Intelligent Secure Substation Asset Management (ISSAM)

UNITED ENERGY

Document № UE PL 2401

STRATEGIC DIRECTION ANALYSIS PLAN

This document outlines the strategic plan for the use of intelligent, secure asset management on the United Energy network.

REPEX Road Map

1. Asset Replacement – Modelled

a. 6 modelled asset categories

2. Asset Replacement – Modelled & Unmodelled

a. Pole top structures + SCADA/protection

3. Other Repex - Unmodelled

a. ZSS Primary Asset Replacement

(i) CEES - Capacitor Banks + Earth Grid + Neutral Earthing Resistors

(ii) CEES - Buildings

b. Non VBRC Safety Projects

(i) Intelligent Secure Substation Asset Management (ISSAM) – UE PL 2401 e.g.CCTV

c. Operational Technology

(i) OT Safety

- Service Mains Deterioration Field Works – PJ1385
- In Meter Capabilities IMC) – PJ1386
- Light Detection and Ranging (LiDAR) Asset Management – PJ1400
- OT Security – PJ1500
- DNSP Intelligent Network Device – PJ5002

(ii) OT Reliability

- Distribution Fault Anticipation Data Collection and Analytics (DFADCAA) – PJ1599
- Fault Location Identification and Application Development – PJ1600

(iii) OT Other

- Dynamic Rating Monitoring Control Communication (DRMCC) – PJ1413
- Test Harness – PJ1398
- Pilot New and Innovative Technologies – PJ1407

d. Network Reliability Assessment UE PL 2304 – Projects

(i) Automatic Circuit Re-closers (ACRs) and Remote Control Gas Switches (RCGSs)

(ii) Fuse Savers

(iii) Rogue Feeders

(iv) Clashing

(v) Animal Proofing

(vi) Communications Upgrade

e. CEES – Environment

f. CEES – Power Quality Maintained

g. Terminal Station Redevelopment HTS and RTS - UE-DOA-S-17-002 & UEDO-14-003

4. VBRC Projects

a. HV Aerial Bundled Cable Strategic Analysis Plan - UE PL 2053

b. DMA and MTN Zone Substation Rapid Earth Fault Current Limiter (REFCL) Installation

c. Other VBRC projects

TABLE OF CONTENTS

List of Tables

Table of Figures

1. PURPOSE

This Strategic Direction Analysis Plan provides the detailed analysis and justification to support United Energy's (UE's) plan to deploy Intelligent Secure Substation Asset Management (ISSAM) technology at critical sites across its electrical distribution network. This plan is supported by a separate project to counter the increased threat of cyber and physical attacks on United Energy's Operational Technology environment in zone substations (refer to UE PJ1500 for details).

This plan supports UE's long term strategy in relation to maintaining safety and security in accordance with our regulatory and statutory obligations. This document and the principles captured within it are derived from and consistent with United Energy's (UE) Asset Management Policy. This document is based on good practice guidance from internationally recognised sources, including the Global Forum on Maintenance and Asset Management (GFMAM) and the Institute of Asset Management (IAM). It has been specifically developed to align with key elements of ISO 55000.

This is a "live" document, and will continue to be updated and revised as new information, tools and technology become available.

2. Asset Management Framework

2.1 Asset management objectives

United Energy is committed to the efficient and safe delivery of reliable services to customers. Efficient and effective management of United Energy's electricity network assets is critical to achieving this outcome.

Accordingly, United Energy has an asset management framework in place, which aims to:

- ensure the safety of the public and United Energy's personnel and contractors at all times;
- ensure that all compliance obligations are met;
- manage risk efficiently; and
- ensure the prudent, efficient and reliable delivery of an essential service that meets customers' and stakeholders' needs.

The asset management framework aligns United Energy's Asset Management Policy, strategy and Life Cycle Management Plans to ensure the achievement of the company's overarching corporate objectives. This is explained in further detail below.

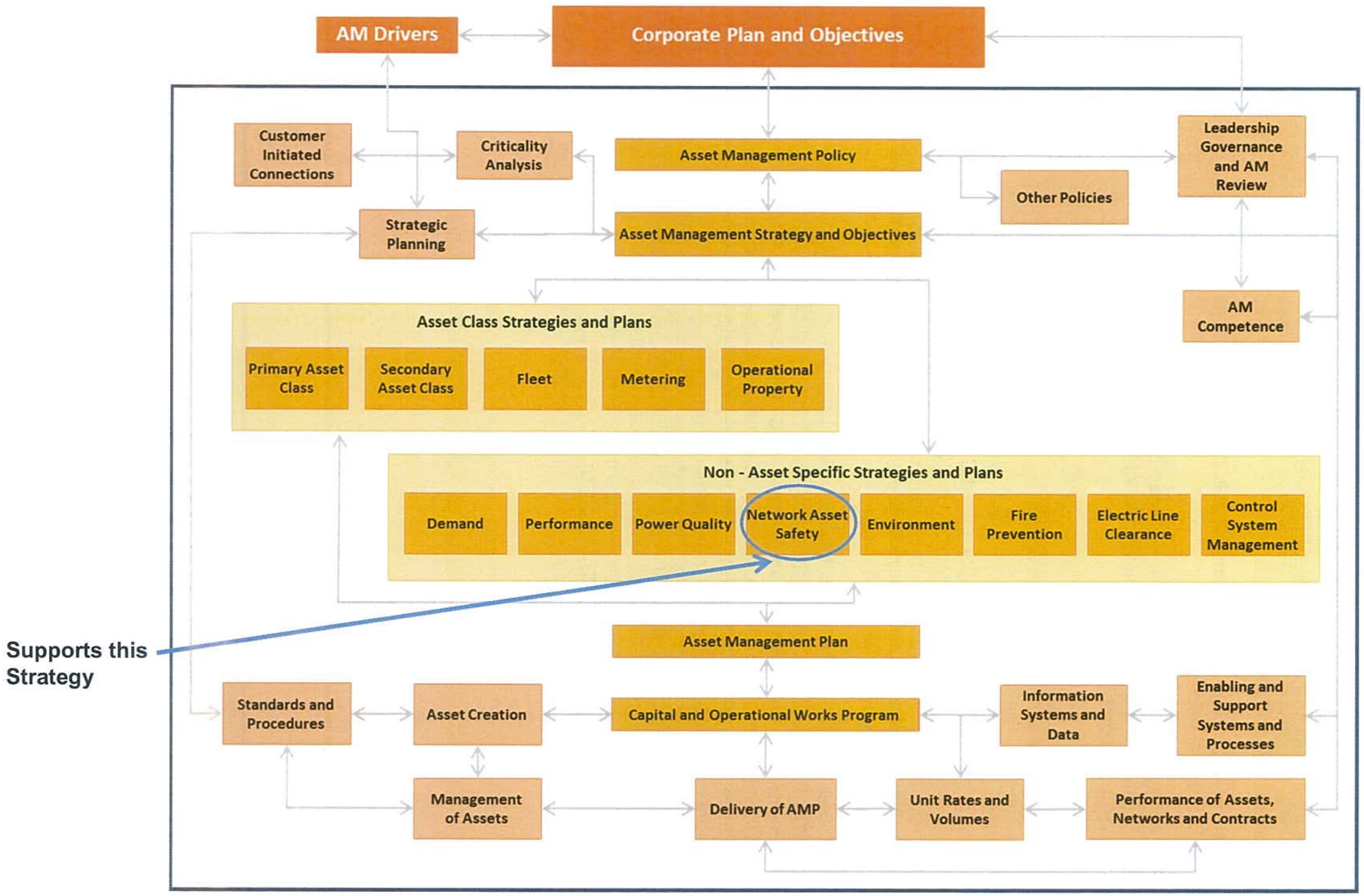
2.2 Overview of the framework

United Energy's asset management framework provides an integrated and structured approach to guide the development, coordination and execution of asset creation and maintenance activities so as to optimise the total lifecycle costs, risk and performance of United Energy's network assets. As such, the framework provides a key conduit for the execution of United Energy's corporate plan. It provides a clear line-of-sight between the delivery of asset management projects and activities, and the company's overarching corporate objectives, which are detailed in UE PR 2051.

The asset management framework translates United Energy's corporate plan into specific asset management objectives and actions. It employs a systematic approach - including processes and documented asset strategies and plans – to ensure that the asset management objectives and actions deliver prudent and efficient outcomes over the asset life cycle. The framework ensures the alignment of asset management activities with all other related management processes, including United Energy's risk management, health and safety, environmental and quality management systems.

The framework is shown in the diagram on the following page. The diagram shows how this Life Cycle Management Plan fits into the overarching asset management framework governed by United Energy's corporate strategy. A detailed description of the framework is provided in United Energy's Asset Management Strategy and Objectives document (UE PO 2050).

Figure 1: Asset Management Framework



2.3 Asset management drivers

United Energy's asset management plans are driven by the Asset Management Strategy and Objectives, which in turn reflects the objectives set out in United Energy's Asset Management Policy (UE PO 2001), which was promulgated by the Chief Executive Officer in December 2014. The Asset Management Policy identifies the following principles as the basis for all asset management expenditure:

- Safety
- Risk
- Performance
- Legal & regulatory
- Customer Service
- Continuous improvement & innovation
- Good asset management
- Adherence to relevant Australian & International standards
- Minimise of long-term cost structure
- Reputation
- Skills and Resources

Further details of the way in which these drivers are taken into account in the development of this particular Life Cycle Management Plan are provided in section 6.

2.4 Alignment with good asset management practice

United Energy's asset management framework has been developed based on good practice guidance from internationally recognised sources, including the Global Forum on Maintenance and Asset Management (GFMAM) and the Institute of Asset Management (IAM).

In January 2014, ISO 55001 was released by the International Organisation for Standardisation as the new international standard for asset management systems. United Energy's asset management framework now aligns with key elements of ISO 55001. Aligning United Energy's asset management system with key requirements of ISO 55001 provides all stakeholders with a high level of confidence that risks and costs associated with the management of assets are carefully considered and optimised.

3. Executive Summary

3.1 Project description

The strategy and analysis presented in this document supports the installation of CCTV at:

- All zone substations that have a high vulnerability and risk rating
- All new zone substations
- At zone substations with a large number of outdoor assets
- At zone substations with a large amount of stored equipment

A 12 year installation programme is envisaged, with the rollout being prioritised based on the assessed risk ratings of the substations. Under the program CCTV will be installed at a total of 20 zone substations over the five year period ending in June 2021. Installation of CCTV at the remaining 25 zone substations would then be completed progressively until the programme is completed in 2027.

This project complements separate plans to counter the increased threat of cyber and physical attacks on United Energy's Operational Technology environment in zone substations (refer to UE PJ1500 for details).

3.2 Project Driver

The principal driver for this project is to maintain safety in accordance with our regulatory obligations. Ensuring the security of the zone substations is a critical aspect of maintaining safety in the face of increased security risks.

3.3 Benefits

The changing national security landscape in Australia and the elevated threat to critical infrastructure has prompted United Energy to evaluate efficient cost effective methods to manage an increase in potential risks and threats. The rollout of Closed-Circuit TV (CCTV) to critical zone substations has been identified as a cost effective mechanism to address the heightened risks to such critical infrastructure in order to maintain safety and security.

