ELECTRICITY ASSET MANAGEMENT PLAN

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EXECUTIVE SUMMARY
WHAT IS THE AMP?

The Asset Management Plan (AMP) is a document which outlines Vector's investments, strategies, and approach for managing our electricity network assets for the benefit of the Auckland energy consumer, for the period 1 April 2018 to 31 March 2028.

The investments we plan to make, set out in this 2018 edition, are essential to achieving our vision to create a new energy future for Aucklanders. They are borne from Vector's need to ensure we:

- Address the impact of increasingly disruptive technology;
- Meet the ever-changing needs and demands of our customers;
- Provide a reliable and secure service for distributing electricity throughout Auckland and elsewhere; and
- Ensure our assets and infrastructure are fit-for-purpose in a rapidly-changing operating environment.

PURPOSE OF THE AMP
As the country's leading electricity distributor, Vector recognises that how we plan, upgrade, and manage both our network and our capability to provide electricity impacts the people and businesses we serve.

This 2018 AMP provides the context and details of our investments and asset management strategies for our electricity network, as well as our increasingly important Information Technology (IT) and digital infrastructure strategy. It explains how we will develop, upgrade and maintain our assets, and foster technological and environmental changes to enable a new energy future.

The objectives of our AMP are to:

- Be transparent with our customers and stakeholders about our plans and investments for the network;
- Detail the projects, improvements, and trials already underway;
- Foster an understanding of about how our asset management approach works by providing details about our assets and Vector's plans and objectives for them; and
- Explain how these plans and strategies align with our corporate mission to bring about a new energy future for Auckland.

AMP PLANNING PERIOD
The AMP covers the 10-year planning period as prescribed by the Commerce Commission's Information Disclosure Determination to meet our obligations as a regulated business.

Vector provides a greater level of detail on the company's strategies and investments for the first three years of this period. The reasoning for this approach is as follows.

Today's electricity environment is more uncertain than at any other point in time since mass consumer electrification. The rate of Auckland's growth; the exponential impact of maturing alternative energy technologies; new energy innovations both in technical capability and cost of production; changing consumer preferences and behaviours; the need to upgrade or maintain older network assets; and the impact of climate change on weather conditions, are all creating more uncertainty for previously settled electricity system asset management strategies.

We believe our planning horizon must be shortened, with more regular planning interventions and smaller-scale investment required to pre-empt and respond to scenarios as they emerge. This is the best way to avoid suboptimal or over-investment in traditional assets and aging technology with poor customer outcomes.

We won't answer the electricity system issues of tomorrow by relying on previous asset management strategies. Meeting the future needs of Auckland is not about continuing to invest in more traditional assets. A more effective approach requires us to reinvent ourselves as agents of change and facilitators of integration.

Distributed generation, customer-owned Distributed Energy Resources (DERs), smarter distribution technology, and advanced analytics give us an opportunity to access new options and choices. The challenges of tomorrow lie in how we build revolutionary energy systems that are highly effective, faster, smaller, more economical, and provide environmental and social benefits.

It is for these reasons that Vector insists that this edition of the AMP is not used by the Commerce Commission as the final forecasts for the setting of Vector's Default Price Path (DPP) from 1 April 2020. Given the uncertainties explained above and in Section 1.9, Vector is currently developing sophisticated scenario models to provide more robust future load and expenditure forecasts. These scenario models will be much more advanced and developed in one year's time, and therefore Vector's 2019 edition of the AMP will be far better suited to providing the load and expenditure forecasts required by the Commerce Commission for setting the DPP. In one year's time, it is also likely that more certainty on the low user fixed charge regulations and tree regulations will be known. These regulations have significant impacts on future forecasts, providing further support for the 2019 AMP to be used (rather than the 2018 AMP) to inform the DPP.

This AMP was certified by Directors on 1 May 2018. On 26 March 2018 the Commerce Commission granted Vector an extension to the date for filing the 2018 AMP from 31 March 2018 to 01 May 2018.

SECTION

01. INTRODUCTION

SECTION 1. INTRODUCTION OUR NEW INVESTMENT APPROACH

1.1 OVERVIEW

The electricity sector is being increasingly disrupted by a number of forces. Vector's core business is to supply electricity to Auckland safely, reliably, and efficiently. This responsibility is unlikely to ever change, but the way people and businesses in Auckland want to use and interact with electricity is.

Feedback from our customers clearly underscores the need for us to move forward with flexibility and careful investment. Average household energy consumption has been declining by one percent year-on-year for a decade as dwellings become smaller, building standards improve, insulation penetration increases, we incorporate more energy efficient appliances and lighting into our homes and businesses, and responsive technology delivers new energy solutions.

Auckland is one of the fastest growing and most diverse cities in the developed world. At the same time as we experience this population growth and new wealth for the region, we also face a world where technology is advancing quickly in the energy sector.

Consumer expectations around choice, control, and experience are rapidly increasing. They are no longer passive users of electricity. This is accelerating the take-up of new technologies like solar panels, electricity storage, and Electric Vehicles (EVs).

The uptake of new electricity technology may have unintended consequences on Vector's network. New technologies could shorten the life cycles for other parts of Vector's network. The new technology is inverting the traditional assumptions around unidirectional electricity flows and electricity consumption.

The cost of solar panels and power batteries are expected to rapidly decline over the planning period of this AMP, which will likely result in more homes and businesses purchasing and using them. This will therefore change the way energy is generated, distributed, and used throughout Auckland. EV ownership is also expected to rise dramatically over the same period, putting added pressure on Vector to accommodate the energy they require to charge and discharge into the network.

Maintaining, replacing, and upgrading our network's physical assets (like power poles, cables, and transformers) while electricity consumers and consumption patterns are changing, is a new complication for electricity distribution asset management. Investments must be planned at a time when there is more uncertainty now than ever before.

At the same time, the condition and health of the infrastructure essential to distributing electricity will continue to degrade over time. Ongoing replacement or maintenance work on our network is essential to ensure the infrastructure remains safe and fit for purpose.

Complementing new energy customer innovations are new capabilities required for network management. The Internet of Energy and artificial intelligence technologies for networks provide significant opportunities for Vector to deliver more resilient, intelligent, and cheaper services to our customers, as well as open the sector to more competition for the benefit of customers.

In such an uncertain and rapidly changing environment, Vector's approach to planning must now allow for shorter horizons, greater uncertainty, and the flexibility to respond to changes quickly and efficiently. This will aid Vector in avoiding poor investment decisions and worst-case performance outcomes, as well as maximise the benefits to customers of these new energy technologies.

In short, we find ourselves increasingly planning for a more software-driven world that is based on probabilities, rather than the traditional working environment we have come from. A new approach is required.

We explore the trends that are driving the need for a new approach in the following sections.

CUSTOMER AND COMMUNITY GROWTH

Vector plays an integral part in allowing for economic growth and social prosperity in the Auckland region. Auckland has experienced high and sustained levels of population and economic growth in recent years. This has translated into higher demand and satisfaction levels from our customers (see Section 1.5). Connecting new power points to our network and relocating assets is at an all-time high thanks to significant construction activity and housing development.

Vector's network is under pressure from the growth in the number of people and businesses demanding electricity connections. Our network needs must reasonably manage customer growth without compromising resilience where the pockets of growth are causing strain.

To meet this growth, Vector has plans to:

- Extend and augment the network to meet demand;
- Improve the network's topology and functionality;
- Increase capacity to maintain and enhance network reliability; and
- Develop a more intelligent, connected and aware network (an internet-based energy platform).

We further set out our planning and strategy to support our growing region in SECTION 3, Asset Management Systems.

