improvements by having an automated system to provide this service as switching instructions are produced. There are two main benefits from each NAR that is avoided:

1) **Efficiency saving from a single outage** – There is a reduced cost when only running one NAR with the avoided admin cost of the NAR and fewer truck rolls, reduced field crew times, etc.

2) **Reduced unserved energy** – Customers will only have a single outage rather than two (or more) within a short period, and therefore have less unserved energy. Data from the OMS in 2017 indicated that only around 25% of NARs resulted in customer outages, but on average this impacts around 40 customers for 6.3 hours.

Alongside the grouping of NARS there is the capability to reduce the number of cancelled jobs. Ausgrid investigations in 2016 found that of every 100 Jobs that have applied for access only 80 ultimately result in switching being undertaken, with 20 being cancelled. Networks constraints are responsible for around 2.5 of these cancellations and the ADMS is expected to reduce these cancellations by 20% once Phase 3 is implemented.

The combined impact of these two elements results in an annual benefit of around $400k per annum.

7.3.6 Reduction in the Number of Switching Errors

The automated writing and checking of switching instructions with the ADMS should lead to a reduction in the number of switching errors. The benefit is derived from three elements:

- Reduced cost of investigating incidents;
- Reduced damage caused by incidents; and
- Reduced time off supply for customers impacted by incidents.

Collectively these benefits are worth around $200k per annum.

7.4 Reliability Benefits

7.4.1 Overview of Reliability Benefits

An overview of the reliability benefits for the ADMS is shown in the chart below with a cumulative benefit of around $17m.

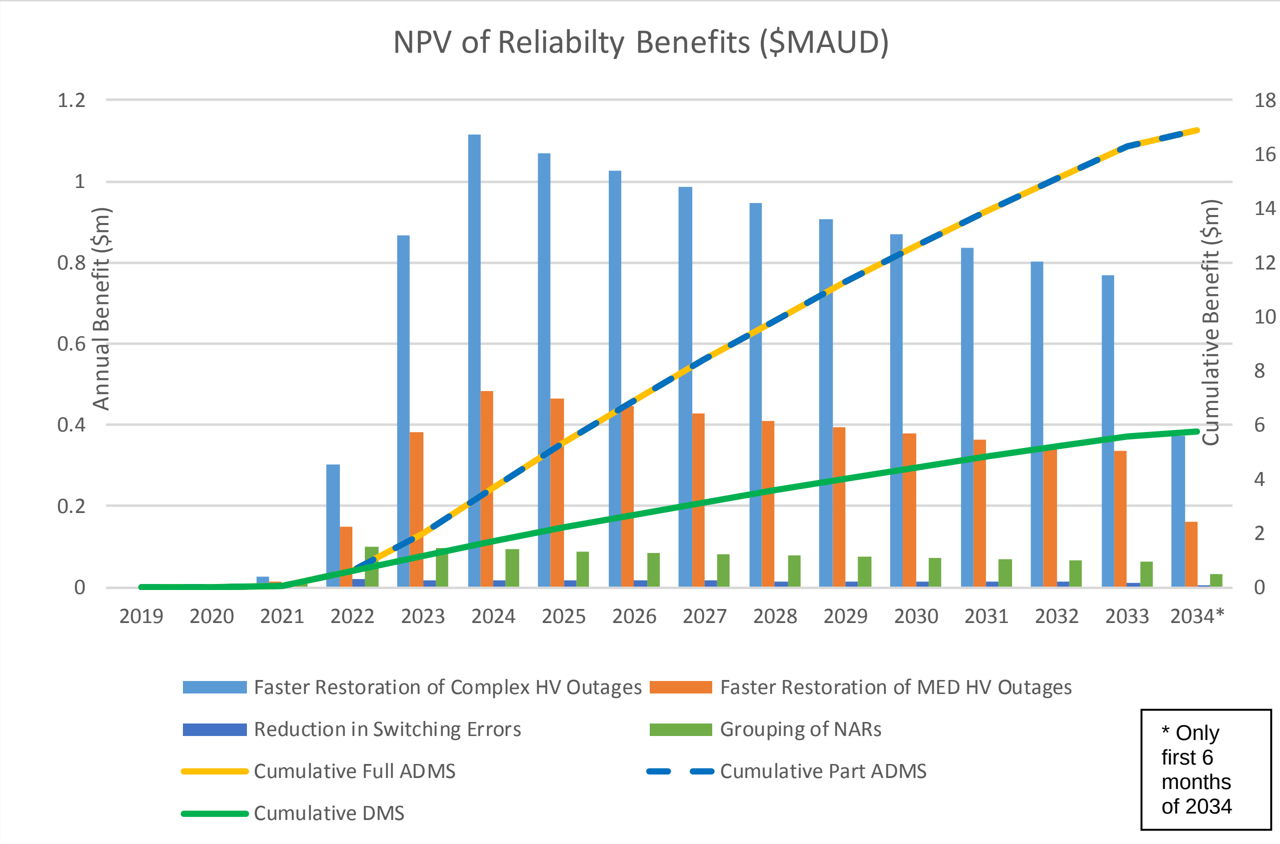

Figure 6 NPV of Reliability Benefits

7.4.2 Faster Restoration of Complex Unplanned HV Outages

This benefit consists of two features of the ADMS that allowed faster restoration of HV customers during a complex[10] outage namely:

- **Faster development of switching plans** – The switching management and network analysis applications would assist in the development of switching plans for complex outages. Whilst for many outages the switching plan can be produced when the crew are travelling to the outage, this may not be possible for the more complex outages where multiple switching options may exist. The switching functionality in the ADMS will automatically produce these options for the Operator's review and will therefore reduce the time taken to develop the optimal switching plan.

- **Electronic (non-verbal) communication of unplanned switching instructions to field crews** – This will include time currently taken to make phone calls to operators to run through the switching process and confirm what actions have been taken by field based operating staff.

[10] Complex events were defined as 'Events on HV feeders or feeder sections where there were more than 3 restoration steps associated with the full restoration of customer supply'

In reviewing Ausgrid's outage data it was estimated that around 15% of high voltage feeder outages would be complex and a saving of 5 minutes could be achieved from both electronic communication and faster development of switching plans. This resulted in an annual benefit of over $1m per annum.

7.4.3 Faster Restoration following a Storm Event

This benefit applies only on Major Event Days (MED) that were due to storms (i.e. excludes sub-transmission faults causing Major Event Days). It is similar to the complex unplanned outages, but the non-verbal communications benefit is assumed to apply to a greater number of customers (50%). This is because the Operators are likely to be overloaded during storm events and the field crews may have delays in verbal communications.

The benefit of switching management is assumed to apply to 25% of the outages during a storm based on a review of Ausgrid's complex outages during MED. Each of these outages is assumed to be restored 10 minutes quicker with the ADMS proposing switching plans to Operators. This is additional to the saving from non-verbal communication.

In total these benefits deliver an annual saving of around $600k.

7.5 Benefits in Avoiding Network Augmentation Costs

7.5.1 Overview of Avoiding Network Augmentation Benefits

An overview of the benefits for avoiding augmentation is shown in the chart below with a cumulative value of $11.6m.