United Energy's zone substations form the central operation and control hubs of the electricity network, providing reliable power to its customers. An attack or security breach on such critical infrastructure can have dire consequences such as system wide power failures, property damage and potential loss of life. Zone substations in United Energy's network are built to varying security standards and the constantly changing security environment provides a challenge to ensure the physical integrity of these assets. Threats to zone substations can range from relatively minor infringements, such as graffiti and theft, to major incidents such as equipment damage, terrorist attack and cyber-attack. The National Terrorism Public Alert System is currently rated 'high', which indicates that a terrorist attack is likely.

[redacted]

There is currently no fully operational CCTV system installed on any of United Energy's zone substations[1]. With regard to zone substation security there has been 27 reported attempted and successful equipment thefts in zone substations over the past 10 years. This has resulted in loss of material, property damage, loss of time and financial losses to United Energy.

[1] Lyndale (LD) is currently a pilot site for the evaluation of CCTV technology.

[redacted]

From 2012- 2014, there has been 29 safety incidents which have occurred within United Energy zone substations. There has been no video footage or records to enable United Energy to determine the sequence of events so as to learn from previous incidents or to provide evidence of process failures or failure to follow required work practices.

Health and safety as outlined in United Energy's Health and Safety Policy as well as the Network Safety Policy is one of United Energy's highest priorities. There is a need to minimise the safety risk to personnel and the public as low as reasonably practicable in zone substations. Electric shock and electrocution remains an ever present hazard for testers, fitters, line workers and other personnel working in zone substations. United Energy faces risk of prosecution should someone be electrocuted in a zone substation.

3.4 Options Analysis

The costs and benefits arising from the use of CCTV have been rigorously assessed in this document The tables below provide a summary of the project costs of delivering Options 1 and 2 per substation, together with an overall evaluation.

Table 1 - Comparison of approximate costs of options / substation

	Business as Usual	Option 1: Dedicated Field Personnel on Site	Option 2: Installation of CCTV
Capital expenditure per site	0	$50,000	$300,000
Operating expenditure per site per year	0	$1,200,000	$5,000

The table above shows that Option 2 (with a capital investment of $300,000 per site, plus an annual operating cost of $5,000) is clearly more cost effective than Option 1 (which involves annual operating expenditure of $1.2 million plus an initial capital investment of $50,000 per site).

Option 2 is preferred, on the basis that it minimises total costs. The table below shows an overall assessment of the options.

Table 2 - Overall Option Assessment

	Business as Usual	Option 1: Dedicated Field Personnel on Site	Option 2: Installation of CCTV
Obligation **Maintain safety**	Not satisfied	Partially Satisfied	Satisfied
Feasible Option	No	Yes	Yes
Ranking of options	3	2	1

It should be noted this project is part of a portfolio of measures, which together will ensure that UE complies with its safety obligations, including ALARP.

3.5 Recommendation

The progressive rollout of CCTV is required in order to maintain safety and security in an environment of increasing risk. The cost to supply, install and commission CCTV is as estimated below. Budget beyond the next regulatory period has not been determined and thus not included in this summary.

Table 3 - Proposed program to install CCTV and forecast capital expenditure budget.

Financial year	No. Zone substations	CAPEX
2016	N/A[2]	$ 994,750
2017	4	$1,333,588
2018	4	$1,339,680
2019	4	$1,351,171
2020	4	$1,370,669
TOTAL	**20**	**$6,389,858**

Note: Figures in Table 3 are inclusive of overheads and real escalators.

[2] Initial preparation, setup of infrastructure and training phase

4. Overview

United Energy (UE) requires a mechanism to:

- assist in safety observations of unaccompanied workers;
- confirm unauthorised entry into selected high risk substations;
- provide a visual record to assist in establishing a chain-of-events an incident; and
- provide visibility of maintenance tasks for safety purposes.

CCTV surveillance can be used as a tool to assist in meeting the objectives of zone substation security and safety strategies. Implementing video surveillance enables United Energy to access real-time footage or perform post event reviews of recorded material for verification of times, events and identities. Such an autonomous monitoring capability provides an effective addition to other security measures tailored for such local operational and security contexts.

Remote monitoring may be undertaken on an ad-hoc basis, enabling equipment in zone substations to be viewed periodically by staff across the company from desktop applications without requiring physical visits to site. Alternatively monitoring could be proactive, triggered by plant monitoring alarms / events or video content analysis allowing for more effective management of events through visual verification of status.

The activities associated with such active monitoring may include:

- Verification of staff presence at the zone substation as part of a planned activity;
- Verification of staff presence at a zone substation under unexpected circumstances (e.g. faults, accidental plant operation);
- Observation of maintenance activities for safety purposes;
- Viewing of plant status health / flags;
- Viewing the state of plant in response to an alarm to assist in determining the seriousness of the event; and
- In combination with calibrated thermal imaging (thermography), initiate and / or verify plant alarms.

Initiatives to address these requirements should be based on a Risk Assessment and Cost Benefit Analysis.

4.1 Security Requirements

Security Strategy

Implementation of CCTV systems for security should follow a clear well documented Security Strategy based on:

- local conditions;
- distribution and frequency of crime and nuisance events;
- business requirements; and
- public perception.

In developing a comprehensive security strategy, steps should include:

- review of a sites security history;
- discussion of local issues with Police;

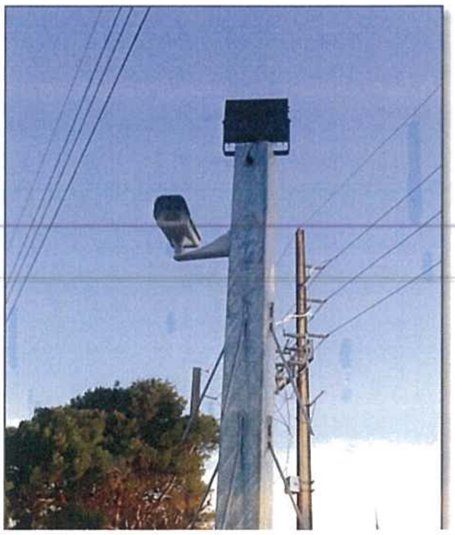


Figure 2 - Camera with IR lighting

- potential applications for Consider Crime Prevention Through Environmental Design (CPTED)[3];
- Review of published experience from other Distributors with similar profiles;
- Research on other physical security treatment options; and
- Research on electronic treatment options including those offered by CCTV surveillance.

Established mechanisms exist for the assessment of security risk, selection of appropriate treatment methods and ongoing security governance. Security threats are present in various forms, potentially affecting IT networks and software applications, physical plant and equipment, employee and contract personnel, electricity network safety and security and various other aspects of United Energy operations. A sound security Risk Assessment framework applied to actual site conditions and researched security treatment options is able to set the groundwork for the selection and application of security treatment options in a planned and cost efficient manner.

CCTV is one such treatment option. Typically used to support other security treatments including alarm systems in buildings and on fencing for remote verification of potential security incidents, it can also be used to detect and analyse video scenes to initiate alarms. CCTV provides an efficient way to remotely monitor a site without requiring a physical response to attend site to investigate every alarm. It provides a way to 'triage' potential security alarm events, discarding those events where nuisance sources are evident and only physically responding to those events with positive video verification of genuine alarm conditions

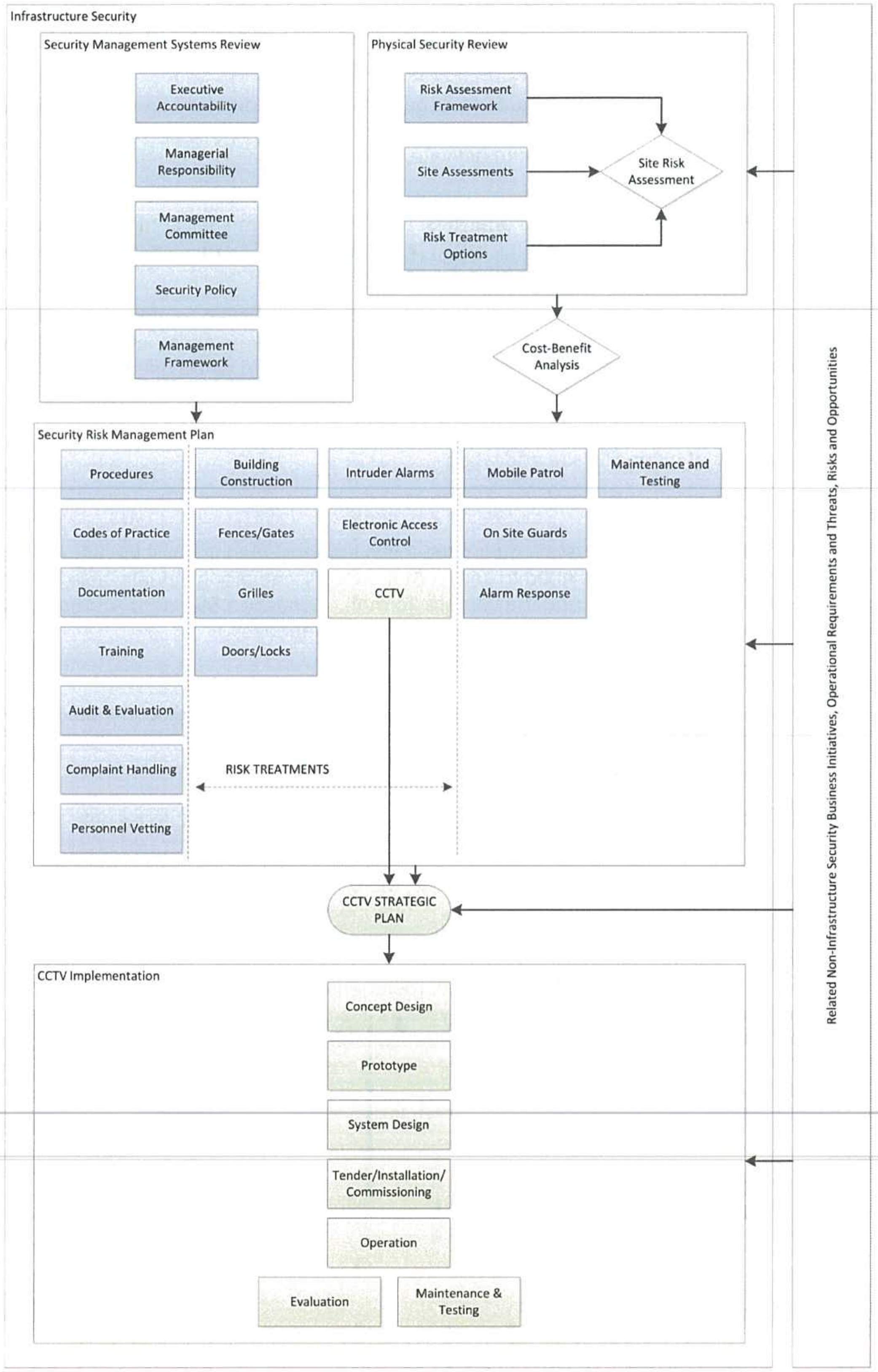
Effective CCTV surveillance relies on establishing clear objectives including a distinct purpose for each camera and well documented policies and procedures governing its system use. Video images retrieved by Police to assist in investigating criminal activities are often of poor quality due to camera location and lighting or shortfalls in the system design, installation and maintenance. To be effective a CCTV site installation must be carefully designed and implemented.

A formal Security Risk Analysis based on methods described in Australian Standard AS/NZS ISO 31000:2009 will assist both in the selection of suitable crime protection strategies and in documenting the logic behind specific initiatives. Cost-benefit analysis using whole-of–life pricing may also assist in choosing between potential options including CCTV.