NEW AND EMERGING TECHNOLOGIES

New and emerging technologies are reshaping and restructuring the entire power sector.

We expect the usage of these technologies to rise over the next few years as prices reduce and they become more accessible and available to our customers. These technologies include:

- EVs and Autonomous Vehicles (AVs);
- Solar panels;
- Power storage batteries;
- Other DERs; and
- Energy management solutions in the home.

These technologies provide benefits for our customers and the community, but also add complexity to how we manage and deliver electricity to people and businesses. Changing power flows, higher demands for electricity at busy times, network security, and the risk to our network's resilience need to be addressed and planned for what will be a more democratised and multi-directional energy eco-system. We need to better understand the impact that these technologies will have on our network, and how we can accommodate them to the benefit of our customers.

In this AMP are included the plans, strategies, and proof-of-concept trials Vector will conduct to better understand and accommodate these technologies on our network. Taking this action now, rather than adopting a reactive approach to their integration, completes Vector's vision of creating a new energy future. For example, the Tesla Powerpack battery storage system we installed at the Glen Innes zone substation has reduced daily peak demand by up to 13%[1] at this zone substation.

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1 Vector, "Creating a New Energy Future," August 2017. Sourced from Vector Annual Report.

RESILIENCE AND SAFETY

As Vector provides critical infrastructure for a functioning modern city, it is imperative that we continue to invest in assets like our power poles, electricity lines, substations, transformers, and supporting IT and digital infrastructure, to ensure that their performance is reliably, safe, and more resilient in the future.

We responsibly manage our assets over their full lifecycle to avoid failures causing interruptions in the supply of power to our customers, pose hazards to our staff, contractors, and the public, or harm the environment. Vector has identified and initiated projects over the next decade that will both help to alleviate performance issues and deliver our new energy vision.

However, forces outside of our control (like extreme and destructive weather events) pose a significant risk to the resiliency of our network and current infrastructure. Vector is committed to future-proofing the network beyond further investment in traditional infrastructure, and is actively pursuing new technology that supports communities during extended outages. Examples of this are Kawakawa Bay and Wellsford, where Vector is building two micro grids that will be powered by solar panels and supported by diesel generators.

Some other key projects include:

- Upgrades and developments to zone substations where the ability to provide consistent electricity supply may be challenged;
- Battery energy storage (BESS) in rural areas affected by numerous extended power outages;
- The roll out of high-voltage cables in Auckland's Central Business District (CBD), to expand our capacity to meet growing volumes of electricity in the area; and
- Investment in key supporting IT and digital infrastructure.

Further details of how Vector will administer a safe, secure, and resilient network is described in SECTION 3, Asset Management System.

SUSTAINABILITY

To meet the current needs of our customers without compromising future generations, it is imperative for Vector to strike the right balance between the environment, society, and the economy.

Vector has established a robust sustainability framework to guide the Company. This includes:

- Clear minimum expectations for all of Vector's activities, based on the United Nations Global Compact;
- Activities that work towards the Company achieving the Paris Climate Commitments;
- Identifying opportunites to contribute to the United Nations Sustainable Development Goals;
- The completion of a detailed assessment of the impact of climate change on our network; and
- The adoption of several management actions to prepare the Company for change.

Climate change forms a significant component of our sustainability commitment. Vector is committed to achieving net zero emissions by 2030 for its own emissions, as well to support the energy and transport sectors to reduce emissions.

Several aspects of our AMP work together to allow Vector to implement strategies that will deliver a more sustainable, energy efficient, and resilient network. How our AMPs contribute to Vector's sustainability commitments can be found in SECTION 3.

1.2 EXPENDITURE FORECASTS

The investments being made into the projects and programmes for the AMP period (see SECTION 5) are planned with the considerations described above to deliver benefit to our customers and improve network reliability, performance, and safety in an efficient manner. Our planned Capital (CAPEX) and Operational (OPEX) expenditures are set out in detail in SECTION 5 of this AMP, and summarised in Table 1-1 and Table 1-2, respectively for FY19 to FY28.

FINANCIAL YEAR ($000)

AMP18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Consumer connection	66,203	65,760	62,779	61,731	58,093	57,093	57,093	53,506	53,465	53,465	589,190
System growth	50,241	41,225	32,575	45,190	52,984	37,823	35,675	46,486	54,262	59,762	456,223
Asset replacement and renewal	89,408	96,840	93,509	106,670	103,399	106,056	99,205	98,445	101,011	99,834	994,376
Asset relocations	17,883	17,626	17,807	17,729	17,560	17,410	17,500	17,500	17,500	17,500	176,014
Reliability, safety and environment:	0	0	0	0	0	0	0	0	0	0	0
Quality of supply	0	0	0	0	0	0	0	0	0	0	0
Legislative and regulatory	0	0	0	0	0	0	0	0	0	0	0
Other reliability, safety and environment	2,700	2,450	2,050	2,050	2,250	1,284	1,050	1,050	1,050	1,050	16,984
Non network asset	18,498	12,215	17,332	18,059	18,723	18,299	14,018	12,991	11,573	11,379	153,088
Total CAPEX	**244,933**	**236,116**	**226,052**	**251,429**	**253,009**	**237,965**	**224,541**	**229,978**	**238,861**	**242,990**	**2,385,875**

Table 1-1 CAPEX for FY19 to FY28

FINANCIAL YEAR ($000)

AMP18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Service interruptions and emergencies	12,862	12,952	13,457	13,548	13,640	13,732	13,826	13,920	14,015	14,111	136,063
Vegetation management	6,522	6,522	5,694	5,694	5,694	5,694	5,694	5,694	5,694	5,694	58,599
Routine and corrective maintenance and inspection	15,620	15,764	16,115	16,260	16,406	16,552	16,698	16,846	16,994	17,150	164,404
Asset replacement and renewal	15,303	15,362	19,770	19,853	19,938	20,022	20,108	18,123	17,162	16,196	181,838
System operations and network support	38,487	37,844	36,713	36,937	36,938	37,035	37,111	37,188	37,265	37,322	372,840
Business support	41,241	41,241	41,241	41,241	41,241	41,241	41,241	41,241	41,241	41,241	412,408
Total OPEX	**130,035**	**129,685**	**132,990**	**133,533**	**133,857**	**134,276**	**134,678**	**133,012**	**132,371**	**131,714**	**1,326,152**

Table 1-2 OPEX for FY19 to FY28

VECTOR OVERVIEW

1.3 COMPANY OVERVIEW

Vector owns and operates the largest electricity distribution network in New Zealand, supplying power to over 551,000 installed connection points (ICPs) throughout the Auckland region. Our network has 18,455 Kilometre (km) of electrical lines and supplied our customers with 8,302 Gigawatt Hours (GWh) of electrical energy in Regulatory Year 17 (RY).

Vector is one of the largest New Zealand Stock Exchange (NZX) listed companies. As well as electricity distribution, we have interests in reticulated and bottled gas, telecommunications, solar power, home energy systems, and energy metering in Australia and New Zealand.

Vector is majority owned by Entrust, a public entity which holds and manages 75.1% of shares on behalf of its beneficiaries – the residents of Auckland. The remaining 24.9% shareholding is listed and publicly traded stock on the NZX. The table below shows the interests of our main stakeholders.

STAKEHOLDER	MAIN INTERESTS
Customers	Service quality and reliability, price, safety, customer service, customer experience
Central and Local Government & Community	Sustainability, public safety, environment
Retailers	Business processes, price, customer service
Regulators	Compliance with Regulations
Employees	Safety, training, remuneration
Transpower	Performance, compliance
Entrust and Investors	Efficient management, financial performance, governance

Table 1-3 Vector's stakeholders

1.4 OUR VISION AND MISSION

Vector's vision and mission is to lead the transformation of the energy sector to create a new energy future. This includes identifying and developing options that will provide value, choice, and service for our customers throughout New Zealand.