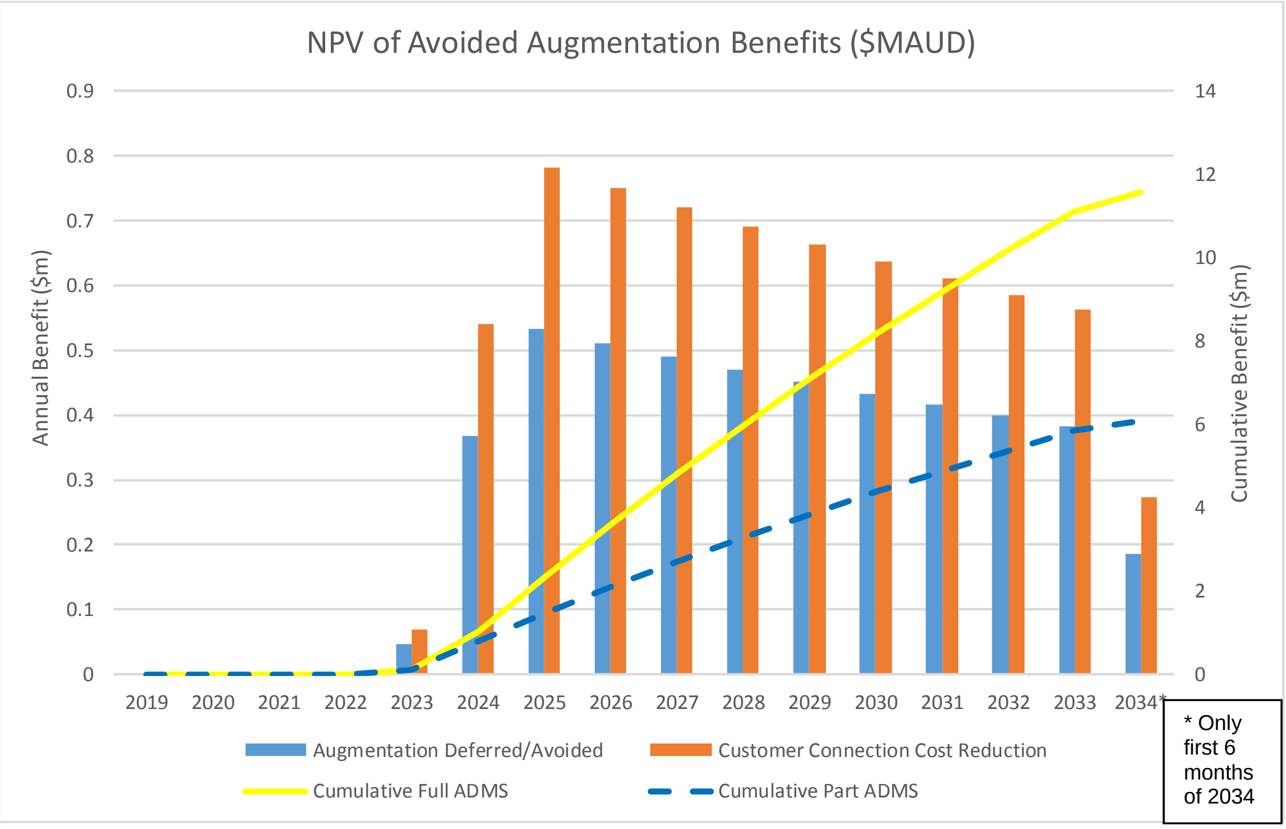

Figure 7 NPV of Avoided Augmentation Benefits

7.5.2 Reduced Augmentation Capex

Several of the applications in ADMS provide Operators with more visibility and control of the network and the ability to run the network harder. Key modules are:

- Power Flow Analysis;
- Dynamic Ratings;
- Load Forecasting;

- Network Security Analysis; and
- Volt-Var Control.

Over the next regulatory period Ausgrid expects to spend around $48m per year on distribution augmentation projects[11]. The suite of advanced network analysis (DMS) applications would provide two benefits:

- **Avoidance of augmentation expenditure** – A small number of projects may be deferred if the advanced DMS applications provide sufficient confidence that the augmentation is no longer required in the time frame defined. This is expected to be relatively small and is set at 1% of planned expenditure.
- **Deferral of augmentation expenditure** – In areas of demand growth it may be possible to delay the expenditure on augmentation by a year. This would also enable the decision on whether augmentation has been required to be reassessed at a later point and could therefore also remove the need for augmentation if demand growth has not continued as forecast. This benefit has been set at 10% of augmentation expenditure that could be deferred by just 1 year.

These benefits are assumed to be delivered in stages with 50% of the benefits achieved 6 months after the delivery of the Part ADMS, which includes load flow modelling. The full benefit is not expected to be achieved until the advanced functionality is delivered as part of the Full ADMS. This results in an annual benefit of just under $0.7m per annum.

7.5.3 Reduced Customer Connection Costs

Ausgrid expects connecting customers to fund more than $500m of connection costs directly attributable to them over the next regulatory period. Part of these costs will relate to network augmentation as capacity is not expected to be sufficient for the customer load or generation capacity. There are two ways in which ADMS may assist in reducing these costs:

- The suite of network applications will provide more visibility and control of the network allowing Ausgrid to run the existing assets harder and to determine that more load/generation can be included without customer funded network augmentation cost.
- The ability to control and curtail (rather than switch off) small scale generation may lead to avoided customer augmentation cost as the generators and Ausgrid can agree to non-firm connection with control available to Ausgrid when required.

This benefit has been set conservatively at 1% of annual expenditure being avoided with the same phasing as assumed for Ausgrid's Augmentation capex avoidance. This will deliver an annual benefit of $1m once fully operational.

7.6 Summary Table of Large Benefits

A summary table of the large benefits for the ADMS is provided below according to category.

Benefit Group	Value ($m)	
Efficiency	$	22.2
Reliability	$	16.7
Network Augmentation	$	11.6
Total	$	50.6

Table 14 Summary Table of Large Benefits

[11] Ausgrid's Regulatory Proposal – Attachment 5.01 indicates expected growth capex for the next regulatory period of $241m.

7.7 Allocation of Large Benefits between Stakeholders

The allocation of benefits between stakeholders is shown in the chart below. The most significant benefits are in efficiency for Ausgrid. However, there are also significant benefits for customers in improved reliability and connection cost savings.

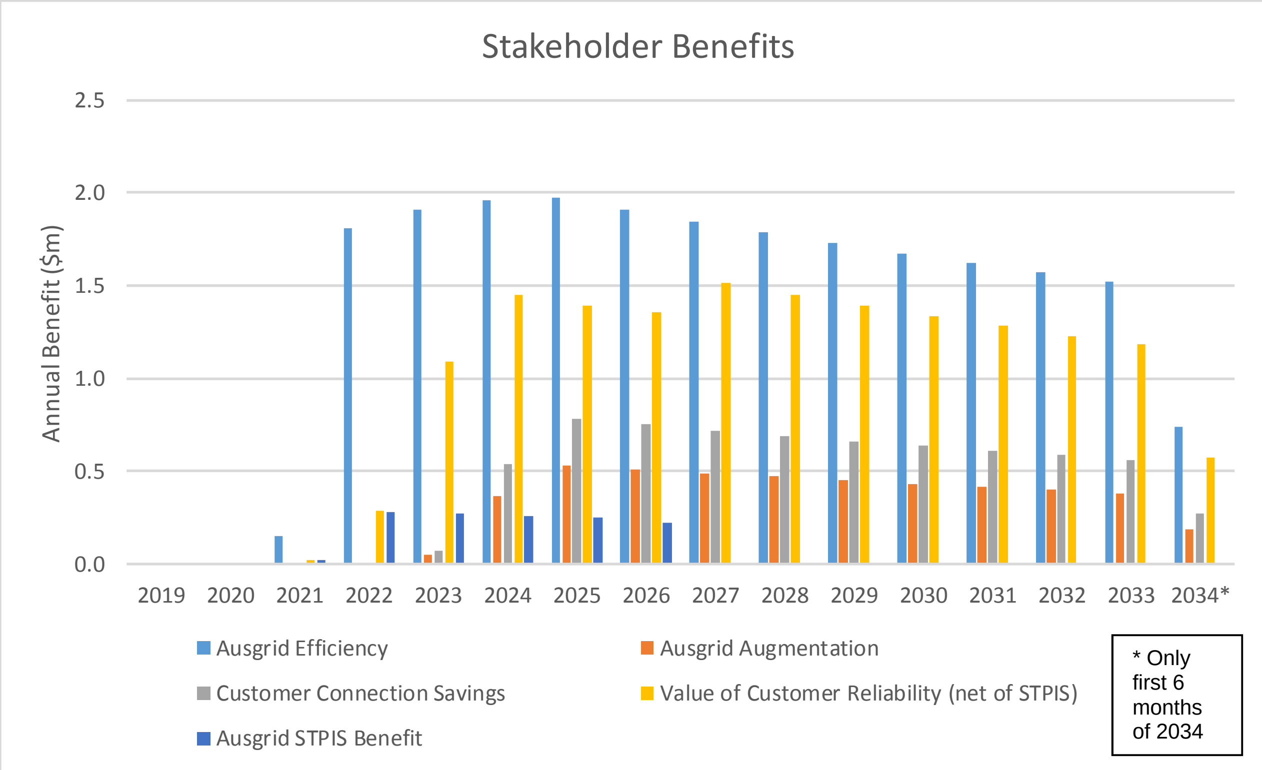

Figure 8 Stakeholder Benefits by Group

7.8 Qualitative Benefits of the Full ADMS

The majority of the quantified benefits are those that can be achieved with the functionality available with the DMS or part ADMS. The Full ADMS expands some of these benefits, but more importantly it provides a platform to manage increased levels of DER and the variable effects of unpredictable DER injections and to achieve improved network optimisation and reliability as more modern field or customer equipment is deployed.

The need for some of the incremental equipment and the uncertainty of the timing of these benefits means they have not been quantified within the business case modelling. However, this does not indicate that they are low materiality. Key benefits that were identified and not quantified were:

- **Fault Location Isolation and Supply Restoration (FLISR).** - FLISR technology provides a centralised function that uses multiple telemetered and controllable devices, and other network state information, to determine the location of network faults, and to recommend (or issue) controls of switching devices to isolate faulted network and to restore as many customers as possible as quickly as possible. When used in an automatic mode FLISR will reduce the number of customers off supply by automatically isolating the area of the fault and restoring other customers to adjacent circuits. When used in an advisory mode FLISR will reduce the duration of interruption for a number of customers through the provision of recommended isolation and restoration switching steps. In both modes the technology will also assist in enabling crews to more rapidly identify the location of the fault. These 2 features should have a material impact on reliability. However, in addition to the ADMS, the functionality will require significant numbers of strategically placed field equipment like automated feeder switches and reclosers and telemetered line fault indicators to realise its full benefit.
- **Reduction in losses through running more of the sub-transmission network in parallel** –Several of the Full ADMS tools (Contingency Analysis and State Estimator) provide Ausgrid with a more accurate view of the network and the ability to gain a fuller understanding of potential events based on the current conditions on the network (rather than a worst-case scenario). This enhanced information should provide more certainty on when there is a need to radialise the network and when it can continue running in parallel, resulting in lower losses.