Once a holistic plan is in place, and the intended place of CCTV surveillance within that plan is understood, the technicalities of implementing an effective CCTV system must be considered. Figure 3 provides a diagram overviewing the relationship between CCTV implementation and the associated UE Network Infrastructure Security Strategy [1] and governance processes that may be required.

[3] Limited in an existing suburban substation environment

Figure 3 - Security Strategy Overview



Appropriate Application

The appropriate application of CCTV to address security risks requires a sound understanding of the purpose for which it is being installed and the complementary or supporting measures that will be implemented in parallel. Potential purposes include one or more of the following:

- To verify an alarm from an external source (e.g. gate switch or Perimeter Intrusion Detection System - PIDS). In this case the external device has initiated the alarm event in response to a potential intrusion and causes the CCTV system to activate, view, record and/or transmit video covering the area of the alarm;
- To initiate an alarm event. Using video analytics, the CCTV system shall continuously review the video footage for activity that does not fall within present or 'learnt' norms for the selected field of view;
- To enable 'general overview' of the site without being specifically linked to alarm detection devices. The CCTV system shall record continuously or on the basis of coarse scene change type movement detection to provide a historical record of activity on the site. This may be used for the purpose of confirming after the event, what happened and potentially who was involved; and/or
- To record entry and exit identification information including vehicles and personnel, sufficient to determine who was at a specific site and when.

Purpose of CCTV

The purpose established for the CCTV system during the initial strategic planning will identify what camera types are required and what the cameras need to see. What a CCTV camera is actually able to see is a function of the type, the lighting, the lens and the camera 'format'. Australian Standard AS4806.2:2006 defines what a camera can see under ideal conditions using four categories;

- Identify – to be able to uniquely identify a person or vehicle;
- Recognise – once an individual person or vehicle is known, to be able to discriminate between that specific person and others;
- Detect – recognise the initial presence of any person or vehicle; and
- Observe (Monitor) – once the presence of any person or vehicle is known, to be able to follow where they go.

While the standard is based on older analogue technology, the underlying concepts apply also to digital systems. A requirement to 'Identify' dictates that the targets appear very large on the display, resulting in a need for many cameras, higher resolution or strategic placement of cameras. It is this last strategy – strategic placement that is described in the *National Code of Practice for CCTV for Mass Transport Systems* and adopted by many authorities. It relies on 'Identify' standards at entry points and lower grades of coverage within the area. While this is appropriate in transport systems it is difficult to achieve in open public spaces. Careful consideration is required to determine what can reasonably be achieved with available lighting and camera technologies identifying clear priorities for camera locations so that cameras are applied where the most benefit will result.

5. Background

5.1 National Electricity Regulations

The principal regulatory drivers in relation to security is derived from the following obligations:

- Clause 6.5.7(a)(4) of the Rules requires United Energy to maintain safety.
- Section 98 of the Electricity Safety Act 1998 requires United Energy to design, construct, operate, maintain and decommission its supply network to minimise as far as practicable - (a) the hazards and risks to the safety of any person arising from the supply network; and (b) the hazards and risks of damage to the property of any person arising from the supply network; and (c) the bushfire danger arising from the supply network.
- Section 4 of the Occupational Health and Safety Act 2004 on the principles of health and safety protection requires "(2) Persons who control or manage matters that give rise or may give rise to risks to health or safety are responsible for eliminating or reducing those risks so far as is reasonably practicable."

5.2 National Guidelines

The National Guidelines for Prevention of Unauthorised Access to Electricity Infrastructure, ENA DOC 015 – 2006, are intended to be used as a tool promoting the understanding of security and safety in considering the design of electrical infrastructure. They are aimed at community safety with an emphasis on children and youth rather than insider or politically motivated threats or theft. Three levels of Control Measures are presented of which CCTV forms part of the *Secondary* level, assisting in identifying persons and methods associated with unauthorised substation entry. It provides a holistic view of substation physical security set against the background of the now well established principals of 'defence in depth' and 'crime prevention through environmental design' recommending that a risk management process equivalent to AS/NZS 4360 (now AS/NZS ISO 31000: 2009) be adopted.

With specific reference to CCTV it recommends:

- linking to alarm systems and loudspeakers to enhance real-time effectiveness;
- 6 hours battery backup capacity;
- consideration for substation EMI / RFI;
- overt presence compliant with relevant State Legislations;
- selection of suitable equipment and its installation;
- monitoring and response arrangements;
- 24 x 7, alarm event or operator activated;
- lighting levels, colour rendering, glare and shadows be considered in the context of lamp type, positioning of the luminaires and control systems;
- monitoring and/or recording; and
- clearly visible signs notifying people that they may be under surveillance.

5.3 Australia

5.3.1. Construction Guidelines

Many electricity network providers have substation construction guidelines identifying requirements for physical and electronic security.

5.3.2. Tasmania

Transend networks [2] in Tasmania implemented an asset security strategy that identified a need for integrated upgrade to their 47 substations consisting of perimeter electric fencing and CCTV surveillance.

The Transend strategy was to mitigate business risk by:

- ensuring the safety of the public, employees and contractors;
- adequately protecting assets from physical damage, thereby sustaining the availability and reliability for supply;
- complying with the relevant acts, codes, standards and guidelines;
- meeting the requirements of good electricity industry practice;
- addressing recommendations and opportunities for improvement by auditors and insurers;
- enhancing remote asset monitoring capability;

This was done through a risk based approach to using:

- site-specific risk assessment;
- site vulnerability assessment; and
- security fence condition and building intruder resistance audits

Approved initially in 2005 to include $8.6M [3] of electronic security of which 25% was CCTV, an additional $4.8M for electronics was allocated to complete the project in 2008.

5.3.3. South Australia

Electranet SA Substation Design Manual 122 [4] includes detailed requirements for substation electronic security with a focus on intruder alarm systems and SCADA integration requirements including alarm system programming by Contractors for consistency across the network. Development and testing of suitable perimeter security and surveillance for critical infrastructure sites is ongoing.

5.3.4. Northern Territory

The NT Power and Water Substation Design Manual includes prescriptive requirements for security systems including interface to existing central monitoring for alarms, electronic access control door and future CCTV.

5.4 North America

The North American Electricity Reliability Corporation (NERC) in their *Security Guideline for the Electricity Sector: Physical Security* [5], June 2012 suggests that current technology solutions for electricity infrastructure includes CCTV and video surveillance management systems with video analytics that detect intrusion reporting to an attended central security station that can then be evaluated and entity personnel or law enforcement authorities dispatched to investigate a potential problem [6].

IEEE Std 1402-2000 (R2008) IEEE Guide for Electric Power Substation Physical and Electronic Security [7] also provides a high level overview of substation physical security, from greenfield site through to operation. Tables in the standard providing survey responses on physical and electronic security treatment effectiveness have insufficient sample size (under 3% of respondents) to report accurately on CCTV.

5.4.1. Case Study – Municipal Electric Authority of Georgia (MEAG) Power

In 2007 MEAG Power trialled automated CCTV at one of their zone substation in response to the increasing number of copper thefts at the zone substation. The copper thefts had resulted in poor network reliability, financial loss as well as health and safety issues. As such the network risk, financial risk, safety risk and potential legal liability were the main drivers to trial an automated CCTV solution.

In order to minimise its risks and liabilities, MEAG Power sought to deter and prevent intrusions from occurring rather than merely detecting their occurrence. MEAG Power implemented an automated CCTV system that integrated into MEAG Power's existing SCADA system. In addition, no additional personnel were needed to constantly monitor the video footage. In the event of a detected potential intrusion, flood lights and sirens were turned on and a notification sent to the control centre in the form of a SCADA alarm.

As a result of the trial, MEAG Power has deployed seven systems across its network with six permanent installations and one mobile application.

Relevance to United Energy

The prevention of intrusion into zone substations is a benefit that is applicable to United Energy. The ability to have the CCTV solution integrated into the SCADA system is also applicable to United Energy.

5.5 Existing Trial Summary

Purpose

United Energy has commenced a CCTV trial project at the Lyndale (LD) zone substation [8].

Manufacturer

For the trial, United Energy has selected a Video Management System (VMS) from Critical Asset Protection (CAP) in South Australia that is the distributor for Pivotal Vision (PV) from the USA. The system provides video content analysis and real-time camera pan-tilt-zoom positioning in order to minimise the required number of cameras and remove the need for real-time monitoring by a human operator. Calculations performed with the PV *Intelligent Video Appliance* identifies movement within predefined areas, tracks that movement through feedback to camera head positioning and records both video and target tracks for later analysis.

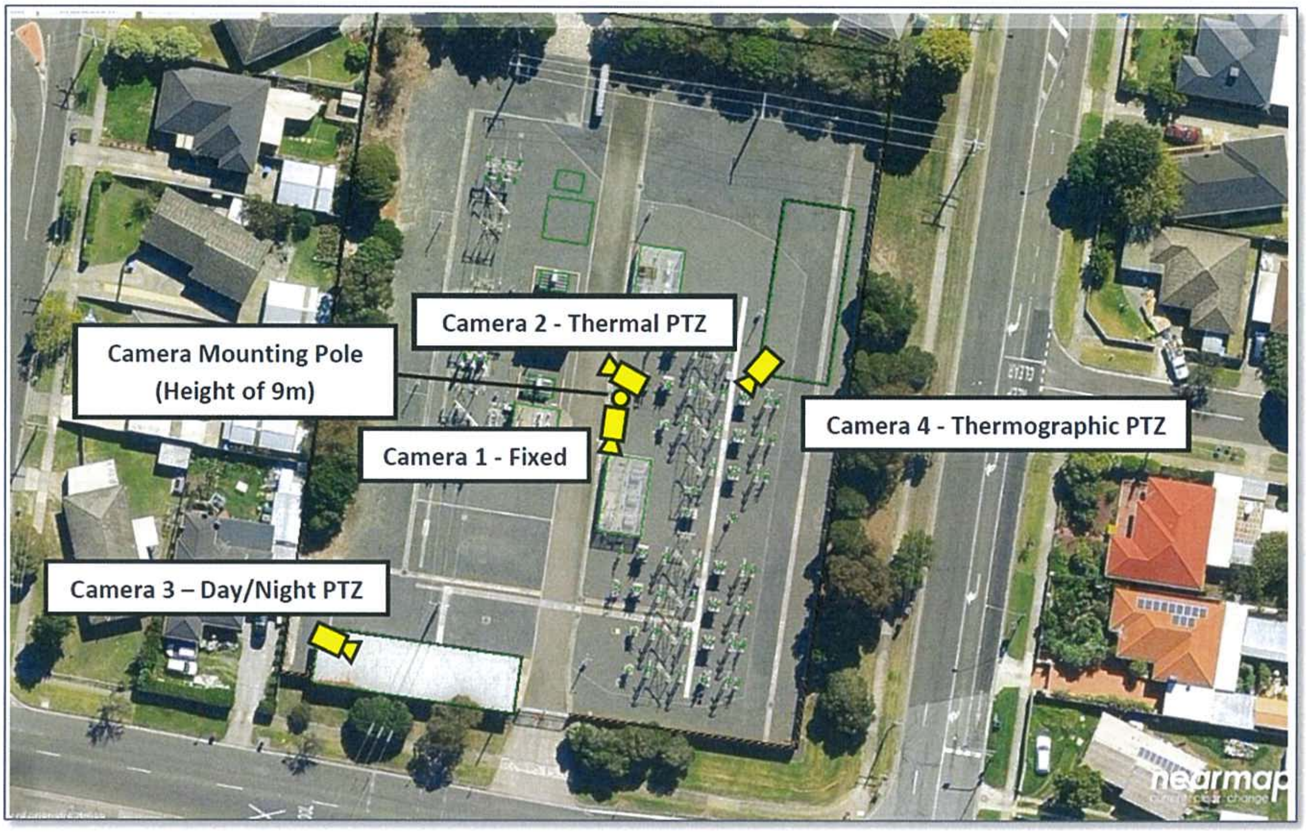
Accurate tracking performance relies on the use of high quality pan-tilt heads provided by MOOG Sensor and Surveillance Systems. This includes the *GeminEye* integrated modular imaging system with both day-night and thermal cameras and the separate *QPT20* PTZ head with FLIR *A3xxf* thermographic camera.