The new energy future will be driven by brilliant infrastructure that will see true on-demand energy delivered in bold new ways. Unprecedented integration and storage capacities will redefine how consumers generate, source, store, and trade energy.

Vector is challenging and transforming how customers connect to energy infrastructure. We aspire for networks to become smaller, more agile, and more responsive, as electricity influences multiple aspects of our lives.

To help bring about the new energy future, Vector has moved beyond the traditional investment mindset of an electricity network. Our focus is less on building more long-life assets that risk becoming obsolete in a changing energy future and more on shaping our network to meet customer demands, while ensuring the network is safe, secure, reliable, and resilient.

Vector is forward-thinking, and we have begun investing in the delivery of an intelligent, connected, open, and aware energy platform that enables the delivery of energy solutions to multiple markets and segments. This allows for lower costs, and greener, more flexible customer energy outcomes.

1.5 OUR OPERATING ENVIRONMENT

The plans, investments, and strategies outlined in this AMP will help Vector prepare for, and take advantage of the complex and rapidly changing environment the electricity sector is facing.

In developing these plans, considerable focus has been placed on identifying the key macro-economic external trends that are expected to influence our business operations, create risks and opportunities, and shape Vector's operating environment. These key trends and how they influence our operating environment are shown in Figure 1-1.

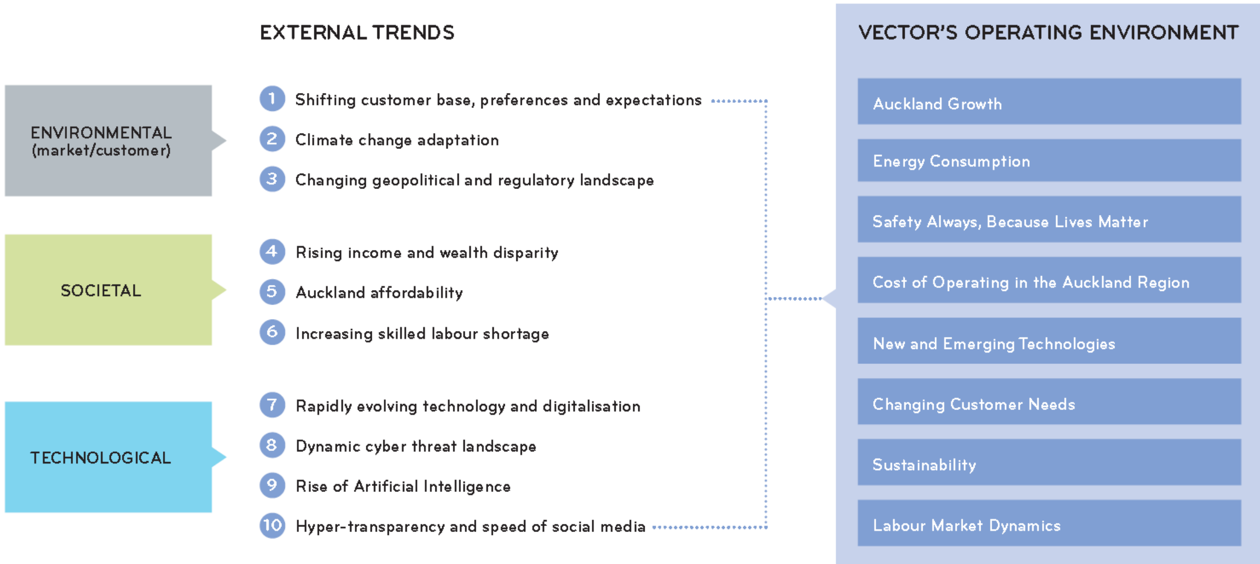


Figure 1-1 Key macro-economic external trends shaping Vector's operating environment

These external trends mean the outlook for our operating environment is one of continuous change. Auckland is continuing to grow; customer behaviour, choice, and participation with Vector is changing; new technologies are impacting our network and how we operate; and global threats and climate change make sustainability an imperative for the Company.

Each of these external trends will shape our network's development over the timeframe of this AMP. In the following sections, we consider each of these trends, assess their implications for our network, and detail how we are responding through our strategies and plans.

CHANGING ENERGY CONSUMPTION

Despite Auckland's growth, an interesting trend has emerged regarding how much energy the region is using. Since 2005, the average level of energy use per residential connection has declined by about 1% per year (see Figure 1-2 and Figure 1-3).

Energy use is declining because of:

- Socio-economic factors, such as affordability and environmental concerns;
- A region-wide shift towards medium- and high-density living;
- Technology: with improved building practices and standards, greater building energy efficiencies, a higher penetration of dwelling insulation, and improving equipment efficiencies;
- The prevalence of "energy efficient" appliances in homes (such as heat pumps and Light-Emitting Diode (LED) lights); and
- New and emerging technologies such as solar panels and storage batteries.

ICP# VS GWH TRANSPORTED

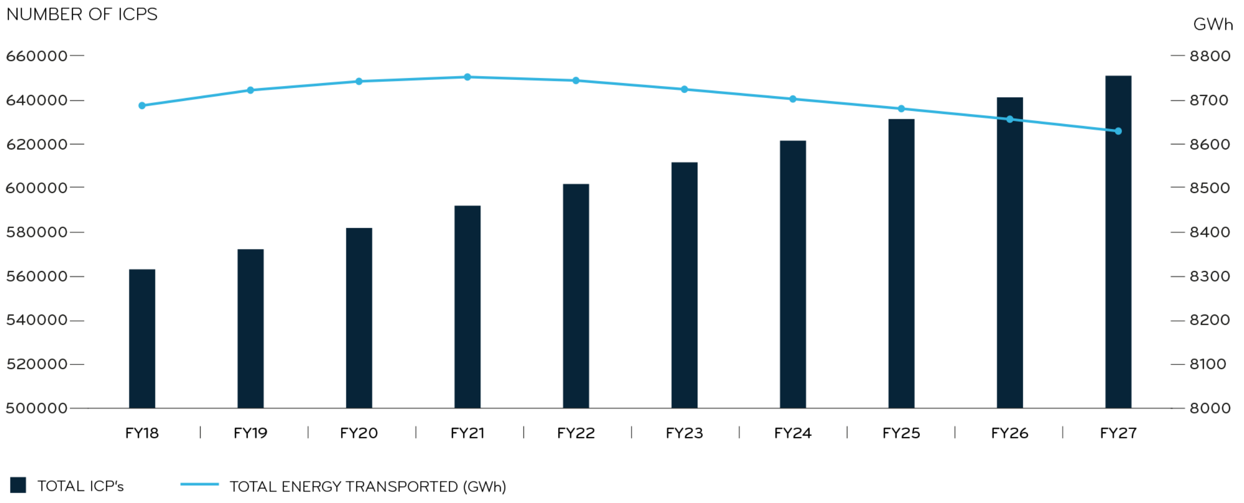
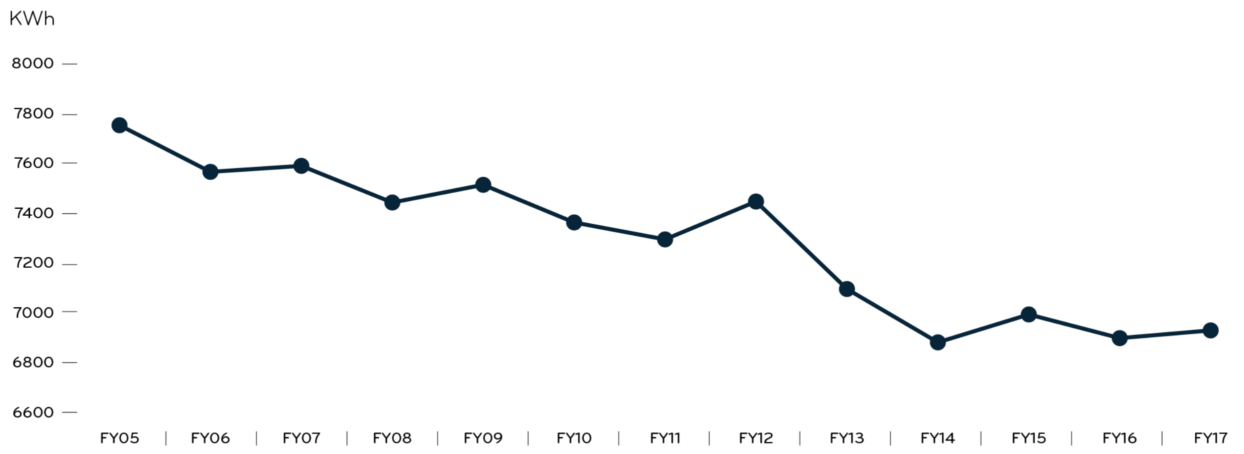