There is some uncertainty on how often the modelling will result in avoided radialisation and therefore the benefit has not been quantified at this stage.

- **Reduction in losses through improvement in distribution network Power Factor with controllable network/customer equipment** – Losses on the network could be reduced by improving the power factor. This requires not only the ADMS, but also field/customer equipment that can be controlled. With increased communications it is expected that over time there will be more controllable network equipment or customer equipment with appropriate commercial agreements that the ADMS can control in areas of poor power factor and therefore reduce losses on the network. All loss reduction benefits will assist retailers, but it is hoped that the benefit would ultimately flow through to customers.
- **Reduced damage and improved operation of customer equipment through voltage control** – One of the issues with increased levels of solar generation is that voltage excursions on the network result in most current inverters tripping off once a pre-set voltage level is reached. This reduces the customers' generation, but likewise consistently running the device at high voltage before it trips could damage the equipment. Over time it is expected that more on-line tap changers and remotely controllable customer equipment will be available to the ADMS to assist in voltage management. However, it is unclear when this equipment will be available and/or the magnitude of the impact on customers equipment.
- **Improved safety from increased skills of operators from the training simulator –** With the training simulator it will be possible to expose all operators to the actual historical emergencies that have been experienced anywhere on the network. This compares to the current situation, where an individual operators' emergency experience is limited to that occurring on his/her shifts. All operators are therefore more likely to have been trained on all credible emergency events and be able to take the appropriate action to minimise risk to the public and Ausgrid personnel
- **Future Inclusion of DERMS Solution –** The Full ADMS will provide a platform for the introduction of the DERMS module currently being developed by the selected Vendor. This has not been included due to lack of clarity on cost and budget, but is expected to provide 3 main benefits namely:
    - **Short Term Forecasting –** More sophisticated and accurate short term forecasting of intermittent generation (using cloud cover projections, wind forecasts etc) and other input parameters to assist in network operations in response to varying conditions
    - **Visibility of Network Impacts** - Monitoring large DER in real time and modelling it with power flow solutions to assess the impact of likely injections on voltage levels and power flows on the network to determine actions in conjunction with control to optimise the utilisation of renewable energy resources
    - **Control of DER** – Either large individual DER or smaller equipment via an aggregator could be controlled by the ADMS and assist in managing the network and to facilitate energy trading at a distribution network level.

With the continued emergence of disruptive technology this list only represents a subset of the benefits that may exist with the enhanced visibility and control from a Full ADMS. However, it does demonstrate these benefits are likely to be material and that a Full ADMS will be a key tool for optimising the operation of the network in the future.

8 Quantitative Assessment

8.1 Approach

This assessment reviews all options to consider which maximise the present value of net economic benefit to all those who produce, consume and transport electricity in the NEM.

It is based on a comparison against the Base Case of continuing with the current DNMS.. Whilst there are many operational issues with the DNMS, and additional qualitative benefits for the Full ADMS, these have been ignored for the purpose of this quantitative assessment.

8.2 Comparison of Lifecycle Costs and Benefits

The table below provides a summary of the costs and benefits for all options.

Cost/Benefits	Current DNMS ($M)	Cont DNMS ($M)	LFL ($M)	DMS ($M)	Part ADMS ($M)	Full ADMS ($M)
Costs	$77.9	$102.9	$83.9	$89.7	$96.1	$105.8
Benefits	$-	$-	$6.1	$24.8	$44.3	$50.6
Net Present Cost	$77.9	$102.9	$77.8	$64.9	$51.8	$55.1
NPV against Base Option	**$-**	**-$24.9**	**$0.1**	**$13.0**	**$26.1**	**$22.8**

Table 15 Summary Costs and Benefits of DNMS Options

8.3 Cashflow for Lifecycle Costs and Benefits

The charts below show how the costs and benefits build up for each option compared with continuation of the BAU solution. Whilst the ADMS options have the largest initial costs they provide many on-going benefits, which results in a positive NPV compared to the Base Case. This results in the Part ADMS having a lower societal cost by FY 2029.