Camera positions

Four cameras were positioned within the Lyndale zone substation as part of the trial as follows:

- Control Room – Day/night PTZ optical camera;
- Main Entrance – Day/night fixed optical camera;
- General Yard – Thermal PTZ camera; and
- Primary Assets – Thermographic PTZ camera.

Figure 4 - Location of cameras at Lyndale (LD) Zone Substation



Test Results

The trial is currently ongoing with findings as yet published. A full test report with analysis of system benefits is expected at the end of the trial in 2015.

Recommendations

Learnings and key recommendations from the Lyndale CCTV trial will be incorporated into this strategic direction analysis plan.

5.6 Technology

5.6.1. Cameras

Features

Camera selection is a trade-off between cost, coverage, image quality, functionality and environmental construction.

Current generation CCTV surveillance systems provide an end-to-end digital solution, reducing complexity and facilitating the use of standard computer network components. Cameras may be powered using a separate cable or over Ethernet cable using the 'power-over-Ethernet' (PoE) standard.

CCTV technology follows the domestic video camera market and capabilities introduced over recent years include image stabilisation, megapixel resolution, low light performance and video content analysis. All the above features are increasingly common in cameras in the market.

Figure 5 – Box type camera in full PT enclosure

Remote **pan-tilt-zoom (PTZ) controllable cameras -** enable a remote operator to direct the camera to a specific target and usually incorporate automatic focus and brightness control. When used for autonomous tracking or with very long lenses, accurate control of PT heads is essential to ensure positioning accuracy. Designed for military applications these units are expensive and often do not support standard CCTV PTZ protocols.

Fixed cameras - are available in *box* or *dome* type, the former may include an integrated lens and environmental enclosure or may require these components to be selected separately. Where identification of distant targets is not required, integrated dome type cameras may be preferable as they have lower setup and maintenance cost and are available with rugged construction also at lower cost. Both should include varifocal lenses and manual pan-tilt adjustment to enable accurate aiming by the installer.

Wide Dynamic Range - cameras are able to optimise image quality under some high contrast lighting conditions by adjusting image exposure on a pixel-by-pixel basis or through blending several images with different electronic shutter speeds into a single image.

Figure 6 - Day-night camera image with IR lighting

Day / night cameras - provide useable video images under daylight, low light and artificial infrared (IR) lighting conditions. An IR cut filter may be required during the day to limit natural IR lighting and enable sharp focussing. This filter is mechanically removed from the optical path at night to allow pick up of ambient and/or artificial IR lighting. This is combined with adjustment of the imager position to match the IR light focal point or provision of day-night lenses with coatings that focus visible and near IR light in the same plane.

Thermal cameras - are sensitive well into the IR range and typically use uncooled microbolometer technology at the imager. Thermal cameras will typically have lower resolution than day/night cameras and will include special lenses and housing windows that permit the passage of thermal energy.

Thermographic cameras - are thermal cameras with a calibrated colourised representation of the thermal image to show the temperature hot or cold spots in the imager field of view.

Megapixel Imaging

Megapixel refers to cameras with high resolution compared to original standard definition television. Megapixel requires more light to operate due to the smaller size of each individual pixel in the imager, but they are still able to produce a usable image at twilight.

The use of Megapixel technology cameras may reduce the overall camera quantities by providing increased resolution and subsequent wider angles of view for the same defined surveillance objective. Cameras with 180° field of view permit recording of a full hemisphere under the camera and allow virtual *dewarped* or *stitched* PTZ around both live and recorded images.

Because of the increased image information, megapixel imaging requires greater signal transmission, processing and storage capacity on top of lenses designed specifically for the imager size and resolution.

Interoperability

CCTV camera interface standards enable cameras from multiple manufacturers to operate together. The Open Video Interface Forum (ONVIF) interoperability standards are a prime example, offering highly detailed specifications for functions supported by, and communications between, video transmitters, displays, recorders and video analytics devices. While uptake of standards is increasing, ONVIF conformance does not mandate implementation of all provisions of the specifications and therefore does not guarantee that devices will be interoperable across their full functional range.

While compliance to standards provides interoperability, a standalone system provided from a single manufacturer does not require interoperability with other cameras or VMS systems.

5.6.2. Image Transmission

Optical Fibre

Video signals over cabled networks have distance limitations depending on the type of cable and capability of electronic repeating devices. Usage of copper cabled signal networks in zone substations are discouraged due to the risk of EMI/RFI switching conditions and the possibility of ground currents under fault conditions. Except for short runs, digital video signal transmission requires the use of optical fibre cable and associated devices at each end to convert the signal from optical to electrical form. One of the main cost influencers is the provision of suitable compliant cable pathways between the cameras and the equipment hubs. Optical fibre cabling provides a reliable, high capacity connection and is the preferable solution in most circumstances. Establishing additional cable pathways in substations however may be cost prohibitive and wireless solutions may offer suitable alternatives under some circumstances on larger sites.

Wireless

Wireless technology is broadly split into three types of products:

- Class licensed – such as Wi-Fi and Bluetooth based products that operate without licence fee
- Apparatus Licenced – used by larger organisations for point-to-point carriage of bulk data requiring spectrum coordination and annual licence fees;
- Spectrum licenced – generally only available as pay-for-use services through mobile phone carriers or ISPs

Class licensed products are used almost exclusively for short range due to their low cost and use of standardised technologies. Sharing radio frequency spectrum for high quality video using IEEE 802 based technology designed for internet web site or file transfer applications however requires professional site surveys and radio frequency design to ensure reliable operation. Similar RFI risks to copper networks exist for wireless transmission within substation environments.

5.6.3. Video Management Systems

Video Management Systems (VMS) generically describe software capable of accepting, analysing, manipulating, distributing, storing and exporting video streams within a unified and uniform user friendly environment. VMS may include Network Video Recorders (NVRs) or Digital Video Recorders (DVRs) but are not point device specific, providing software for network wide and often hardware agnostic systems.

VMS software controls the CCTV video information and the cameras, requesting video streams, serving the images to the operator and managing recording and replay. The VMS software may be built into a device provided by the manufacturer or purchased separately and installed on suitable standard computer hardware. The VMS should provide:

- a user friendly keyboard-mouse controlled operator interface;
- unique identification for cameras and time/date stamping of video information;
- support for a range of cameras and camera types available within Australia;
- smooth control, viewing, recording, replay and export under all conditions;
- facility to select recorded video from any or all cameras from a graphical timeline;
- clearly identified requirements for hardware that meets performance requirements depending on the number of cameras, operators and days of video storage required;
- integration with video content analysis software if required; and
- support for legacy analogue cameras as required.

Some developers tie VMS software to specific elements of the system hardware including the server, storage subsystem, analogue video encoders/decoders and cameras. The link between hardware and software serves to ensure that both the hardware is suitable for the video processing requirements and provides a model for sales that ensures development and distribution costs are recovered. Some manufacturers provide user interface software ‘for free’ and build cost and profit into proprietary hardware elements. Others provide tiered software licensing based on the number of cameras, amount of storage, interface or video analytics functionality that allows users to select their own (compliant) hardware. A third group provide a combination of the two, with partial hardware, software or optional mixed solutions. Where proprietary and third party standards compliant equipment can be mixed, it is often the case that the mixed solution provides a reduced level of functionality compared to a system using an individual manufacturers native components. The following table shows a range of solutions from the main distributors of large scale networked VMS.

Table 4 – VMS Cost Distribution by Manufacturer

Make	Software		Hardware				
	PC Station	Server	PC Station	Server	Storage	Codec	Camera
Pacom Endura	Included	Included	Proprietary	Proprietary	Proprietary	Both	Both
IndigoVison	Free	Included	Commercial	Proprietary	Proprietary	Both	Both
Geutebruck	Licence	Licence	Commercial	Both	Both	Both	Commercial

Make	Software		Hardware				
DVTEL	Licence	Licence	Commercial	Commercial	Commercial	Both	Both
Honeywell*	Licence	Licence	Commercial	Commercial	Commercial	Commercial	Commercial
Milestone	Licence	Licence	Commercial	Commercial	Commercial	Commercial	Commercial
March Networks	Free	Licence	Commercial	Commercial	Commercial	Both	Both
Avigilon	Free	Licence	Commercial	Commercial	Commercial	Both	Both
Pivotal Vision	Licence	Licence	Commercial	Proprietary	Proprietary	Commercial	Commercial
Lenel	Licence	Licence	Commercial	Commercial	Commercial	Commercial	Commercial

5.7 ICT Hardware

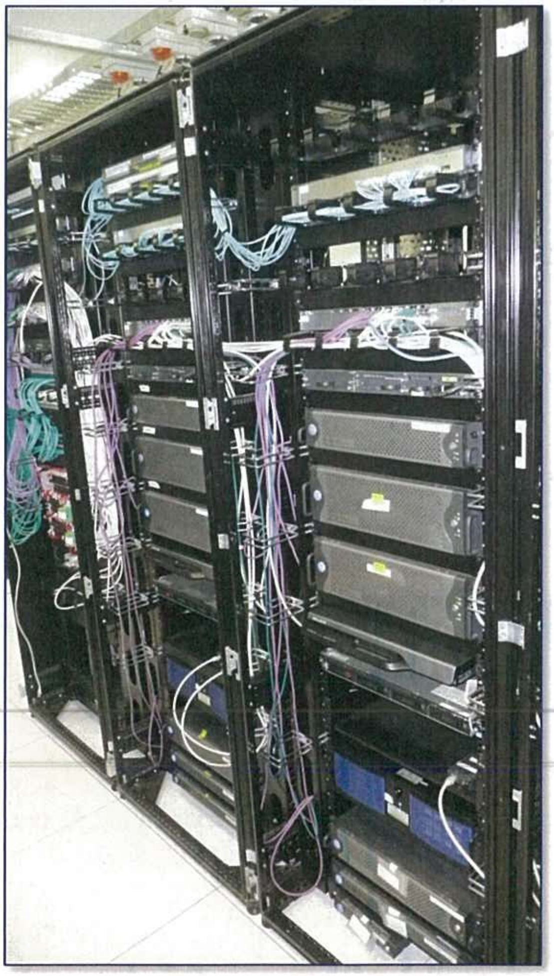
Information and Communications Technology hardware must be selected to meet the performance requirements of the VMS software based on the size of the network and the amount of video storage required. This hardware includes:

- Ethernet interfaces and media converters;
- Wireless transmitters and receivers;
- Ethernet switches and routers;
- VMS servers;
- VMS video storage subsystems; and
- VMS workstations.