Figure 1-2 ICP numbers vs GWh transported

ANNUAL RESIDENTIAL ENERGY CONSUMPTION PER ICP



Source: Scott Armstrong Finance

Figure 1-3 Annual residential energy consumption (kWh) per ICP

AUCKLAND GROWTH

Auckland is a rapidly growing and diverse city. Auckland's population is expected to grow the size of Tauranga city every three years, and Auckland's polulation is estimated to be two million by 2028[2] . Housing developments are following a similar trend. New residential building consents have increased every year since 2011, and in 2016 consents reached over 10,000 per year[3] . This represents a five-year average annual growth rate of 20.7%[4] , while non residential building growth has averaged 13.7%[5] . Approximately 41% of New Zealand's construction activity occurs in Auckland. Since 2011 this has stretched public infrastructure, which in investment terms is expected to grow by over 30% over the next five to six years[6].

Auckland's growth has significant implications for Vector's asset investment. With such growth, there is more demand for asset relocations and new connections. The region's growth also has significant implications for managing the network's reliability and capability, and how Vector invests to meet this population growth and accompanying construction activity.

NEW CONNECTIONS FORECAST

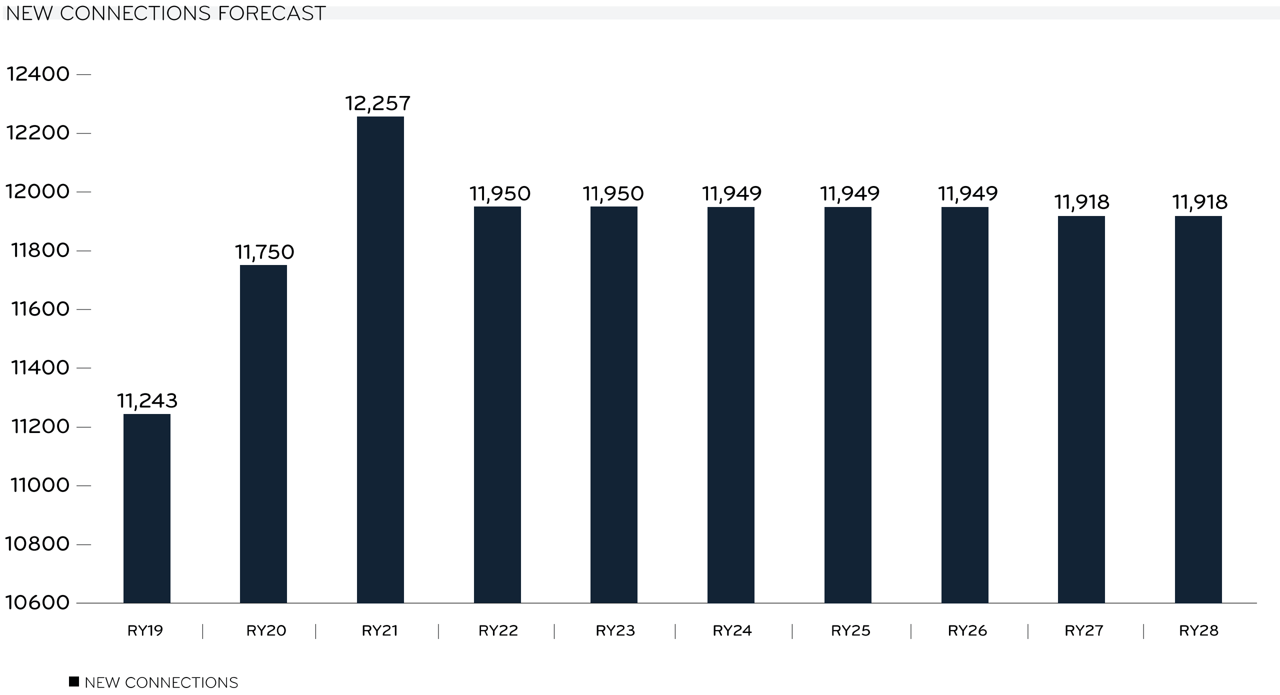


Figure 1-4 New ICP forecast growth over the AMP period

Auckland's growth is also impacting how long it takes for Vector's field crews to reach, then fix, power outages across the city. Commonly-used arterial roads and routes in Auckland are now increasingly affected by traffic congestion, and this is affecting outage response times. The higher volume of vehicles on Auckland roads and sustained construction activity in the road corridor also appear to be driving a higher number of third-party incidents causing power outages (i.e. vehicles hitting power poles, and construction workers cutting into underground cables).

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2 Auckland Council, "Have your say on Auckland's future – consultation document," March 2018. Sourced from: https://www.aucklandcouncil.govt.nz/have-your-say/topics-you-can-have-your-say-on/ak-have-your-say/Pages/have-your-say-on-aucklands-future-consultation-document.aspx

3 Stats New Zealand (2017). Building plans put to work. Retrieved from www.stats.govt.nz. ISBN 978-0-9941463-2-8 (online), Published 28 March 2017.

4 Auckland Council, "Auckland Economic Quarterly," May 2017.

5 Auckland Council, "Auckland Economic Quarterly," May 2017.

6 Ministry of Business, Innovation and Employment, "National Construction Pipeline Report 2017: A Forecast of Building and Construction Activity'" 5th Edition. July 2017, p. 29, 32.