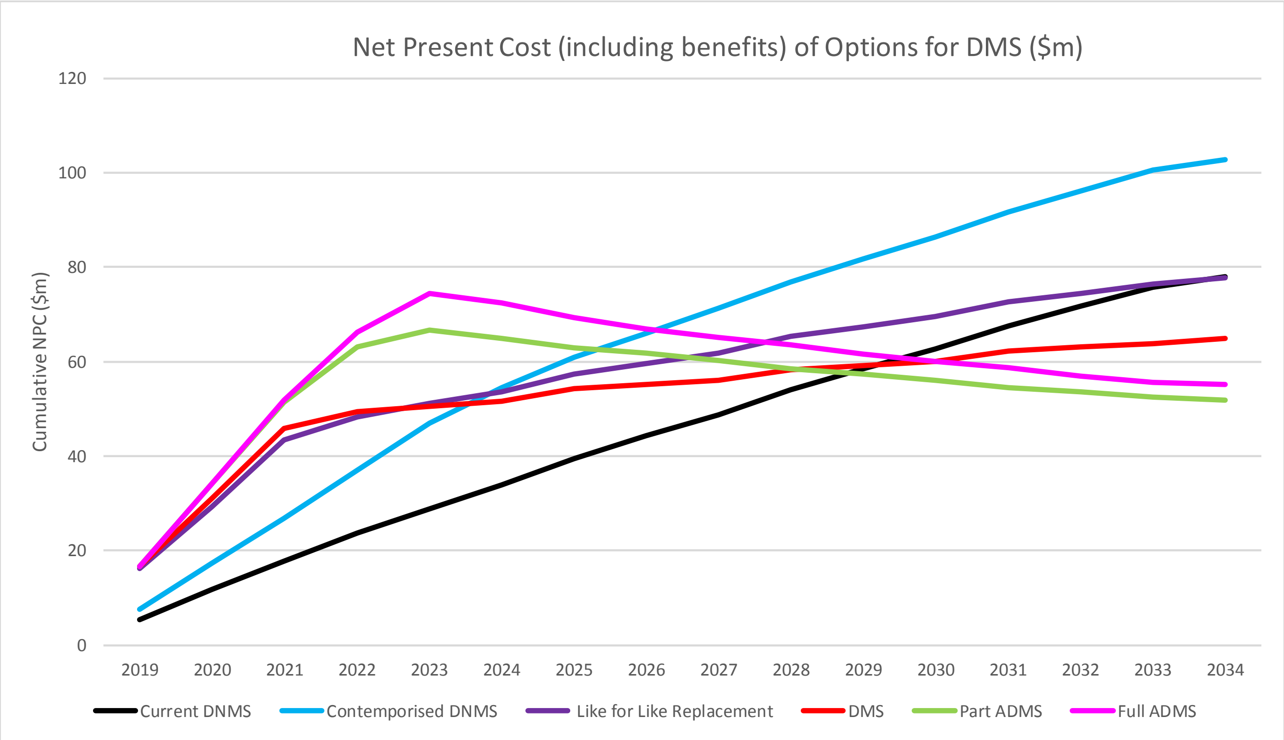

Figure 9 Net Present Cost for DNMS Options

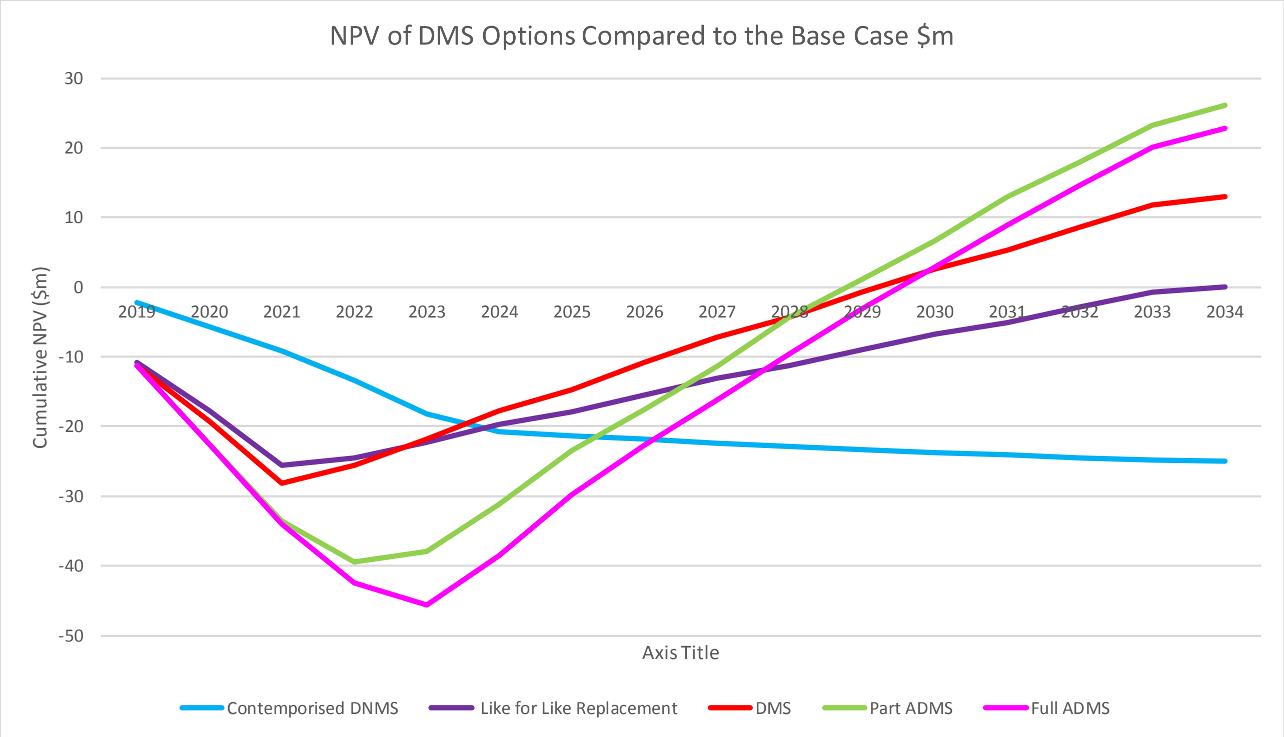

Figure 10 NPV of DMS Options Compared to the Base Case

8.4 Comparision between Base Case and Full ADMS

The assessment has focussed on the incremental difference between the Base Case and the Full ADMS option. This has a difference of $22.8m considering the most likely value of all the key parameters. The modelling included sensitivity analysis, which demonstrated that no individual parameters would stop the NPV for the Option being positive. The largest impact on the differential was changing the project assessment range. If this was reduced to 13 years, which is less than 8 years after ADMS Phase 3 goes live, then the benefit would reduce to $11.8m.

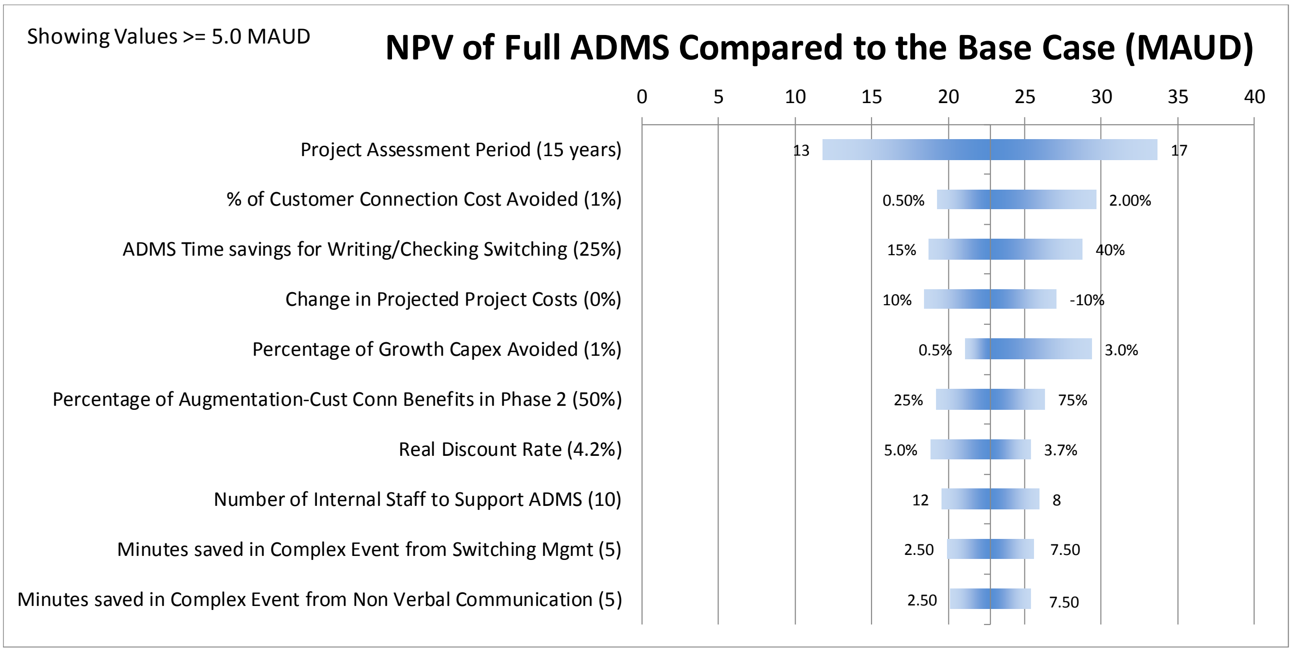

Figure 11 Sensitivity Analysis of Full ADMS over Base Case Solution

8.5 Monte-Carlo Simulation without Reliability

The modelling included a Monte-Carlo simulation to examine the difference between the options. This has been reviewed both with and without reliability benefits. With reliability benefits included, almost all simulations showed a positive NPV for both ADMS options and the DMS. The simulation shown below was the Full ADMS compared to the Base Case. This had close to 100% of trials with a positive NPV and 98% with an NPV greater than $10m.

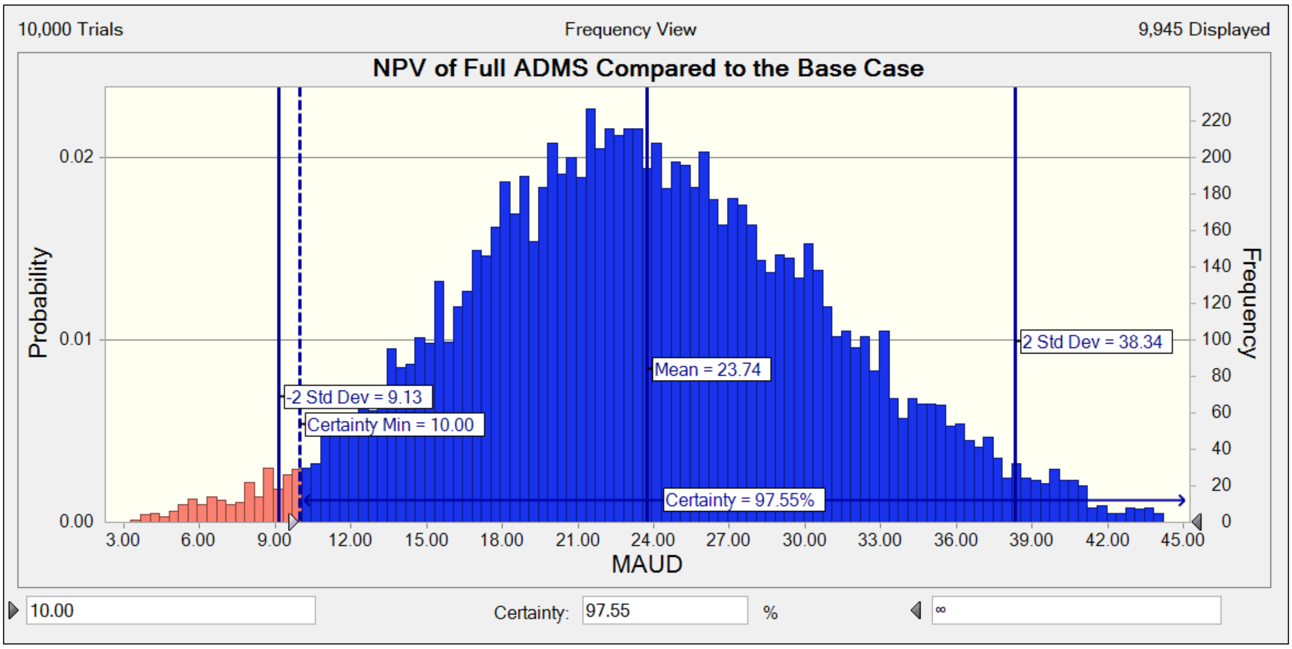

Figure 12 Monte-Carlo Simulation for Full ADMS including Reliability Benefits

If reliability benefits were excluded the Full ADMS still has a positive NPV for around 88% of the trials, whilst the Part ADMS has a positive NPV for around 97% of trials. This is shown in the charts below.