On smaller systems the VMS server, storage and workstation may be built around a single personal computer.

Larger systems require an enterprise solution as illustrated in Figure 7 below

Figure 7 – VMS for a 250 camera single site installation



6. Performance

6.1 Lighting

6.1.1. Standards

Lighting levels are measured in *lumens per square metre* or *lux*. AS/NZS 1680.2.4:1997 identifies illumination requirements for general movement in Electricity (Generating) Stations of 40 lx. Australian Standard AS/NZS 1158.3.1:2005 identifies requirements for pedestrian movement outside substations at much lower levels that will also generally be suitable for CCTV.

Caution should be exercised when considering IR lighting in areas where visible spill lighting is also present as some cameras will not be able to focus correctly under both conditions.

Figure 8 - Lighting glare at night

6.1.2. Measurements

A good understanding of existing artificial illumination levels from both zone substation lighting and spill from adjacent street lighting is strongly recommended to ensure night time performance can be assessed against camera capabilities. This should be undertaken using measurements throughout the anticipated field of view of each camera at 1.5m altitude above ground level (AGL) in the vertical plane facing the proposed camera location. While a design level of 10 lx is preferred, lighting levels as low as 1 lx may be acceptable depending on the purpose of the camera, the distance to the subject, the format of the camera and the type of lens. Below 1 lx (even where camera specifications claim performance below this level) or where bright – dark ratios in the camera field of view exceed 10:1, consideration should be given to the use of artificial lighting, including:

- Infill for existing substation lighting;
- Dedicated visible lighting activated using photocell or alarm trigger (incandescent only due to the fast start up time required); and
- Infrared lighting.

6.2 Video Quality

Perception of video quality is a combination of factors combining frame rate and resolution with compression necessary for transmission or storage. Most cameras and VMS support high definition Video at 720 vertical pixels with 25 full frame images per second in 16:9 format using *H.264/MPEG4 AVC Part 10 Main Profile* compression. This should be considered the minimum requirement for video images. Greater resolution including HD1080 and higher megapixel imagers, if used, should not compromise on the minimum frame or maximum compression rates above. A system design that reduces image quality to achieve savings in transmission, processing or storage costs will result in poorer video images in low light and with fast moving targets.

Thermal cameras will provide lower resolution and possibly lower frame rates to ensure sufficient size and exposure times for thermal imaging elements.

6.3 Recording Duration

It is recommended that video images are stored for 31 days in accordance with Australian Standard 4806.1–2006: *Closed-Circuit Television (CCTV)—Management and Operation.* This equates to about 1.4TB per camera per month with the minimum quality settings detailed in Section 6.2 Video Quality above.

6.4 Image Availability and Export

To facilitate ready access by law enforcement personnel, the VMS should permit simple selection of recorded video image segments between times and dates. Images from multiple cameras should be able to be selected at once for synchronised replay and be able to be exported to removable media (DVD, Blu-ray or USB storage) in a format that permits replay on a standard computer with generic software players. Camera image segments should be able to be exported as a set of separate clearly time-date labelled files for each camera. Images should also be able to be exported in the VMS native format complete with any image watermarking or verification mechanism and standalone VMS proprietary software video player.

7. Design Considerations

7.1 Governance Requirements

A clear understanding of the policies and procedures surrounding the eventual operation of the CCTV system will assist in initial system design. Sound governance policies will identify the purpose of CCTV surveillance and help to ensure confidence that CCTV is provided to support safety and security strategies.

The UK Home Office Surveillance Camera Code of Practice identifies twelve guiding principles for CCTV system operators covering clear aims, purpose, scope, privacy, transparency, security, responsibility, accountability, access, review and audit as well as the requirement for operational and technical competency standards. These may be appropriate if CCTV cameras are capable of viewing public or third party private spaces outside substations or provide covert surveillance through IR or thermal capability.

7.2 Purpose Statement

A clear purpose statement is required for the overall CCTV system (and prior to considering requirements at each substation) to guide the work at each site. The System purpose needs to be prioritised, including the following:

- **Priority 1** – Plant condition monitoring
- **Priority 2** – Safety of both authorised and unauthorised people
- **Priority 3** – Vandalism and terrorism

Cost-benefit analysis against operational and security requirements will also identify requirements for any complementary measures to achieve the system purpose. Complementary measures may include fencing, lighting, alarm systems etc.

7.3 Method of Operation

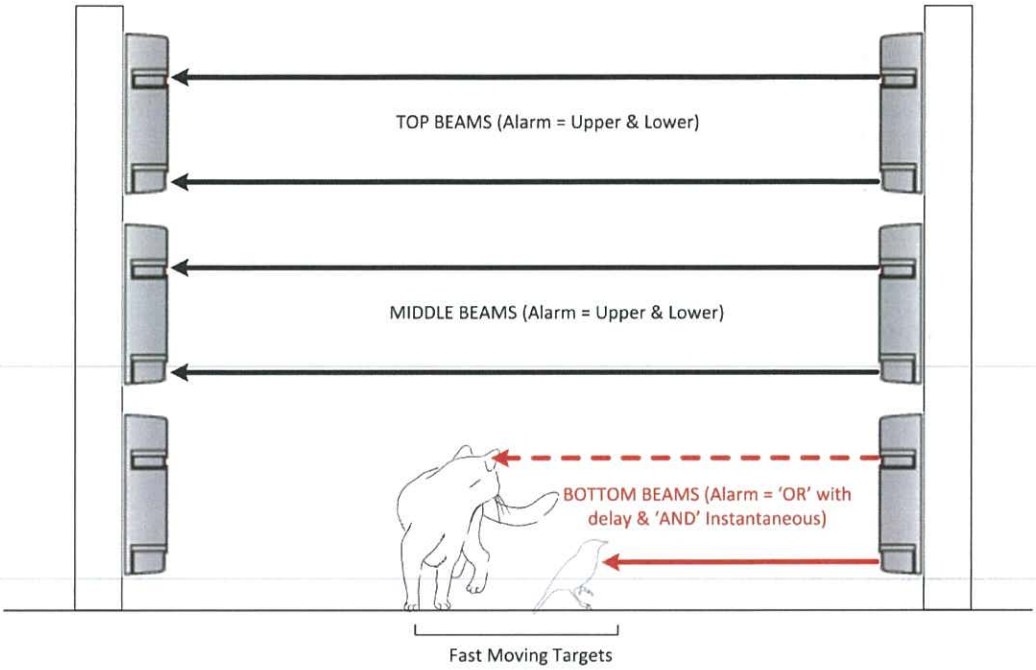
The CCTV System Method of Operation will be guided by the system purpose. Except in very high pedestrian traffic areas, under special circumstances or for limited periods it is expected that CCTV systems will not be operated by surveillance personnel. If periodic manual operation is planned, accommodation for the operator must be commensurate with the duration and magnitude of the task. Consideration needs to be given to:

- how many camera and video display monitors are required;
- accommodation required to meet Work, Health and Safety requirements;
- security of people and equipment;
- planning of response to incidents; and
- communication and record keeping.

7.4 Trigger Mechanisms

Effective and efficient CCTV surveillance relies on trigger mechanisms to highlight events of significance. The trigger mechanisms may be external to the CCTV system, with dry contact or serial data transfer to signal the event, or may be direct automated image analysis of the video content. External event triggers include; gate or door switches, beam or other 'linear' perimeter detection systems (PIDS), space-motion detection such as passive infrared (PIR) pyrometer based devices or specialist electrical plant monitoring, possibly via setpoint trip in RTU devices.

Figure 9 – PIDS using triple stacked IR beams



In the Pivotal Vision system marketed by CAP in Australia, video analytics are used to determine the presence of a person or vehicle in a prohibited area or crossing of a virtual fence into that area. They extend the capability of each camera by driving the PT heads to track potential intruders without operator intervention.

Thermal cameras are also used in conjunction with video analytics to identify unusual thermal conditions in the zone substation or to identify the presence of an intruder at night without artificial lighting.

Trigger mechanisms, either requiring existing interfaces or installed as part of the CCTV system must be considered in overall cost-benefit assessment of the surveillance solution.

7.5 Individual Camera Purpose

Following a clear statement of the CCTV System Purpose, CCTV requirements at each substation should be defined identifying; what is to be achieved, how maximum benefit will be derived from each camera and how an effective installation will be assessed. The purpose statement should include requirements in priority order, including:

Essential

- **Priority 1** – entire zone substation fence line to be able to confirm the presence of an intruder following PIDS alarms
- **Priority 2** – entries to zone substation buildings to confirm the presence of an intruder following a door switch alarm
- **Priority 3** – view of zone substation equipment (day time only)
- **Priority 4** – view of authorised personnel working in zone substation

Optional

- **Priority 5** – thermographic view of zone substation equipment
- **Priority 6** – view of zone substation area within boundary (daytime only)
- **Priority 7** – view of control room equipment (remote light switching)

- **Priority 8** – view of control room internal spaces (remote light switching)

7.6 Camera Locations

The design should provide a minimum number of strategically placed cameras to meet the purpose of the system. Below are the criteria identified for potential camera locations:

- primary purpose of the camera (what does the camera need to see);
- various target parameters (Identify, Recognise, Detect, Observe);
- field of view over which the camera will be able to achieve that performance;
- number of cameras required;
- potential variations in day and night lighting that will prevent effective camera operation;
- requirement for additional lighting;
- requirement for glare screens on the camera or nearby light fittings;
- temporary signage or foliage that will routinely affect the chosen field of view;
- protection against vandalism;
- power supply location;
- camera signal transmission path; and
- Camera fixing and support.

7.7 Equipment Hubs

A secure location is required for CCTV equipment including power supply, signal conversion or concentration points and server, storage and operator interface equipment within a controlled environment. External equipment cabinets need to be designed and located to provide maintenance access and environmental protection. Lockable cabinets are essential to provide security and maintain privacy of recorded images. External cabinets should ensure that the cabinet design takes into consideration the equipment rating to prevent failure on hot days. Internal cabinets should also be located to allow free airflow around the equipment to ensure that rated temperatures are not exceeded when control room air-conditioning is not running.

7.8 Signal Paths

A comprehensive understanding of existing communications infrastructure in the area of the CCTV cameras proposed to be installed must be developed, including;

- compliant cable pathways (ducts, pits, conduit) available;
- existing available optical fibre cabling; and
- available data networks for video signal transmission.

The condition and capabilities of the existing infrastructure shall be taken into consideration during the determination of the signal path from the cameras to the video equipment hub. Wireless connections should be considered if the cost of wired signal path proves to be prohibitive.

7.9 Monitoring

Depending on the identified risk and local security context, the CCTV system shall be required to:

- provide monitoring in real-time by an Operator;
- provide automated alarms;

- record to storage for retrieval only when necessary; or
- a combination of each.

Live monitoring provides intelligence for system operation enabling the use of fewer cameras watching wider areas. If a significant event occurs, the operator can adjust the field of view to follow a target, effectively going from *Detect* resolution to *Identify* resolution with the same camera. Cameras used in this manner also have the advantage of being able to adjust to available light levels depending on where the camera is pointing. A camera viewing a sunny or well illuminated streetscape will provide better image quality when subsequently directed to view a shaded scene under an awning or in a dark cross street than a single camera trying to view both scenes at once.