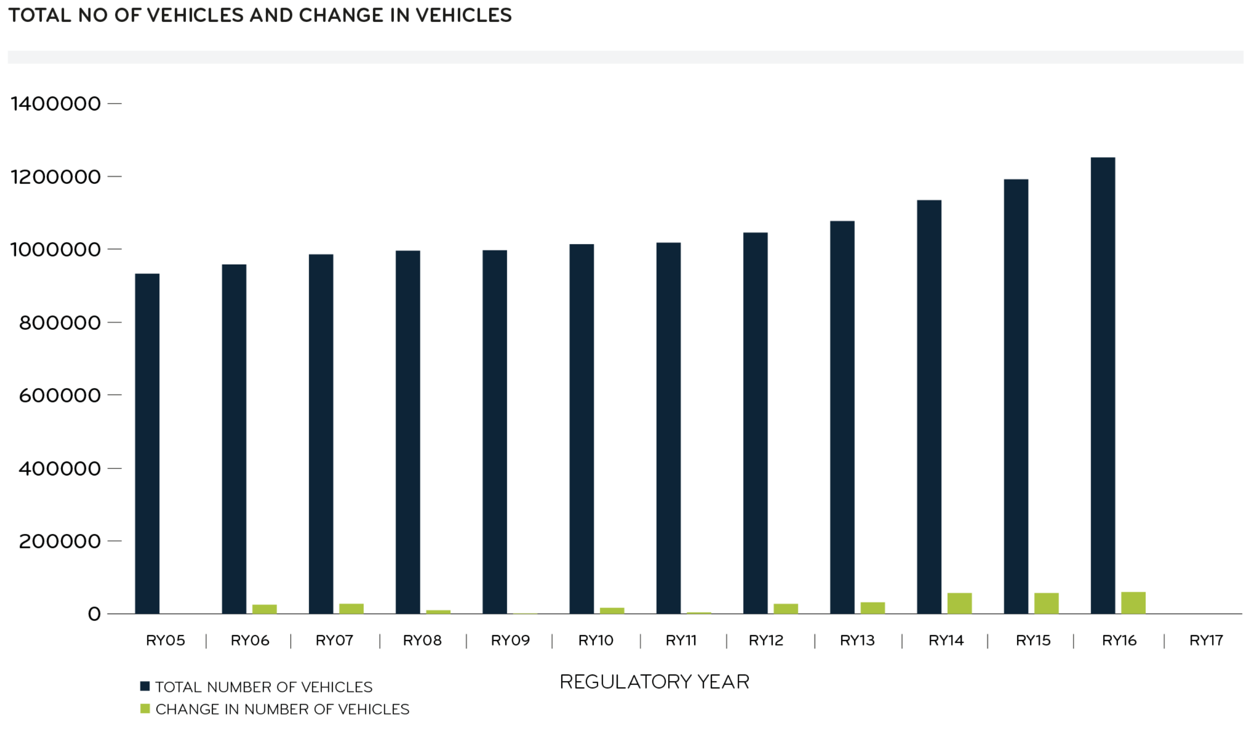

Figure 1-5 Total number of vehicles and change in vehicles per regulatory year

We cannot burden Auckland now or into the future with traditional network investments when there are potentially cheaper, smarter options available. We believe it is in the long-term interests of our customers that we invest in and bring new energy solutions to market that will ultimately enable our customers to have lower electricity costs, access to greater electricity control, and more choice.

Over the period of this AMP, we expect to see our region's growing population drive the expansion of Vector's network.

To meet this growth, Vector plans to extend our network for new customer connections and, to the extent necessary, augment strained capacity to address an increase in demand. The details of Vector's plans to respond to Auckland's growth are set out in SECTION 5.

1.6 NEW AND EMERGING TECHNOLOGIES

The electricity sector is currently experiencing, and will continue to experience at an accelerating speed, disruption to the way it is designed and operates. While the impact of new energy technologies on Vector's network are still being considered and catered for, we must also plan for the changes still to come.

Innovative building practices and materials have impacted how and when energy is used in homes and buildings. Space heating is much more efficient than what it was in previous decades, requiring much less overall usage and less energy intensity to deliver comfort. Highly-efficient household appliances and electrical fittings are also creating more user empowerment than historic electricity usage.

EVs and AVs (and moves to electrify more forms of public transport like light rail, buses and trucks) will affect both the amount, timing, and type of energy used in transport. Current technological revolutions like solar panels, storage batteries, and internet-based consumption optimisation programmes will further impact energy consumption.

That is why we are investing in assets that have optionality that is not sunk or tethered to one location, with the possibility of more than one function. One example of this is a battery that can be deployed in one area to meet a period of need, then redeployed in another area as consumer usage rises or falls in different parts of the network. These assets also provide a logical solution to the need for affordable, innovative infrastructure development to support Auckland's growth. They also address the possibilities technology has in changing customer demand.

This energy revolution can be broadly considered in these terms:

- Renewable energy generation;
- Energy storage;
- Energy utilisation and management ;
- The electrification of transport; and
- The Internet of Energy.

RENEWABLE ENERGY GENERATION

Foremost in this energy revolution is the emergence of technologies that can renew or generate their own electricity, such as solar panels. These technologies are trickling down from an industrial level (solar energy farms) to become directly available to people and businesses (solar panels installed in the home) as the technology is continually innovated and prices drop as they become more available and affordable. Solar panels still have much further to progress in terms of production cost and efficiency for solar conversion into electrical energy. The impact of both these trends mean that solar panels will have a much greater influence on the electrical system going forward.

Until now, the energy generation/retail model has been based on getting power from elsewhere and customers paying for this in an unsophisticated way. Solar panels are changing that. They will let households and businesses become generators and, through channels such as peer-to-peer trading, allow solar energy to be traded within local communities using their own terms. Solar panel households will be able to generate clean electricity on-site and convert any solar energy surplus from excess production to a customer's revenue by trading locally.

These changing power flows undermine the unidirectional flow from what our current networks were designed for, as well as rendering other power system infrastructure and assets obsolete. As a result, we anticipate the investment in electricity distribution networks to shift away from where money has traditionally been spent, towards the lower-voltage networks that will support customer technology adoption and enablement at a local level.

ENERGY STORAGE

Upgrades to the way energy is stored, and how much electricity batteries can hold, will mean that mass energy storage could soon become cheaper to purchase, build, and manage.

Much like solar panels, lithium ion storage batteries are becoming more and more common in people's homes and businesses. At an industrial scale metal air batteries, hydrogen, supercapacitors, and even superconductors, are also emerging.

This proliferation of energy storage options could also change the way power flows through electricity networks. If managed well, these storage options could lead to less demand for energy from homes and businesses, which would result in less strain on the network and other economic and operational benefits. Storage options would provide the capability for people to store excess energy generated from solar panels.

ENERGY UTILISATION AND MANAGEMENT

Energy utilisation and management technologies are also advancing. There is a growing array of electrical devices and equipment that are increasingly more energy-efficient and "smart."

High-efficiency electrical motors, LED lighting, heat pumps, refrigeration, and energy efficient air handling systems have reduced the energy needs of our factories, offices, and homes. Internet- and cloud-based software, which controls and manages how energy is used and coordinated across different sites, are also helping create "smart" buildings and infrastructure.

As these smart technologies evolve, eventually even smarter developments like machine learning and artificial intelligence will lead to these technologies able to self-manage and become autonomous.

For Vector's network, the potential implications of these technologies on an industrial scale to better manage, control, and utilise our network and the Auckland region's demand for energy are significant.

THE ELECTRIFICATION OF TRANSPORT
EVs are proliferating not just globally but also in Auckland, and will continue to do so as the cost of owning one declines over the next decade.

Vector has deployed a number of 50 Kilowatt (kW) rapid EV chargers across the city for the region's growing fleet of EVs. But in doing so, a wider issue is beginning to appear – when EV use increases, it will only be a matter of time before repowering them puts pressure on Vector's current electricity grid. A greater penetration of EVs charging at peak times on residential feeders may lead to a need for more infrastructure to meet that peak. A standard dwelling tends to operate at 2.5 kW capacity: therefore a proliferation of chargers (even at trickle charge capacities) will cause challenges for peak demand management.

Vector's investment in vehicle-to-grid (V2G) technology will help limit the challenges of an EV-driven residential peak demand. Not only can V2G chargers take power from the grid to charge EVs, they can reverse the process by putting power back in. This has the potential to transform EVs into mobile power sources for homes and businesses (for example, an EV with a 30 Kilowatt Hour (kWh) battery could supply the average household for 10 hours[7] before fully depleting).