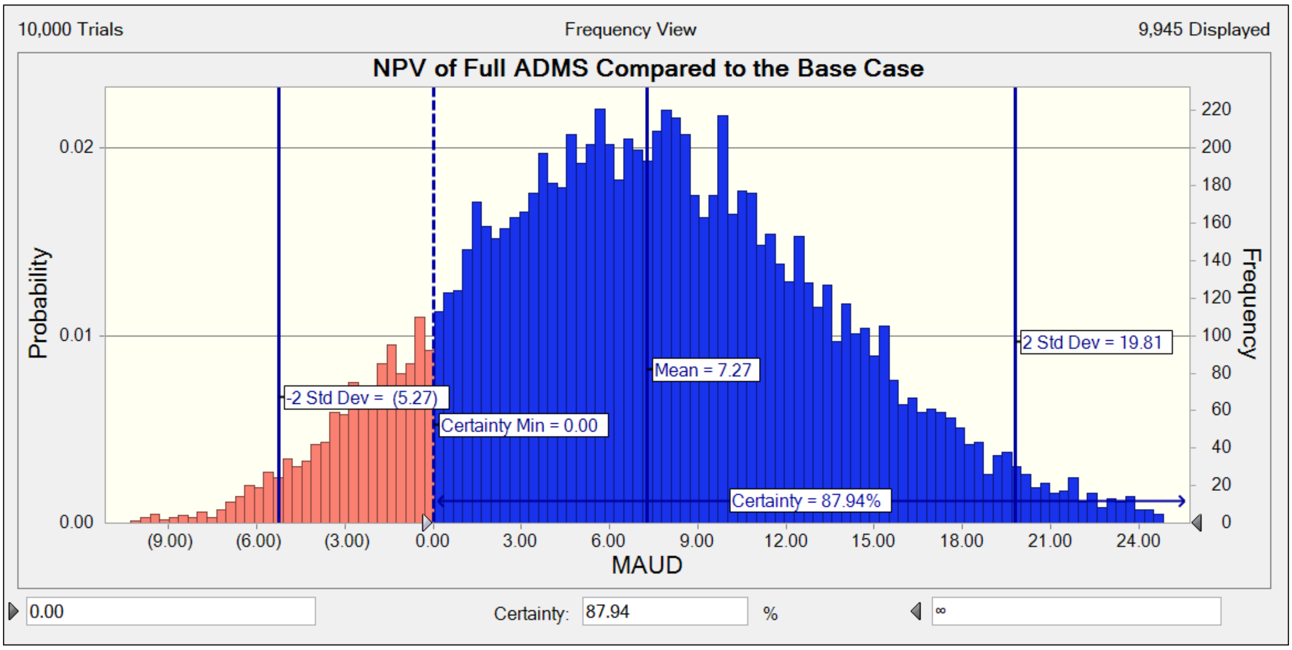

Figure 13 Monte-Carlo Simulation for Full ADMS with Reliability Benefits Removed

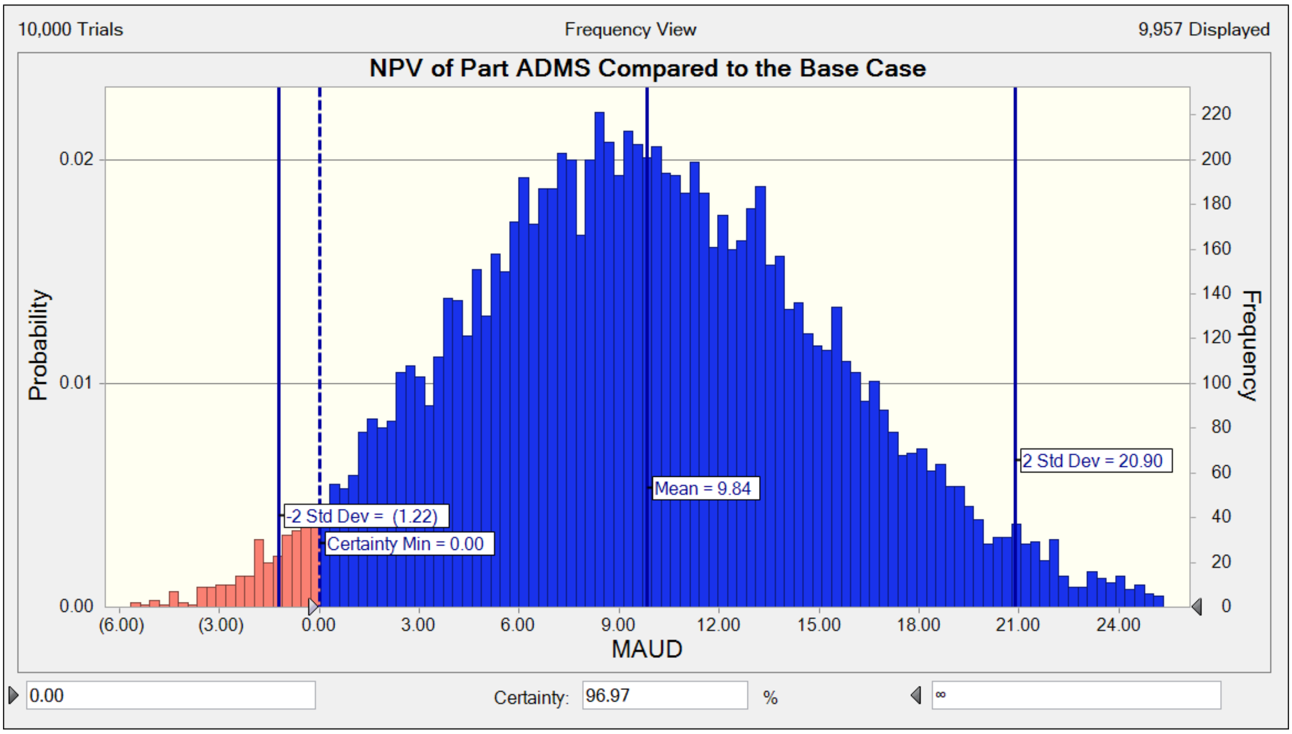

Figure 14 Monte-Carlo Simulation for Part ADMS with Reliability Benefits Removed

8.6 Recommended Approach

The analysis showed that all DMS/ADMS solutions have a strongly positive NPV compared to the base solution over the assessed operational life. This more favourable outcome remains valid even if reliability improvements were excluded. The differential between the credible options and the current DNMS solution would be enhanced if more of the identified benefits had been quantified, of if value was ascribed to the foundational platform the ADMS provides to cope with customers' future network demands for disruptive technologies.

All the DMS/ADMS solutions meet the Capital Expenditure Objectives and have a positive NPV compared to the Base Case. The two options with the highest NPV were:

- The Part ADMS with an NPV of $26.1m over the assessed project life; and
- The Full ADMS with an NPV of $222.8m over the assessed project life. This solution does have a large number of qualitative benefits with functionality that will be essential for operating the network and delivering customer benefits over the next 15 years.

Whilst the Part ADMS has the highest NPV it does lack the functionality available in the Full ADMS. It is recommended that the Full ADMS is the option selected as this enables Ausgrid to provide the greatest customer benefit by managing the network of the future with increased distributed energy resources and the ability to continued providing the network services customers expect.

Appendix A – Vendor Engagement Process

Ausgrid has been planning for some time to replace components of its current OT infrastructure. This has included a significant pre-implementation phase, which began in June 2017.

The pre-implementation phase of the project is aimed at:

- Conducting a robust requirements driven procurement process to recommend a suitable ADMS vendor (i.e. the Preferred Vendor – or 'PV');
- Completing the documentation of the current 'as-is' business processes;
- Undertaking core preparatory tasks to enable Ausgrid to be able to accept an ADMS (e.g. data alignment activities); and
- Refining and reducing assumptions and 'unknowns' with vendors regarding the implementation costs and risks of an ADMS.

In June and July 2017, Ausgrid undertook a substantive scoping exercise of the requirements for a replacement system, which culminated in a Pre-Qualification Questionnaire (PQQ). This engagement with the market was a closed tender process commencing with six vendors (all whom have had a local Australian presence).

All six vendors were assessed/evaluated at this stage and Ausgrid down-selected to three potential vendors to progress to a Proof of Concept (PoC) and Initial Solution Plan and Offer (ISPO) stages over November to December 2017.

In January 2018, Ausgrid assessed/evaluated both PoC & ISPO material provided by vendors to-date and down-selected the potential vendors list to two vendors.

Ausgrid then conducted a week-long Joint Solution Design (JSD) workshop with these two that focused on multiple layers and supported two work-streams of Business Integration Services and Technical Integration Services.

The JSD achieved:

- Confirmation of capability to meet required functionality – the JSDs generated broad confidence that both solutions can largely fulfil Ausgrid's functional requirements;
- Reduction of 'submission' risk – the risks to which both Ausgrid and the vendors would have been exposed on the basis of written tender submissions alone was significantly reduced during the JSD stage (this assertion is supported by both vendors); and
- Exposure to each vendors' 'way-of-doing business' – the program and broader Ausgrid teams were also exposed to the culture and way-of-doing-business of each vendor, which can only effectively be understood in a face-to-face environment.