When used with motorised zoom lenses, content analysis software linked to camera PTZ control may approximate control of the cameras by a human operator. Live monitoring however has a high operational cost and the number of images able to be effectively watched by an operator is limited by number and duration. When unattended, a CCTV system designed for operator interactive control must default to a series of 'home' positions set as a compromise between wide area *Detect* and close up *Recognise* capabilities. Images recorded during these times may have insufficient resolution for Police purposes and while various automated video processing products are available to assist in this process, all rely on the wide area view to trigger camera movement.

In contrast, a system designed from the outset without operator intervention in mind, using automated alarming, may use a greater number of fixed cameras to provide the same level of surveillance. This removes the need for Operator intervention but increases the quantity of video data needing to be processed, analysed and stored.

7.10 Typical Configuration

7.10.1. Cameras

Camera connection to zone substation hub equipment may require signal conversion from analogue to digital (particularly for some thermal or thermographic cameras). Typical connections are as shown in Figure 11 including:

- Analogue connection via digital network;
- Digital camera via digital network; and
- Analogue camera via analogue connection.

Figure 10 - Dome and box style cameras

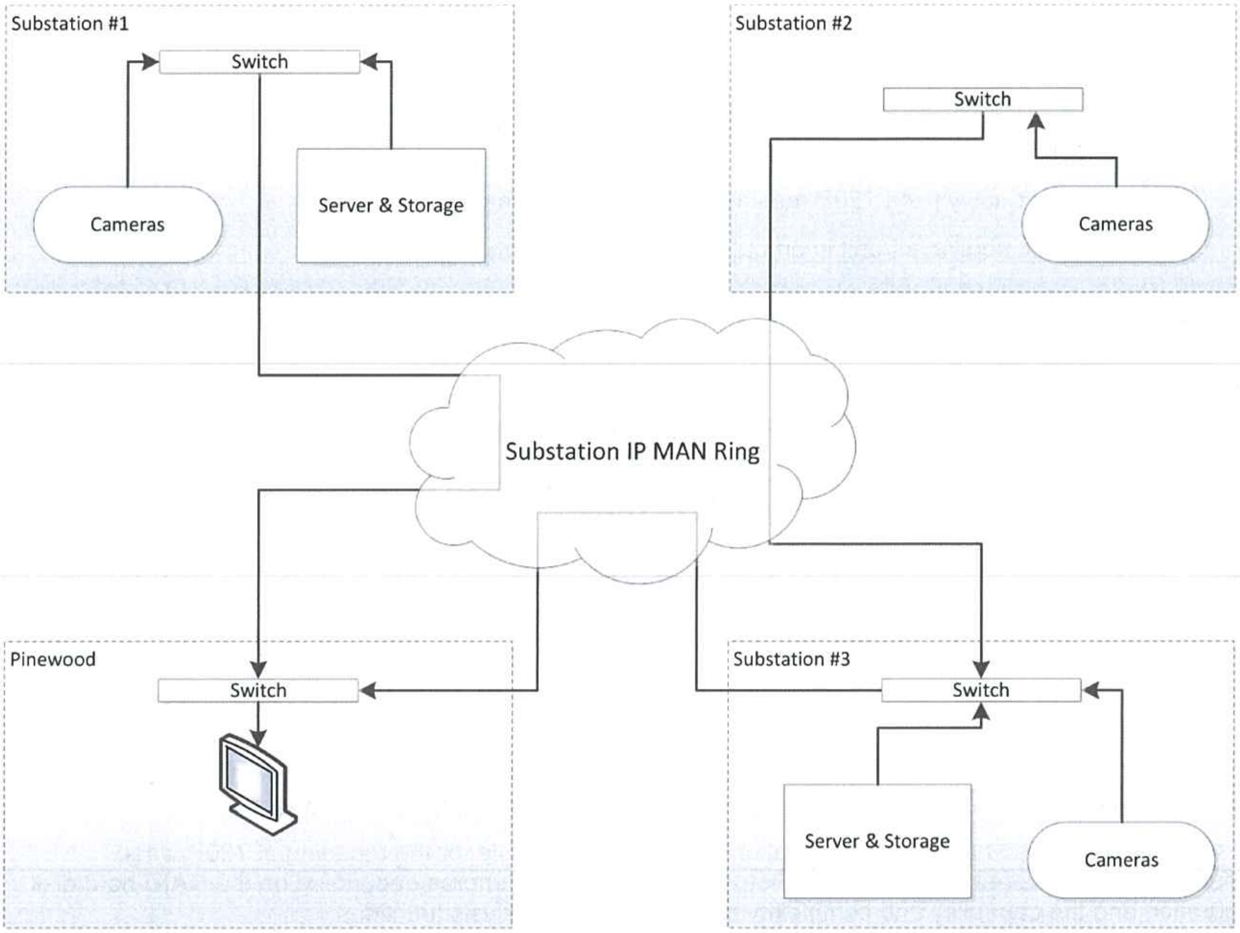
Figure 11 – Typical Camera – Equipment Hub Connections

7.10.2. Equipment Hubs

CCTV Equipment Hubs including video content analysis and storage capability may be provided in each zone substation. Locating CCTV Hub equipment in the zone substation minimises video traffic on the substation communications MAN and provides diversity for video storage and analysis functions. At smaller sites, optimum cost efficiency may be achieved by locating some or all of the associated CCTV Hub equipment at adjacent sites. Figure 12 provides the options available, showing:

- Substation with a local video server (video content analysis if required) and storage – Substations #1 & #3;
- Substation with remote Hub Equipment – Substation #2; and
- Remote Monitoring without local server or storage.

Figure 12 – Options for Substation CCTV Hub Equipment Location



8. Cost

8.1 Cameras

Typical costs vary substantially based on the purpose of the CCTV network and the type of equipment installed. Typical camera costs range from:

- $1k for a good quality fixed 720P resolution IP day/night camera through to
- Over $3k for an equivalent unit in an outdoor ruggedised housing

8.2 Thermal cameras:

- start at about $5k for a fixed 320 x 240 IP camera to
- over $30k for ruggedised outdoor units with precision PT heads

Thermal continuous zoom cameras are not common due to the high cost of zoom lenses made with IR transparent material. Thermographic camera costs vary depending on resolution and features but for 320 x 240 resolution units may vary from:

- $10k for OEM boxes to
- over $60k for outdoor ruggedised PT units.

8.3 Hub Equipment

As identified in section 5.6.3 Video Management Systems, system costs may be distributed across hardware costs or identified as separate components depending on the manufacturer sales model.

VMS server software and hardware combinations for systems suitable for the recoding of 720P video continuously from all cameras vary from $15k to over $30k for 16 cameras depending on the RAID hard disk configuration and the capability and complexity of video content analysis functions.

8.4 Associated Costs

Installation, operation and maintenance considerations extending beyond the actual camera and recording hardware include support structures, power and video cabling and enclosures and artificial lighting. Without thermal capabilities, CCTV installed for operational support or substation security requires artificial lighting to operate effectively at night. Both infrared (IR) capable and visible wavelength cameras require minimum lighting levels and maximum variances as prescribed by the manufacturer to ensure reliable observation of intrusion and plant events.

9. Rollout priorities

The following table summarises the results from United Energy's Network Infrastructure Audit - Annual Zone Substation Audit 2015 report [9] providing associated risk rating for each zone substation.

[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

It is intended that the strategy rollout be based upon the findings of this report. All critical or at risk zone substations would be prioritised and the order of rollout shall be based on the risk ratings.

9.1 Timeline and estimate

It is proposed that all the options identified below be rolled out progressively with reference to the rollout priority. As such, a 12 year rollout programme is envisioned:

[4] LD is rated lower due to the installation of CCTV at this site.

[5] Surrey Hills was not assessed due to the ongoing new transformer project. It is assumed to be up to current security standards.

Table 6 - Number of Zone Substations with CCTV Rolled out per year (North and South)

Year	No. of Zone Substations
2016	2
2017	4
2018	4
2019	4
2020	4
2021	4
2022	4
2023	4
2024	4
2025	4
2026	4
2027	3

The estimates for CAPEX and OPEX costs are listed in Table 7 below. A further breakdown of the capex costs from the preferred option are provided in Appendix A.

Table 7 - Estimate of costs per zone substation (per option)

Costs	Options	
	1	**2**
	Field Crew on site	**CCTV Deployment (recommended)**
CAPEX per site	$50,000	$300,000
OPEX per site	$1,200,000	$5,000

10. Needs Analysis

10.1 Context (Current State)

There is currently no fully operational ISSAM or CCTV system installed on any of United Energy's zone substation[6].

With regard to zone substation security, due to lack of perimeter security cameras which act as deterrents, there has been 27 reported attempted and successful equipment thefts in zone substations over the past 10 years.

Unauthorised access by public (intruders) into zone substation and coming into contact with HV/LV plant poses a safety risk with severe consequences (death or serious injury).

The break-ins resulting in theft of tools, portable assets and spares holdings in zone substations will have direct financial consequences as well as the potential to delay planned CAPEX. If the break-ins result in damage to zone substation assets or compromise the inherent safety of the zone substation assets then this will not only have financial consequences but could also disrupt supply (SAIDI) and make the zone substation environment unsafe for the intruder as well as unsuspecting personnel which may result in death or serious injury.

[redacted]

From 2012- 2014, there has been 29 safety incidents which have occurred within United Energy zone substations. There has been no video footage or records to enable United Energy to determine the sequence of event so as to learn from previous incidents or to provide evidence of process failures or failure to follow required work practices. There is also no record of access into zone substations if a person entering a zone substation fails to notify the control centre. This poses a safety risk as the person in question may not be aware of the safety hazards and the control centre has no means of knowing if anyone is in the zone substation to notify the person before undertaking switching.

In addition, there are no thermal monitoring of the zone substation assets that could otherwise potentially prevent significant asset failures by providing early alerts (i.e. expensive transformer failure).

10.2 Strategic Objectives & Assessment Criteria

10.2.1. General Strategic Objectives

United Energy is committed to maximising the long-term value of our stakeholders' investment in a legally and environmentally compliant, safe and sustainable manner through a structured framework for stewardship of the network over its total life cycle. The following key asset management objectives have been set to ensure that corporate requirements are met:

- Employ good industry asset management practice to prudently manage the assets over the total life cycle, without compromising the health and safety of our employees, stakeholders or the public.

[6] Lyndale (LD) is currently a pilot site for the evaluation of CCTV technology.

[redacted]

- Ensure compliance with applicable laws, rules and regulations.
- Undertake all activities and execute our obligations in adherence to good industry practice.
- Be prudent and efficient in the deployment of capital to optimise the performance of the business in the long term for the benefit of all stakeholders.
- Prudently manage reasonably foreseeable and credible hazards and risks to As Low As Reasonably Practicable (ALARP) by maintaining a robust and transparent framework to ensure a systematic and strategic approach for the continual identification, management and mitigation of risk.
- Build our reputation with customers and key stakeholders by striving for innovation, safety and excellent customer service in the face of increasing customer and community expectations.
- Undertake continuous improvement, through constant and timely review of asset management practices.
- Engage in all relevant industry issues to ensure that the business, its stakeholders and customers positions are well understood and effectively represented to deliver superior outcomes.

More specific objectives relating to this plan are contained below. These criteria shall be used to evaluate the various options available that satisfy the business requirements.