This new rechargeable energy source could be used to introduce extra power to buildings as a cheaper power source during peak-hour consumption; as a way to power homes during power outages, and to release energy back to the grid to support the network during high demand for energy.

As New Zealand's biggest distributor of energy, Vector cannot afford to wait and see how all the changes that affect us will play out before we act. V2G is just one example of the way Vector is leading the industry in transforming the way energy is managed.

THE INTERNET OF ENERGY
Traditionally, energy has always moved in one direction: from generation to distribution, and finally to an end-point in appliances and devices. However, the introduction of technologies like solar panels and storage batteries, which can send energy back the other way into the electricity network, is changing the way people interact with energy.

In partnership with mPrest, Vector is developing a "system of systems" to better manage these multi-directional flows. The idea behind this (that one platform integrates with, and manages, multiple aspects of a network) is sometimes referred to as the Internet of Energy.

Partnering with mPrest allows us to manage this complex system easier through automation and machine learning. The software will sit over our customers, the energy market, distributed energy resources, and network systems, and manage their performance in real time. Through self-learning, it will use artificial intelligence to optimise our network and predict multiple factors at once, including loads in different parts of the network, market dynamics, storage, customer demand, and capacity.

The system Vector is developing will allow us to control not only how energy is used but also the assets required to connect energy with customers. It challenges the traditional mindset that has seen energy companies traditionally growing their networks to accommodate greater peaks. It also helps Vector to defer network reinforcements costs, reduce the risk of stranded assets at a time when energy consumption per ICP is slowing in Auckland, and promote a rapid increase in new solutions to generate and manage energy.

1.7 CHANGING CUSTOMERS NEEDS AND EXPECTATIONS
The standards electricity customers are holding their power providers to, are getting higher across the globe. Increasingly, they are demanding more flexibility and choice in the services power companies provide whether they're a distributor,

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7 Vector, "Creating a New Energy Future," August 2017. Sourced from Vector Annual Report.

retailer, or generator of energy. They are also demanding improved experiences with lower friction and greater value and utility as they have come to expect from digital service providers such as Amazon, Netflix, and Spotify.

For distributors like Vector, this means expectations for us to ensure a reliable supply of energy. On top of those expectations is an increasing willingness from customers to take control of their energy options, which is leading to a change in the way the energy market operates.

As a responsible energy provider and customer-focused Company, Vector must enable our network to be able to support and accommodate their choices and meet their demands.

Vector is responding to this imperative by seeking to develop a deeper understanding of our customers' changing needs, preferences, and expectations through our Customer Insight Strategy. This strategy supplements our existing customer survey programme with broader market research, and employs smart analytics and "big data" methods to draw on a wide range of data sources (e.g. the census, spending, transport) that enable greater customer insights. Our strategy will enable Vector to gain greater knowledge of our customers' technology expectations and energy needs.

1.8 SUSTAINABILITY

Vector has established a sustainability framework underpinning how we manage our network equipment over its entire lifecycle, and considers the impacts of climate change.

Modelled climate data suggests that wind speeds are projected to significantly increase in the near future. Summer and winter temperatures are expected to increase by almost 1°C by 2050. Other causes for concern include rising sea levels, storm surges, flooding, and erosion. We expect climate change will lead to a higher incidence of damage to overhead assets caused by wind and falling trees or vegetation; possible reductions in equipment capacity; and the potential inability to supply electricity to isolated coastal areas via traditional overhead electrical assets. The impact of climate change is illustrated by recent intensive storms which will mean additional challenges for managing the network. This may require AMPs and the expenditure forecasts contained in them to be constantly changed as we learn more about the ongoing impacts climate change will have on the management of our network assets.

Vector's assessments are a starting point in improving our understanding of the impact climate change will have on the network. Areas of the network that are deemed to be at higher risk will be assessed in more detail over the period of this AMP. This will include studies to determine the impact of lightning on line insulators, ensure proper insulation coordination of the network as well as determine the need for additional lightning arrestors in our network.

There is no single identifiable plan in this AMP that directly addresses sustainability or climate change. However, there are aspects of our plans and strategies that work together to deliver a more sustainable, energy efficient, and resilient network. Where our AMPs contribute to Vector's sustainability commitments, we have noted them against the plans in SECTION 5.

1.9 MANAGING INVESTMENT UNCERTAINTY AND FACILITATING CUSTOMER CHOICE

CUSTOMER OVERVIEW

We deliver electricity to over 550,000 homes and businesses across the wider Auckland area. These customers include residential homes; small, medium and large businesses; and large industrial customers (where some have relatively energy intensive businesses). These customers are generally contracted through retailers. Our network is also directly connected to a range of distributed generators, some with quite significant electrical output.

We use a variety of means to engage with our customers and capture their feedback in order to identify areas for improvement (see Table 1-4). From our customer engagement, we gather clear insight into the areas of our service that our customers value, which are:

- Reliability of supply;
- Speed of restoration;
- Value for money; and
- Communication and service

Additionally, we anticipate that customers will increasingly expect choice and control in how they buy, use, store and sell energy as more products and services enter the market. In addition to the formalised measurement processes summarised below, we also capture ad-hoc feedback from direct community engagements such as our presence at the Lantern and Pasifika Festivals. In these instances, we receive verbatim comments from customers and we use these along with our other customer insights, to improve our services to customers. This is part of embedding a culture where every employee is responsible for the customer experience.

MEASURE	PURPOSE	FREQUENCY
Vector Customer Satisfaction Score	To understand how satisfied customers are with our faults and new connections service	Continuously tracked, reported quarterly
Customer Effort Score	To understand how easy customers find our faults and new connections service	Continuously tracked, reported quarterly
Customer Advisory Board	To gather qualitative feedback on current services and proposed new services	Quarterly
Lifestyle Survey	Gather quantitative insights into customers evolving behaviours and attitudes to energy	Annually
Focus groups	Inform the design and test new services and tools	For each new project e.g. Peer to peer trading
Complaints	Volumes and root causes analysed to identify areas for improvement	Continuously tracked, reported monthly

Table 1-4 Customer satisfaction measures

IMPORTANCE OF MANAGING PLANNING UNCERTAINTY

Our traditional physical asset investments are characterised by long lifetimes and the irreversibility of the investment decision (i.e. a power line cannot simply be moved to different locations throughout its lifetime). This means that decisions to deploy assets today will impact future generations of Aucklanders. In the past, while uncertainty about the future was low due to steady demand growth and low technology innovation, the approach to mainly rely on long term assets has served us well in building today's system.

Today, however, this approach is ill-suited. Uncertainty around future electricity demand is at an unprecedent height, mainly due to the materialisation of the Auckland Unitary plan, new customer expectations, the penetration of new demand technologies, and ubiquitous information and communication technologies (digitalisation). To optimise our investment planning process in the face of high uncertainty, we are harnessing scenario planning to develop network strategies for different future scenarios.

ELECTRICITY DEMAND SCENARIOS AND SCENARIO PLANNING TOOL

Scenarios are narratives that, through a set of different assumptions, draw probable future developments that enable us to derive robust business strategies to respond to these developments.

Vector's scenario planning tool models electricity demand growth for different future assumptions up to 2050 in 5-year steps, starting from 2017. The methodology stems from a mixture of bottom-up and top-down approaches considering every ICP and its attributes on the Vector network. The model is highly granular across the Auckland region as it subdivides the region into small geographical areas of approximately 1,000 dwellings. These small areas can be aggregated to an area of interest (e.g. new urban areas and areas of network constraint) or to existing zone substation assets.