Following the JSD, both vendors submitted a Final Solution Plan and Offer (FSPO), which is a refined ISPO by the vendors based on the JSD sessions. This allowed vendors to remove assumptions and any identified risks. Both vendors committed to almost full compliance with Ausgrid's requirements with no material non-compliances identified.

This market engagement process to refine the vendors' proposals in a collaborative manner has resulted in a refined and de-risked proposal from the vendors removing core assumptions for both parties and enabling the forecast project costs to be further refined

Following receipt of the FSPO's, Ausgrid reviewed each submission and conducted a further risk-based assessment. This resulted in Ausgrid selecting a Preferred Vendor (PV) and a Held Vendor (HV). Detailed negotiations were undertaken with the Preferred Vendor including:

  - A negotiation process to address all T&C issues, and any points of clarification etc.
  - An Initial Solution Design activity (ISD).

If issues had arisen with the PV which Ausgrid considered material and insurmountable, Ausgrid had retained the option to reverse its PV/HV decision, re-engage with the HV, and commence an ISD activity with the HV. However, the PV Initial Solution Design and negotiations aligned with Ausgrid's requirements and this step was not necessary.

The ISD activity was focused on developing the program documents, which supported the Ausgrid ADMS business case. This includes the Statement of Works and the required underpinning documentation, which will subsequently be contractually formalised as schedules.

Data Onshoring Requirements

Given Ausgrid's Critical Infrastructure Licence Conditions and placement on the register of Australia's critical infrastructure assets, it is required to ensure its data security obligations are being met in alignment with discussions with the Department of Home Affairs and the CIC (Critical Infrastructure Centre). This is an enduring obligation that must be complied with both during the implementation of the ADMS system, as well as during its ongoing support and maintenance.

In order to comply with the data security constraints, Ausgrid are taking action to retain Ausgrid Restricted Data on its own premises whereby no remote access is permitted and no artefacts relating to Ausgrid's network, or its ADMS system, are permitted to be removed from Ausgrid's premises.

This action will require Ausgrid to develop a parallel ADMS environment sufficiently representative of its Production ADMS environment so as to adequately mimic Production system behaviours (in particular, faults and problem issues) so they can be securely passed over to the system vendor at an offshore location without comprising any cyber security obligations.

Appendix B – Benefits from ADMS

Safety Benefits

A combination of switching management, Automatic NAR checking (for NECF breaches) and non-verbal communication delivered the largest safety benefits. These are summarised in the table below

Benefit	Size
Reducing the number of switching incidents through switching management applications and non-verbal communications	Large
Increased skill of operators from the training simulator results in a reduction in safety incidents	Medium
Reducing NECF breaches from automatic NAR checking including more accurate customer checking against network model	Medium
Improved Alarm Management with better highlighting of safety implications	Small
Reduced switching actions for potential events that may have been unnecessary (Contingency Analysis)	Small

Table 16 Safety Benefits from ADMS

Efficiency Benefits

There were many efficiency benefits that could be identified by the introduction of an ADMS with 5 identified as large. Further investigation is required to quantify some of the small-medium benefits and as a group this set of benefits could also be material.

Benefit	Size
Time saving in writing and checking switching instructions for the HV network	Large
Reducing the number of control room incidents through switching management applications and non-verbal communications	Large
Retirement and savings in support costs of several satellite systems	Large
Reduction in scheduled Jobs by grouping NARs and reducing cancellations due to network constraints.	Large
Maintaining a single data model rather than separate data models	Large
Efficiencies from improved NAR Process (Review and improvements scheduled for ADMS Phase 2)	Medium
Avoiding duplicate data entry into OMS and SAP	Medium
Time saving in receiving switching instructions in real time electronically (i.e. not waiting for phone conversation)	Medium
Less switching steps from network security analysis	Small
More timely ‘untagging’ of defectives and return to service due to SAP to ADMS link	Small
Reduced Customer Calls through more accurate and timely management of Estimated Restoration Times (ERT) for Outages	Small

Reduced Customer complaints through more accurate and timely management of ERT for Outages	Small
Avoided actions with run-time Contingency Analysis	Small

Table 17 Efficiency Benefits

Customer Benefits

This set of benefits are direct customer benefits from ADMS.

Benefit	Size
Ability to provide lower cost of connection (less curtailment) to generators results in less projects abandoned due to high cost of connection	Large for Society (Jobs, income etc)
Lower restrictions on embedded Generation - Capability to control distributed generation and curtail the generators rather than turn off where the network has peak demand issues. This is based on small scale generation connected to the distribution network, rather than large generators that may connect to the sub-transmission network.	Medium – (Could turn into Large)
Avoided repeat outages by improved grouping of NARs	Medium
Reduction in NECF breaches and improved outage Information	Small
Improved information on outages from consolidated OMS/ADMS	Small
Avoided damage to Customer equipment from voltage issues	Small
Ability to connect increased quantities of DER and utilise demand management (ADMS is enabling technology providing visibility and some control. It may require additional equipment to deliver the benefits and therefore it has not been quantified)	Enabling Technology – Not Quantified

Table 18 Customer Benefits

Retailer Benefits

Two large retailer benefits were identified but not quantified in the options assessment

Benefit	Size
Reduction in Losses through running more of the sub transmission network in parallel	Large
Reduction in Losses through improvement in Power Factor with controllable Capacitor Banks	Large

Table 19 Retailer Benefits

Reliability Benefits

There are a set of reliability benefits for customers. However, not all of these will have a positive SAIDI/STPIS impacts for Ausgrid.

Benefit	Size
Avoiding major outages through the use of the contingency analysis module in ADMS	Large
Impact of Integrated OMS providing more accurate Start Time for Outages (Note – This is a reporting benefit as Operators will start resolving HV outages as soon as the SCADA information is received. At times the information that is entered in OMS may be rounded. This may mean the actual SAIDI calculations are slightly higher than actuals)	Medium (Impacts Statistics only)
Faster writing and checking of unplanned switching instructions for complex outages combined with non-verbal communication	Large
Faster development of unplanned switching and non-verbal communication during major event days	Large
Reduced outage time from automatic restoration for some customers using FLISR (Capability Demonstration rather than full benefit)	Initially Small – With more devices will be large

Table 20 Reliability Benefits

Regulatory Reporting/Audit Benefits

There are benefits in improved accuracy of information, but these are difficult to quantify. These benefits have therefore been allocated to the ‘small’ category.

Benefit	Size
More accurate reporting with data direct from ADMS/OMS	Small
Timing of all switching instructions will be recorded on ADMS creating a clear audit record should there be a need for any investigations	Small

Table 21 Regulatory Reporting/Audit Benefits

Network Augmentation Benefits

There is a material benefit with Ausgrid having more confidence on the operating conditions of the network and a level of control that allows it to run the network closer to its operational limits. This could defer, or in a best case avoid, network augmentation

Benefit	Size
Avoided capital investment for reinforcement from a combination of tools/techniques that allows Ausgrid to run the network in a less conservative manner.	Large
Reduced costs of customer connections through better visibility of the network and increased control allowing the network to be run in a less conservative manner avoiding the cost of some connections	Large
Facilitate the use of increased non-network solutions including DER and demand management through improved understanding of the state of the network. (The benefit is only the incremental saving between non-network solutions and augmentation, but there may be some augmentation that is ultimately not needed and therefore an option value could be associated with the non-network option.)	Medium (could become Large)

Table 22 Network Augmentation Benefits

Appendix C – Sensitivity Analysis for all Options

This section provides a set of comparison charts between options as a supplement to section 8. It is broken down into a review of Individual Key Parameters and Monte Carlo Analysis. The Monte-Carlo Analysis has been run without Reliability as with Reliability almost all of the ADMS/DMS options have close to 100% of simulations with a positive NPV compared to the Base Case.

As sensitivity and Monte-Carlo charts for the full ADMS Option are presented in section 8 they are not repeated in this appendix.

Sensitivity Charts for Individual Key Parameters Charts

This section shows the key parameter charts for each of the options with a short description of key points.

The contemporised DNMS was a high cost option with similar operating costs to the current DNMS. There are no key parameters that can make this option positive.