10.2.2. Specific Strategic Objectives

In this Strategic Direction Analysis Plan, United Energy is aiming to achieve the following:

- To improve the safety of its distribution network, i.e. reduce the risk of electric shock, electric burns and loss of life and injury in zone substations.
- To reduce the risk of widespread, more intense, long duration power outage(s) by remote monitoring of unauthorised access and intrusions.
- To improve the security of the zone substation and its assets by deterring unauthorised access and intrusions.
- To comply with all legal and moral obligations to minimise the above risks to as low as reasonably practicable.
- To achieve the above objectives using innovation and leadership to work intelligently in the best interests of all our stakeholders.
- To achieve the above objectives in a fiscally responsible way without dramatic increases in network expenditure that increase network tariffs which would not be supported by the majority of United Energy's customers (United Energy will leverage the capabilities of its fibre optic cable network).

10.2.3. Assessment Criteria

The following assessment criteria are proposed to assist in the comparison of the Options:

Table 8 - Assessment criteria used to evaluate options to meet the business objectives

Objective	Assessment Criteria
Health and safety	In accordance with United Energy's policy, health and safety risks and decisions to implement controls shall be assessed using a risk assessment. Where a risk exists and reasonable practicable controls are available to reduce or eliminate such risks then United Energy shall adopt the control.
Zone Substation Network Security	UE shall assess zone substation network security using risk based assessment.

Objective	Assessment Criteria
Cost Implications	The cost implications of each option should be quantified.
Innovation	Where options exist for problems that require the trial of new technology or unproven methods United Energy shall downplay the risks associated with start-up costs and potential failure and shall focus on the potential upside. This will ensure United Energy remains innovative.
Overall assessment	The options should be assessed using a discounted cash flow analysis. The final decision to implement options shall consider economic drivers but shall also consider minimisation of health, safety and environmental risk in accordance with the risk assessment.

11. Option Evaluation

11.1 Options Identification

Option 0 - Business as Usual

The status quo option means continuing to rely solely on existing zone substation security arrangements and hand held thermo image scanning. Status quo does not resolve the existing risk and issues faced by United Energy as mentioned previously. It is considered unacceptable to persist with the status quo while a practical and cost effective alternative option exists.

Option 1 - Dedicated Field Personnel on Site

By having dedicated field personnel on site, many of the risks as identified above can be addressed. Zone substation security will be enhanced as the duty officer will be present as both a deterrent and a response. Field data will be more readily and speedily available as the duty officer would be able to directly obtain data from the field devices. Response to certain faults and incidents at the zone substation would also be improved. The field personnel will be able to provide additional information to the control room to enable a more informed decision to be made.

This option requires United Energy to have at least an extra 138 employees. This is based on the assumption that every zone substation would have at least 1 person on site per shift with 3 shifts of eight hours each day. A pool of additional staff may also be required to ensure that all critical zone substations are fully staffed. Further facility upgrades will be required to accommodate these field personnel.

Option 2 - Installation of CCTV

In this option CCTV is to be rolled out to all zone substations classified as critical. United Energy will possess the capability of automated monitoring and alarming of the zone substation. Zone substation security will be improved with the CCTV system. United Energy would also be able to remotely identify faults, audit work practices and have video recording of safety incidents and intrusions in the zone substation.

There would not be any need for additional operators for the implementation of the CCTV system. The CCTV system shall be integrated into United Energy's SCADA system and it will be accessible to the controllers in the control room. The CCTV rollout will be able to utilise existing infrastructure put into place for the Lyndale (LD) CCTV trial.

11.2 Option Feasibility Analysis

Option 0 – Business as Usual

As described in the preceding section the status quo to continue with business as usual (BAU) is not recommended however this option has been included as the basis to compare alternative options.

Table 9 - Assessment of Option 0 - Business as Usual

Objective	Assessment
Health and safety	The BAU option does not address the risks as outlined above. No video recording of safety incidents will be available. The Control centre will not be aware of situations in the zone substation which could include injured or unconscious personnel and personnel who have not reported to the control centre on entry but are in the vicinity of equipment the controller intends to operate.
Zone Substation Security	The BAU option does not improve on current security measures. Zone substations remain prone to unauthorised access and theft.
Cost implications	The BAU option retains the status quo.
Innovation	BAU is not innovative and does not demonstrate leadership to address the problems and risks United Energy faces.
Overall assessment	The option is not feasible as United Energy would remain vulnerable to the risks highlighted.

Option 1 – Dedicated Field Personnel on Site

Table 10 - Assessment of Option 1 - Dedicated Field Personnel on Site

Objective	Assessment
Health and safety	Having field personnel on site would provide a heightened level of awareness about the situation in the zone substation. Field personnel will be able to ensure safety rules and safe work practices are adhered to. However, having a person on site at all times increases the exposure to the inherent risk of being in a zone substation. No video recording would be available for post incident review.
Zone Substation Security	Field personnel on site would increase the security at zone substations. Patrols by the field personnel will act as a deterrent, providing rapid detection and response against unauthorised intrusion. However, personnel will be placed at risk if intruders are aggressive or well-armed. Theft would be reduced.
Cost implications	Having dedicated field personnel on site substantially reduces the security risk. However, United Energy is exposed to more safety risk with someone permanently at a zone substation. In terms of cost efficiency, the cost of manning each zone substation is prohibitive.
Innovation	This option is not innovative and does not demonstrate leadership to address the problems and risks United Energy faces.
Overall assessment	This option is not cost effective. Despite having the lowest upfront cost, throughout the present value, the total cost is the highest due to the high OPEX required.

Option 1 addresses the risk of security at zone substations. Nevertheless, having field personnel at the zone substation increases the risks of a safety incident event occurring at the zone substation.

The cost of employing such a crew to be stationed at every zone substation is prohibitive. It is envisaged that 3 lots of eight hour shifts would be required to ensure the zone substation is manned at all times, which is comparable to having CCTV installed. The following shows that salary expenses required to man a zone substation at all times is approximately $3050 per day and these figures do not include meal and other special allowances. The annual cost to have dedicated field personnel at a single site at all times will amount to approximately $1,200,000:

- **Shift 1:-** 7AM to 3PM = 8 @ normal rate ($100) = $800

- **Shift 2:-** 3PM to 11PM = 3 @ normal rate ($100) + 5 @ 150% of normal rate = $1050
- **Shift 3:-** 11PM to 7AM = 8 @ 150% of normal rate $1200
- **Annual leave** for three field personnel per year = $800 x 3 x 28 days = $67,200

The need to have a workforce of at least 138 employees to ensure all United Energy zone substations are manned is also impractical. In order to gain from the benefit as listed above, it would be extremely difficult to recruit people with the required skills. The field personnel must be trained to perform as a security guard, safety observer, operator or substation tester. It is unlikely that there are many in the workforce who possesses such a skillset. This will require United Energy to hire additional personnel in order to gain the benefits listed above. It should also be noted that even if such a workforce existed, it is an inefficient use of resources.

It is therefore not economic to have field personnel stationed at every zone substation.

Option 2 – Installation of CCTV

Table 11 - Assessment of Option 2 - CCTV complete with thermographic cameras

Objective	Assessment
Health and safety	CCTV would be able to monitor and alarm the current situation at the zone substation in real-time. Any safety incidents would be recorded. Safety audits could also be performed remotely.
Zone Substation Security	Zone substation security will be enhanced. The presence of CCTV will be a deterrent against any potential criminal activity. The CCTV system will be able to detect intrusions and respond accordingly with and without operator intervention. There will also be security footage of any thefts at the zone substation which will increase the probability the culprit will be arrested.
Cost implications	United Energy's risk exposure to safety lawsuits and security threats would be substantially reduced. Therefore the potential risk from lawsuits and fines are reduced.
Innovation	CCTV technology is widely used in zone substations worldwide but usage of thermographic cameras are still comparatively limited. United Energy is currently the only electricity distributor in Victoria investigating the use of thermographic cameras.
Overall assessment	This option has the lowest present value cost of those options that are feasible. This option also provides the most benefits as compared to the other options considered.

The installation of CCTV would enable United Energy to maintain safety and security at zone substations in an environment characterised by heightened risk. Cameras can motion detect and record all activity within the defined zone substation perimeter, providing automated alarming. CCTV will actively deter possible intrusions and will assist in identifying intruders. Any cost associated with the theft, property damage, law suits for intruder injury and loss of time to investigate an incident may all be avoided by using video footage as valid evidence in a court of law.

In addition, CCTV recordings can also be used during fault investigations to determine the events leading up to the incident and also improve the effectiveness of remedial action. In the event of an emergency such as a bushfire or blocked access, the CCTV system will be able to provide remote monitoring and inspection without placing staff at risk.

In relation to safety, CCTV will enable the control centre to quickly locate personnel in cases where any individual was injured or rendered unconscious working alone in the zone substation. Footage of any safety incidents would also be recorded and more effective measures or procedures can be taken to prevent the safety incident from reoccurring. Safety audits can also be done more effectively to ensure that United Energy work practices are being followed.

11.3 Option Evaluation

The tables below provide a summary of the project costs of delivering Options 1 and 2, together with an overall evaluation.

Table 12 - Comparison of costs of options

	Business as Usual	Option 1: Dedicated Field Personnel on Site	Option 2: Installation of CCTV
Capital expenditure per site	0	$50,000	$300,000
Operating expenditure per site per year	0	$1,200,000	$5,000

The table above shows that Option 2 (with a capital investment of $300,000 per site, plus an annual operating cost of $5,000) is clearly more cost effective than Option 1 (which involves annual operating expenditure of $1.2 million plus an initial capital investment of $50,000 per site).

Option 2 is preferred, on the basis that it minimises total costs.

For options 1 and 2, a modest benefit per site is expected as a result of reduced theft. There have been 27 thefts in zone substation across a 6 year span. On average every event costs approximately $26,000 on average (inclusive of stolen material, cost of loss of time, labour and material cost to repair any damages). However, the inclusion of this benefit does not affect the selection between Options 1 and 2, as it is common to both Options.

The table below shows an overall assessment of the options.

Table 13 - Overall Option Assessment

	Business as Usual	Option 1: Dedicated Field Personnel on Site	Option 2: Installation of CCTV
Obligation			
Maintain safety	Not satisfied	Partially Satisfied	Satisfied
Feasible Option	No	Yes	Yes
Ranking of options	3	2	1

11.4 Recommendation

In summary, Option 2 - Installing CCTV - is the most economic option. This option satisfies our statutory and regulatory obligations at the lowest present value cost.

It should be noted this project is part of a portfolio of measures, which together will ensure that UE complies with its safety obligations, including ALARP. Option 2 will only proceed if it is ranked ahead of other safety projects, as detailed in UE's Network Safety Assessment.

12. Risk Assessment

Table 14 - Health and Safety

Health and Safety Risks	Option 0 - BAU			Option 1 - Dedicated Field Personnel			Option 2 - CCTV		
Risks:	Likelihood	Consequence	Risk Rating	Likelihood	Consequence	Risk Rating	Likelihood	Consequence	Risk Rating
Electrocution and other injuries	2	3	M	3	3	[redacted]	1	3	L
Electrocution - death	2	4	[redacted]	2	4	[redacted]	1	4	M
Legal Liability	2	4	[redacted]	2	4	[redacted]	1	4	M

[redacted]

12.1 Timing Analysis

It is proposed that the rollout of CCTV commence in the 2015 - 2016 FY. A proposed timeline is listed in Section 9.1 Timeline and estimate.

Option 2 works should commence in the 2015 - 2016 FY after successful completion of the Lyndale trial with a staged rollout to zone substations over several years.

13. Risk Analysis

13.1 Business / Network Risks

Refer to section 12 for an assessment of the residual risks and risk reduction afforded by each of the considered options.