Most importantly, the model is based on a rich list of data sources and assumptions from different national statistics on for example; demographics, dwelling characteristics, household composition, appliance sales and motor vehicle sales, and international studies and reports on technology development (refer Table 1-5). Customer growth is the same in all scenarios and is based on the Auckland Forecasting Network's Household and Employee forecast. This forecast provides net change in households and employees for each of the Auckland Transport zones that cover Vector's electricity network.

The model converts this forecast into ICP numbers for Residential, Small Medium Enterprise and Industrial and Commercial, and scales the first 10 years to match Vector's 10 year ICP forecast.

The cross-pollination of this data ensures the future demand outputs are realistic and robust.

MODEL INPUTS

Billing data	Technology trials	Council district valuation roll	Public research
Smart metering	Unitary plan	Pricing plans	Crowd wisdom
ICP geolocation	Electricity registry	Statistics New Zealand	
Census	Council forecasting	Building consents	

Table 1-5 Overview of scenario planning inputs

The scenarios can analyse different future energy growth patterns. The two largest uncertainties around future demand growth is the level of customer uptake and speed of new customer side technologies and the network response to such technologies. New customer side technologies modelled include residential energy efficiency gains caused by improved insulation, LED lighting, modern energy efficient appliances, the use of home energy management systems, and the extended use of residential solar generation and battery storage. In our scenario modelling attention was given to the impact of residential EV charging, public and business EV charging at places such as service stations, in carparks, and at fleet vehicle depots.

Based on those two uncertainties (customer-side technology uptake and network response), we have derived three key scenarios to inform our AMP investments: we named these after music genres to reflect the high-level narrative in each scenario: POP, ROCK and SYMPHONY.

- POP is well-established today. The customers steadily adopt new energy technology (mainly EVs and energy efficiency) and the network responds by granularly becoming more intelligent;
- ROCK is counterfactual to POP where customers aggressively adopt new technology, but the network relies primarily on physical assets to meet growing demand; and
- SYMPHONY is where the network proactively facilitates customer engagement and technology uptake leading to Low Voltage (LV) network and customer integration. Symphony results in the alignment between technology, incentives and customer behaviour.

Figure 1-6 and Table 1-6 provide a description of the AMP investment scenarios.

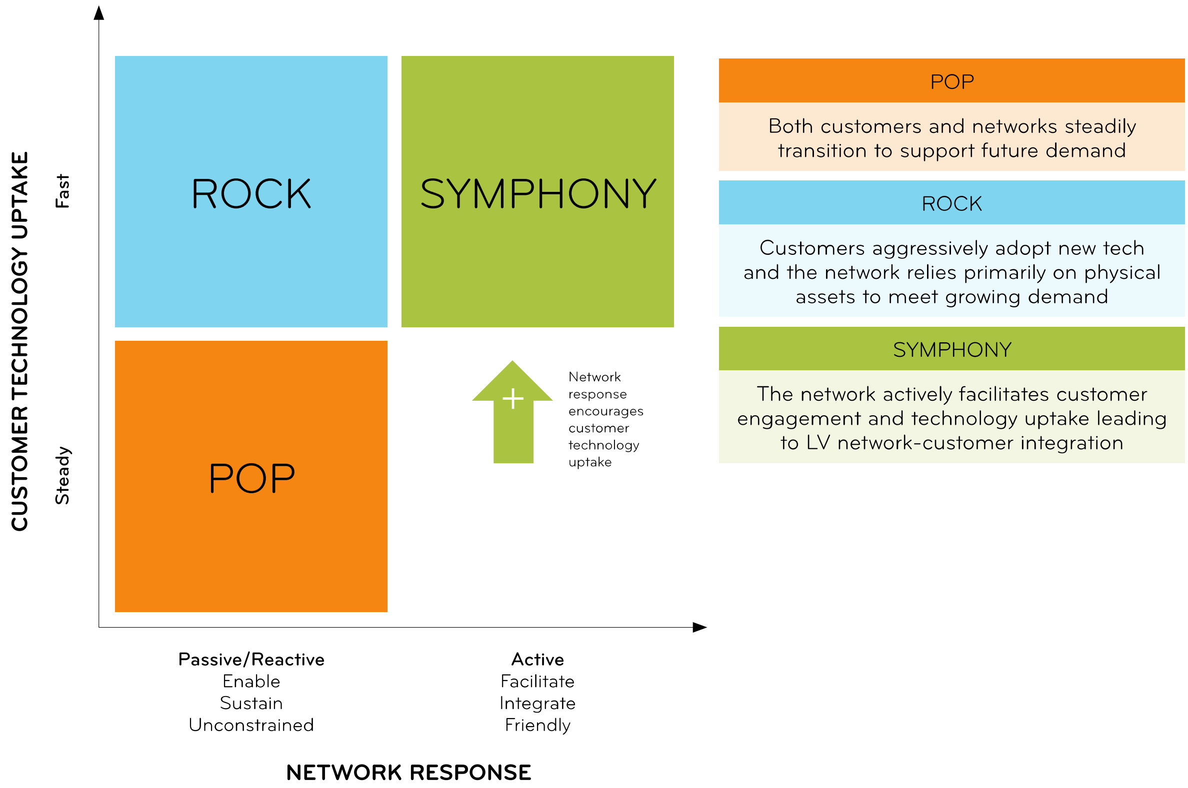

Figure 1-6 AMP investment scenarios aligned with music genres

POP	ROCK	SYMPHONY
• 28% total **network demand growth** by 2027	• 56% total **network demand growth** by 2027	• 21% total **network demand reduction** by 2027
Customer Behaviour: • **Steady** energy efficiency uptake • **Low** solar and battery uptake • Batteries **discharge** random and not at network peak • **Steady** EV uptake meet government target and then steady growth continues to 2027 • EV charging **clustered at peak**	Customer Behaviour: • **Steady** energy efficiency uptake • **Steady** solar and battery uptake • Batteries discharge random and **don't discharge** at network peak • **Strong** EV uptake doubles government target and high growth continues to 2027 • EV charging **clustered at peak**	Customer Behaviour Incentivised: • **Fast** energy efficiency uptake • **High** solar and battery uptake • **Batteries discharge** at peak in response to an incentive and enabled by technology at LV interface • **Steady** EV uptake meets government target and then steady growth continues to 2027 • EV charging **off-peak** enabled and incentivised
Vector Response: • Network is intelligent • LV network at customer interface is predominantly passive (AMP Baseline)	Vector Response: • Network is intelligent • LV network at customer interface is predominantly passive • Outcome is higher Regulatory Asset Base (RAB)	Vector Response Enables Integration: • LV network intelligence enables shared capacity and integration at interface • Innovative pricing signals, enabling digital platforms, integration of customer renewables with the LV network, etc. • Lower RAB than in ROCK/counterfactual
AMP base case scenario	AMP counterfactual scenario	AMP active scenario

Table 1-6 Narrative of AMP investment scenarios aligned with music genres

The network capacity demand in the three different AMP scenarios diverges until the end of the AMP period in 2028, as shown in Figure 1-7. The graph also illustrates two of many other alternative Vector modelled demand scenarios that diverge more significantly after 2028, which is why they are not further analysed in the AMP, even if they are probable future alternatives, that we continuously evaluate. These scenarios are: Car-as-a-Service (CaaS) and Revenue Risk.

CaaS assumes a business model shift in mobility where most EVs will be owned by service providers and not privately owned, meaning fewer EVs on the road compared to the ROCK scenario and charging occurring in commercial zones (not in the home). Revenue Risk represents a future where customers are becoming increasingly self-sufficient through energy efficiency gains and solar/battery systems that power their homes and their own EVs.