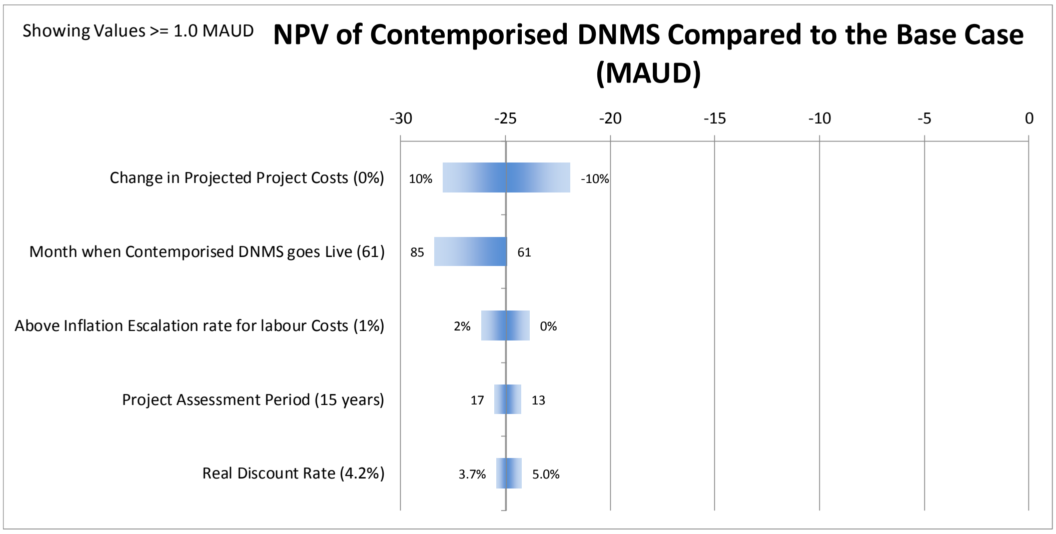

Figure 15 Comparison of Contemporised DNMS to the Base Case

The Like-for-Like solution was only marginally positive and there are consequently a number of parameters that could make the NPV negative, although many of these would also potentially increase the positive NPV. The most significant are the project assessment period and the costs associated with Onshoring for support and maintenance.

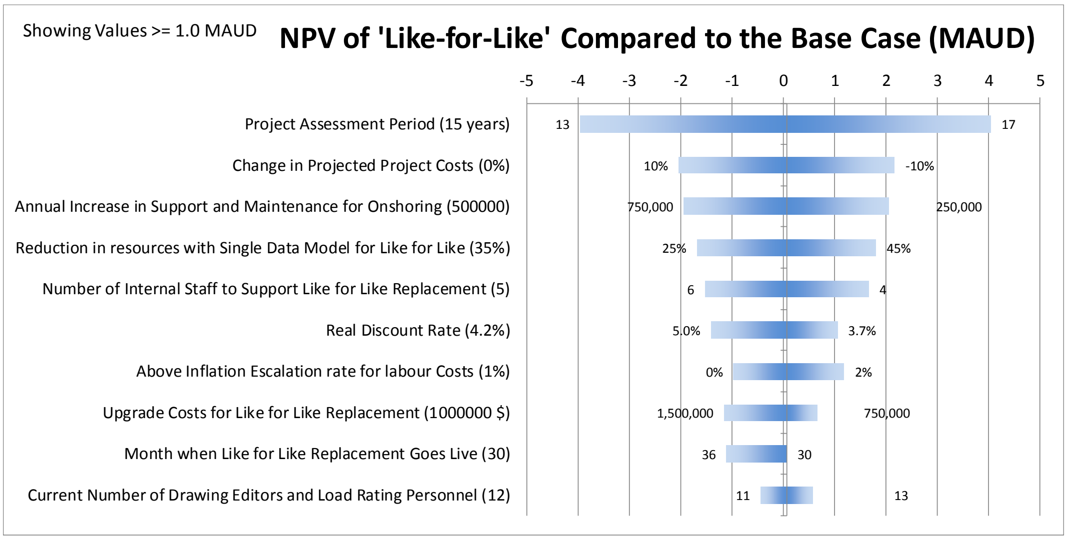

Figure 16 Comparison of Like-for-Like Solution to the Base Case

The DMS has an NPV of nearly $15m and no parameters have the potential to make this negative. The largest influence is the project assessment period which can reduce the NPV to $7m

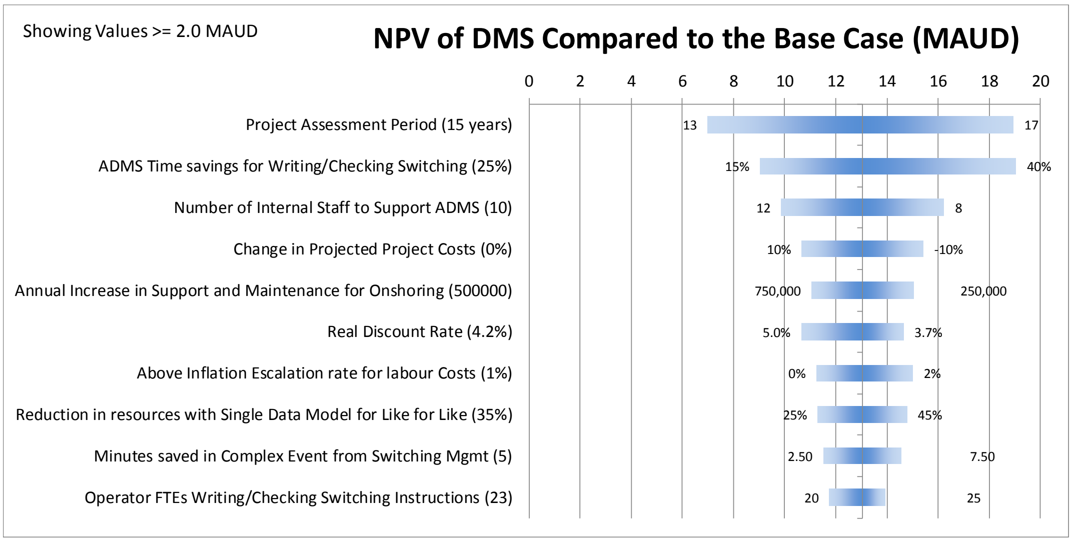

Figure 17 Comparison of DMS to the Base Case

Only 1 parameter with the Part ADMS has the potential to reduce the NPV below $20m. This is the reduction in the project assessment period to 13 years, which still results in an NPV of over $15m

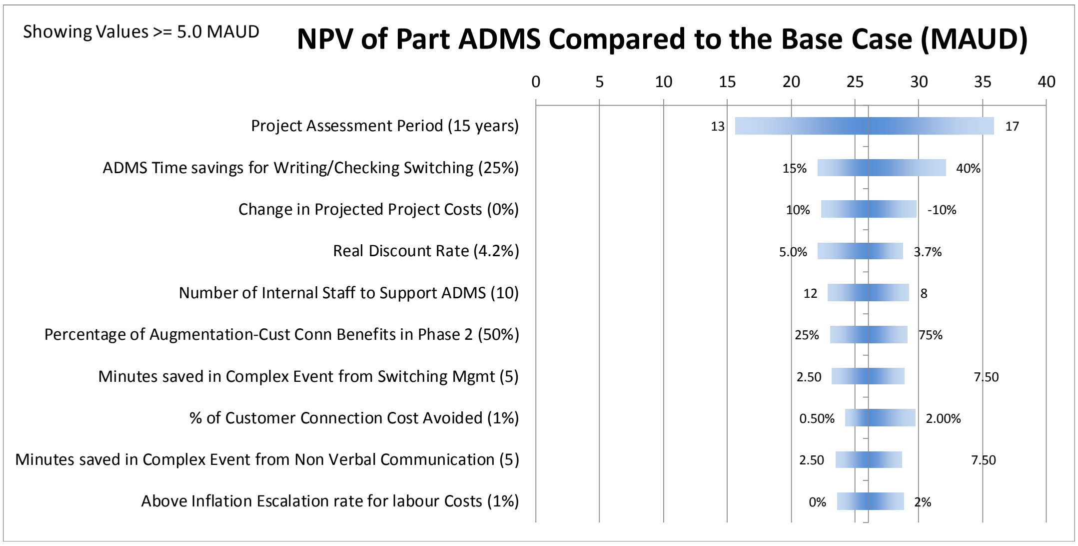

Figure 18 Comparison of Part ADMS to the Base Case

Monte Carlo Assessment without Reliability

The Contemporised DNMS has no associated benefits compared to the Base Case. The impact of changes in the costs is relatively small as many of the changing assumptions also impact the current DNMS. This results in no simulations with a positive NPV compared to the Base Case.