13.2 Sensitivity Analysis

The key assumptions behind the analysis of the assessment criteria are subjected to a sensitivity analysis in this section.

13.2.1. Safety

Optimistic Scenario - Increased automation

In the optimistic scenario, visits to zone substations are increasingly done by drones or remote controlled robots (assuming this technology becomes more economically viable). This would significantly reduce the risk posed by zone substations to personnel safety. Certain task could be done without the need of human intervention and site visits could also be done remotely.

Nevertheless, a human presence would still be necessary from time to time and the benefits provided by having someone on site or a CCTV system is still applicable but the benefit is reduced. It is concluded that the increased automation would not have a significant impact on the safety benefits from proceeding with the recommended option.

Pessimistic Scenario - Increased safety incidents at zone substations

The pessimistic scenario will further highlight the need for further action taken to address safety at zone substations. It is expected with increased safety incidents, there would be extra scrutiny from safety regulators such as the ESV, WorkSafe and also media outlets. This may also result in industrial action for steps to be taken to improve safety. As such, this scenario is detrimental to United Energy. Therefore, the need for having CCTV is further highlighted.

13.2.2. Security

Optimistic Scenario - Terrorist threat neutralised and reduced criminal activity

The reduction in a terrorist threat and criminal activity will reduce the benefits of having CCTV installed in zone substations. However, security threats and criminal activity are persistent and CCTV will still provide benefits from a security standpoint (inclusive of monitoring the entry and exit of personnel).

Pessimistic Scenario - Increased terrorist threat and criminal activity

The pessimistic scenario will further highlight the need for further action taken to address the security at zone substations. The increased threat would attract government attention to maintain the integrity of the electricity network. Increased theft and sabotage would also result in substantial costs to United Energy from both material lost and potential death or injury of unauthorised parties gaining access to zone substations. Therefore the installation of CCTV would be beneficial.

13.2.3. Cost

Pessimistic Scenario - Increased Costs

An additional 10% increase of total cost would still be a cost effective measure considering the benefits provided from having CCTV at zone substations.

13.3 Risk Analysis – Option 2 Deployment

Risks have been evaluated in accordance with United Energy's risk management framework (version 2.1, dated January 2015). Undesirable and hazardous scenarios are identified and the risks are quantified according to the table below based on the consequence and likelihood of an undesirable scenario occurring.

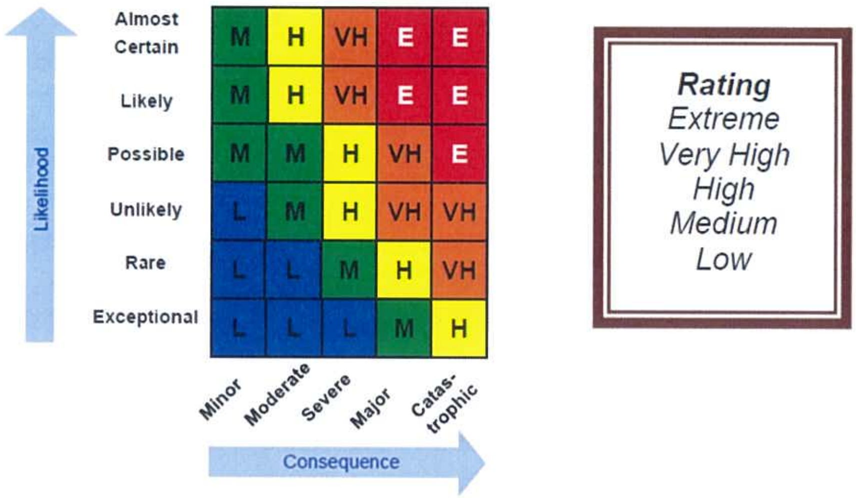


Figure 13 - Risk Rating Matrix

The following risks associated with the implementation of CCTV have been identified:

Table 16 - Strategy Implementation Risks

Risk	Consequence	Likelihood	Risk	Comments
Privacy Intrusion	3	4	High	The installation of CCTV might potentially be in violation of the privacy rights of staff members and stakeholders at zone substations. May attract complaints from neighbours and council which may result in negative media attention.
Data Loss or malicious use	2	3	Medium	Sensitive data recorded by the CCTV may be lost or stolen due to hacking, natural disaster or human error.
Loss of trust and confidence of staff	3	3	High	The trust and confidence of employees and/or contractors may potentially be affected due to the perceived lack of trust from United Energy.
False positive of intrusion	1	4	Medium	Animal or other objects triggering nuisance alarms, resulting in controller's time wasted and lack of confidence in system.
Communication System performance impact	3	3	High	Data generated by the CCTV system might impact the performance of the communications network and SCADA system.

13.4 Risk Treatment – Option 2 Deployment

This section will identify how the identified risks and sensitivities above will be treated.

Table 15 - Risk controls

Risk	Treated Risk			Control
	Consequence	Likelihood	Risk	
Privacy intrusion	3	2	Medium	Implement a comprehensive policy and procedure around the implementation of the CCTV system to ensure that privacy rights are not breached. Provide the provision for removal of sensitive data.
Data loss or malicious use	2	1	Low	Implement a comprehensive security policy and procedure. Maintain multiple backups and employ strong encryption of data and user access. Ensure access to sensitive data is restricted.
Loss of trust and confidence of staff	3	1	Low	Communicate the purpose and benefits of installing CCTV at zone substations to all relevant parties. Organise stakeholder consultation to understand and address the concerns raised by staff.
False positive of intrusion	1	2	Low	Ensure system requirements are clearly defined and documented. Work closely with the vendor to fine tune and optimise the configuration, ensuring extensive testing and evaluation to reduce false positives.
Communication system performance impact	3	2	Medium	Configure the system to reduce the volume of traffic and only send information when an incident occurs. Co-ordinate the rollout with communication networks rollout to ensure there is sufficient bandwidth at each site.

14. Recommendation

The purpose of this document is to determine the most efficient and effective way to maintain zone substation safety and security against a background of increased risk.

Within this document feasible options have been identified and evaluated. These options include having dedicated on site field personnel and the installation of CCTV at critical zone substations. Each option has its own advantages, but the CCTV option has been identified to provide the risk reduction required at the lowest possible cost.

While CCTV has some remarkable features, on its own it is not the silver bullet which will eliminate all risks. A comprehensive approach to security and safety is required to deter and detect any intrusions into zone substations and ensure that safe work practices are adhered to. Therefore this strategy recommends that United Energy:

- Not proceed with **Option 0** – Business as Usual
- Not proceed with **Option 1** – Dedicated Field Personnel
- Implement **Option 2** – CCTV Implementation

It is recommended that the rollout and management of the CCTV system be closely co-ordinated between the United Energy Primary Assets team, Secondary Assets team, the Control Centre and the Manager Emergency & Security.

Appendix A - Supporting Information

A1: Scope of Works

A brief scope of works for the recommended option to install CCTV is contained below.

- The design shall ensure that each camera is positioned in the most optimal location to achieve United Energy's objectives. Any civil works are to be done as necessary.
- The procurement of all necessary equipment such as cameras and video appliances.
- Make all necessary changes to United Energy's network infrastructure including modifying the firewall rules to accept traffic from the Intelligent Video Appliance (IVA) installed at the zone substation. Existing server hardware shall be utilised for the system management server (SMS - VMS) and any other software required to manage and support CCTV.
- A web based CCTV interface shall be made available to users on the United Energy corporate network.

A2: Governance

The Asset Management group is responsible for developing and maintaining the CCTV strategic direction analysis plan (this document), preparing and submitting regulatory submissions and seeking budget, preparing business cases to justify individual projects, preparing scopes of work and technical standards and for the initiation of individual works and the general management of the program. The Asset Management group also has ultimate responsibility for approving the selection of plant and equipment and third party service providers outside the OMSA. The strategy has been developed based on information known at the time however it is subject to review and possible change. The timing of works or options selected could vary depending upon circumstances.

The Service Delivery group is responsible for fulfilling the capital and maintenance works plans in a timely manner, managing the defects and control processes, and maintaining the relationship with Service Providers to ensure they effectively manage the CAPEX works and the day-to-day operation of the network.

Service Delivery and the Health, Safety and Environment and Work Practices groups are responsible for implementing United Energy's Health, Safety and Environment policies, and administering the work manuals and competency certification of contract staff.

A3: Financial Evaluation

financial project ranking based on Capex and Opex costs for implementation of the system in 20 substations until 2020.

Table 16 **Financial Summary**

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]

A4: Budget Estimate and Works Program

The estimated cost of installing CCTV at a zone substation is:

[redacted]

[redacted]	[redacted]
[redacted]	[redacted] [redacted] [redacted] [redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

Appendix B - Abbreviations

The following abbreviations are used throughout this document.

Abbreviation	Description
AGL	Above ground level
AS/ANZ	Australia/New Zealand
AVC	Advanced Video Coding
CAP	Critical Asset Protection Pty Ltd
CAPEX	Capital Expenditure
CCTV	Closed Circuit Television
CPTED	Crime Prevention through environmental design
Codec	Video encoder/decoder
DVD	Digital Video (Versatile) Disk
ENA	Energy Networks Association
EMI	Electromagnetic Interference
HD	High Definition
ICT	Information & Communication Technology
IEEE	Institute of Electrical and Electronic Engineers
IP	Internet Protocol
IR	Infrared
ISSAM	Intelligent Secure Substation Asset Management
ISO	International Organisation for Standardisation
lx	lux (unit of illumination)
MAN	Metropolitan Area Network
NER	National Electricity Regulations
NERC	North American Electricity Reliability Corporation
NT	Northern Territory
DVR	Digital Video Recorder
NVR	Network Video Recorder
PV	Pivotal Vision LLC (US)
OPEX	Operational expenditure
ONVIF	Open Video Interface Forum
PIDS	Perimeter Intrusion Detection System
PoE	Power over Ethernet
PIR	Passive Infrared
PT	Pan-tilt
PTZ	Pan-tilt-zoom
RAID	Redundant Array of Independent Disks

Abbreviation	Description
RFI	Radio Frequency Interference
RTU	Remote Terminal Unit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
STPIS	Service Target Performance Incentive Scheme
SCADA	Supervisory Control and Data Acquisition
UE	United Energy
UK	United Kingdom
USA	United States of America
USB	Universal Serial Bus
VMS	Video Management System

Appendix C - Citations

[1] United Energy, "UE PL 0003 - Network Infrastructure Security Plan," 2015.

[2] CIGRE Australia Panel, "B3 Substations," 2010.

[3] Transend, "Review of Transend Transmission Network Revenue Proposal 2009-2014," 2008.

[4] Electra SA, "Substation Design Manual 122".

[5] North America Electric Reliability Council, "Physical Security Guideline," 2012.

[6] North America Electric Reliability Council, "An Approach to Action for the Electricity Sector: Critical Infrastructure Protection," 2001.

[7] IEEE, "Guide for Electric Power Substation Physical and Electronic Security," 2008.

[8] United Energy, "UE -PZA-S-14-011: Lyndale (LD) Zone Substation CCTV Trial," 2013.

[9] United Energy, "Network Infrastructure Audit - Annual Zone Substation Audit 2015 Report," 2015.

[10] State Government of Victoria: Department of Premier and Cabinet, "Critical Infrastructure Resilience Interim Strategy," 2013.

[11] Australia Energy Market Commission (AEMC), *National Electricity Rules,* V66.