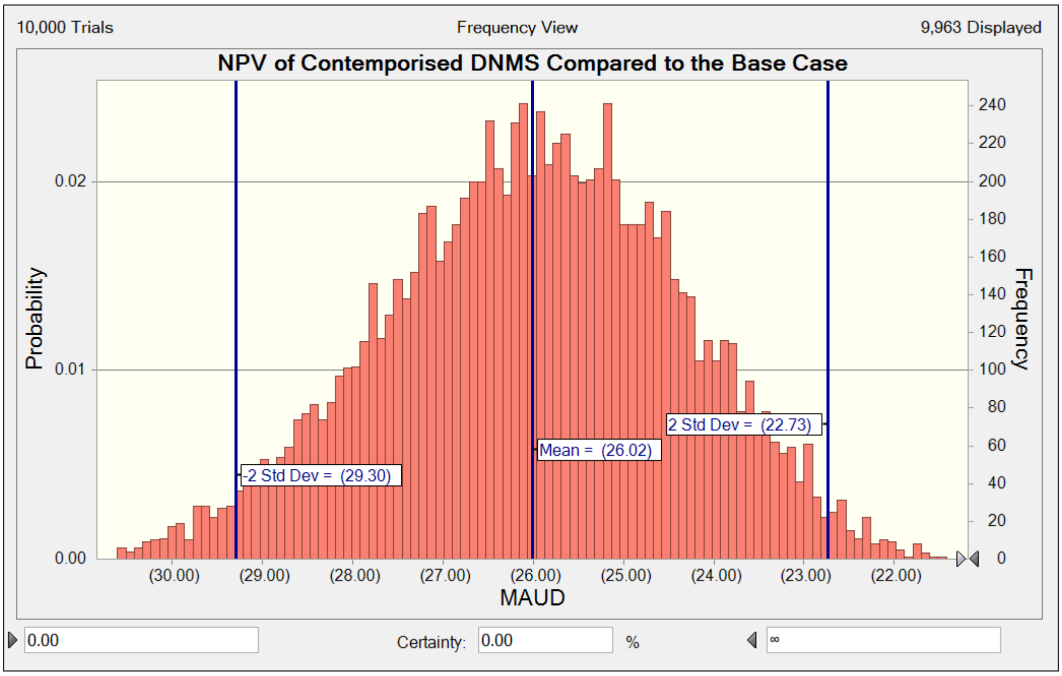

Figure 19 Monte Carlo Simulation for Contemporised DNMS

The Like-for-Like replacement has a reduced mean with only 39% of simulations that are NPV positive.

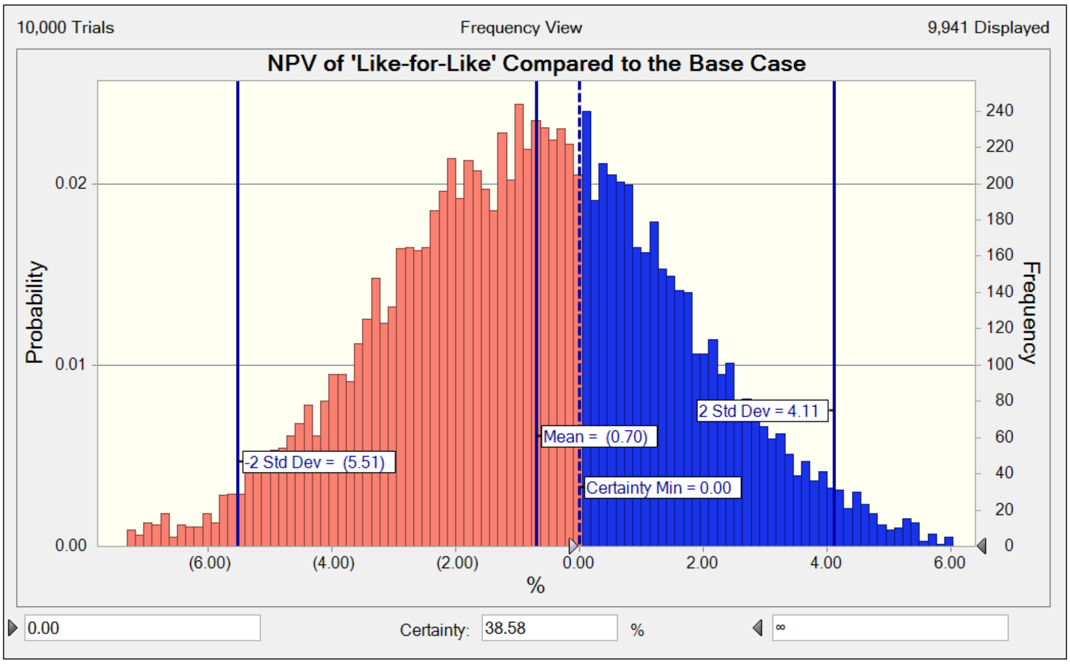

Figure 20 Monte-Carlo Simulation for 'Like for Like' Replacement

The removal of the reliability benefits from the DMS reduced the most likely NPV by over $6m. However, the Monte Carlo simulation still showed that 98% of simulations would be NPV positive compared to the Base Case.

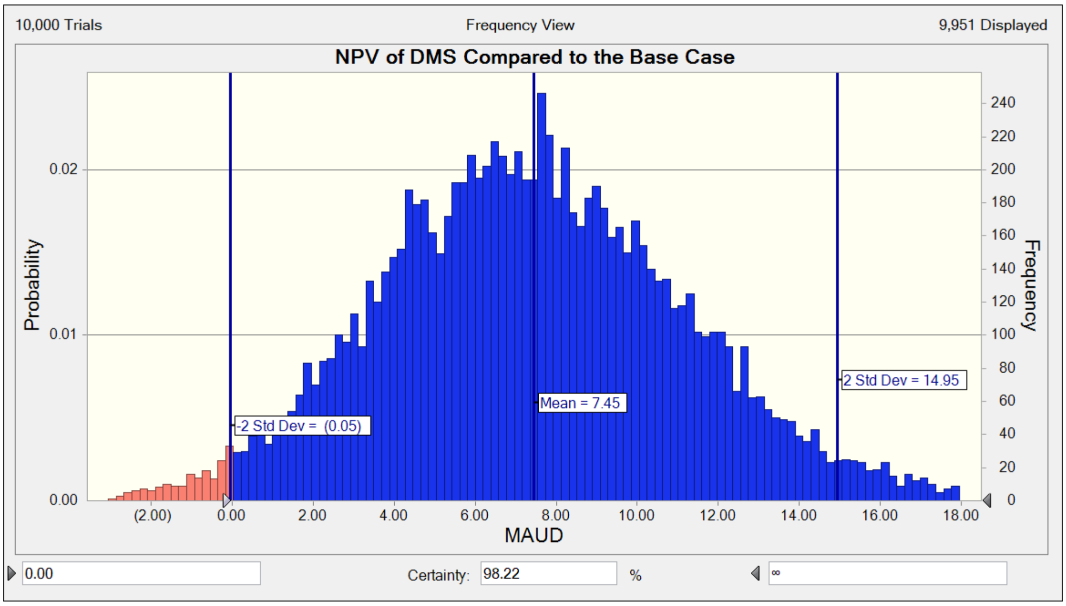

Figure 21 Monte-Carlo Simulation for DMS with Reliability Benefits Removed

The highest NPV without reliability was the Part ADMS even after the removal of almost $17m of reliability benefits. The Monte Carlo Simulation indicated a 97% probability of a positive NPV.

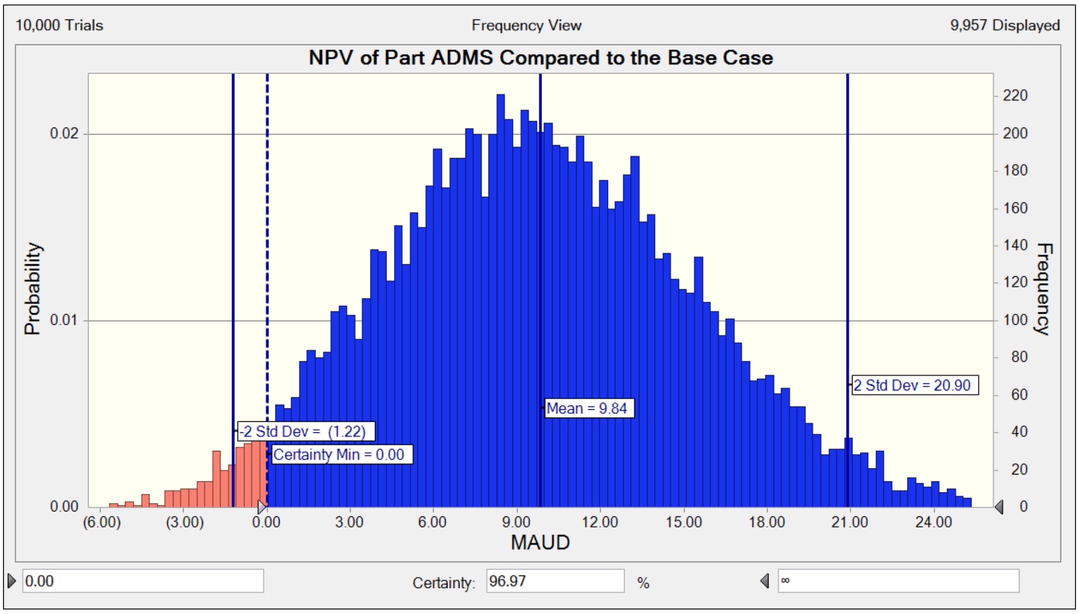

Figure 22 Monte-Carlo Simulation for Part ADMS with Reliability Benefits Removed