NETWORK LOAD ALL SCENARIOS

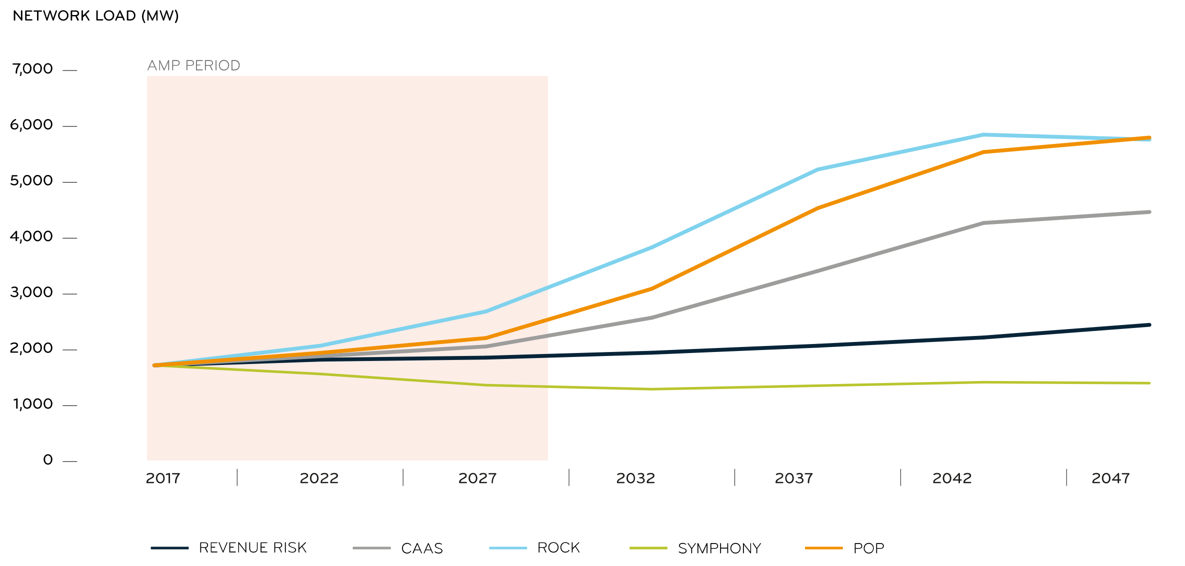

Figure 1-7 Network load (MW) across 5 different scenarios across 2017-2050

INVESTMENT AND BENEFITS OF DIFFERENT AMP SCENARIOS

The investments and customer outcomes in each scenario differ. The POP scenario is the basis for this AMP as it seamlessly fits under the legacy regulatory framework. This scenario assumes steady technology uptake and a network response that mainly involves deploying physical assets, both traditional and new network-side energy technologies such as batteries and solar Photovoltaic (PV). Figure 1-8 summarises the POP Capex (i.e. base AMP scenario) for each investment category. Figure 1-8 also highlights under Legacy what this year's AMP investment requirements would have looked like, if we had not transitioned our planning tools from deterministic to an innovative probabilistic methodology. The difference between POP and Legacy represents financial benefits for our customers.

However, we also wish to highlight how our investment could differ under the ROCK and SYMPHONY scenarios in the face of uncertainty. This will also assess how resilient the different network strategies are to responding to different customer-led futures.

Under ROCK, an additional $115m CAPEX is required and will increase the RAB. Roughly half of this is needed for System Growth to accommodate additional loads and the other half would be assigned to non-networks assets to expand customer engagement and business enablement tools for a larger innovative asset base.

Although investments in SYMPHONY are similar to ROCK, the scenario stands in stark contrast to ROCK. The additional spend on LV network measuring and sensing devices and non-network (digital) assets, particularly a full Energy Internet of Things (IoT) platform, enables the integration of network and customer. This results in an active network that engages fully with customers and considerably lowers system growth requirement by $140m compared to POP and nearly $200m compared to ROCK. Additionally, 'asset renewal' is reduced as assets are less stressed and/or better monitored which increases their lifetime and defers renewals. The increased intelligence of this network through monitoring, control, analytics and real-time diagnosis means the network would rely less on physical assets. As a result, the network is more agile and flexible to respond to future developments as time progresses. We believe that SYMPHONY future-proofs the network to transition to a new customer-centric energy network. The POP and ROCK scenarios however, increase the stranded asset risk and could potentially transfer a large physical asset base to future generations that may not be required.

HIGHLEVEL SPEND ALL SCENARIOS

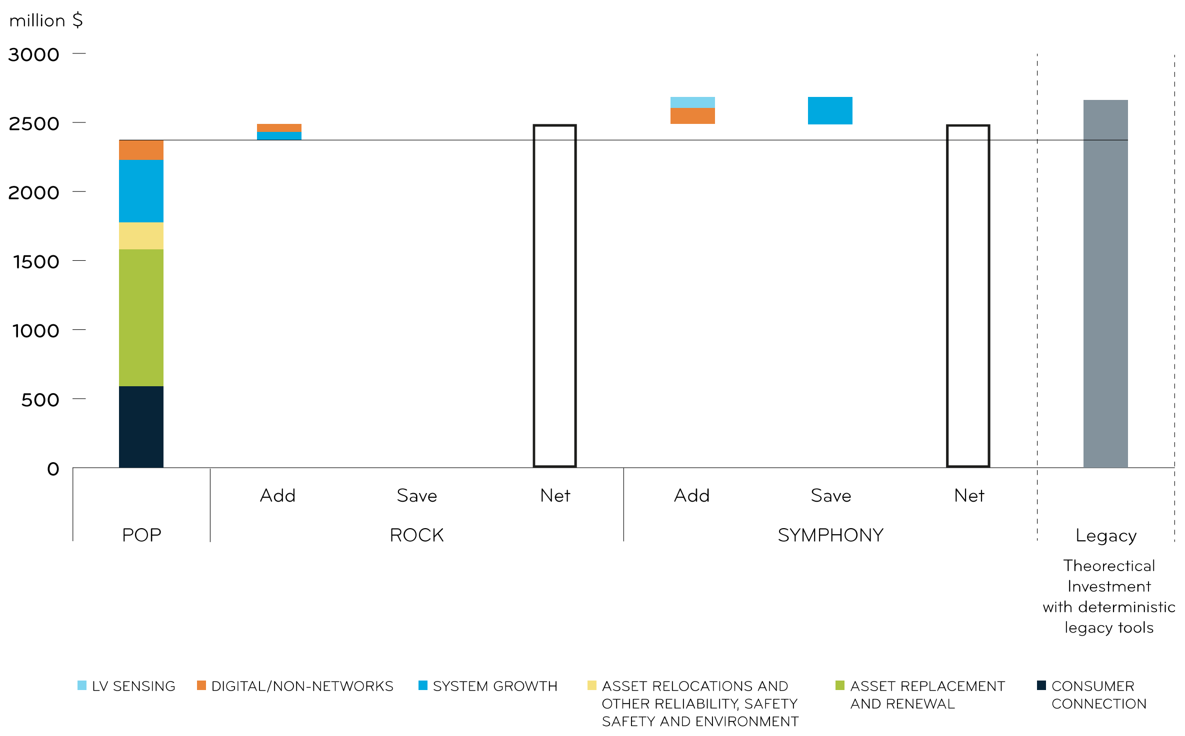

Figure 1-8 CAPEX expenditure by modelled demand scenario

A full assessment of the different scenarios should not just be limited to the investment requirement, but needs to evaluate the benefits that each scenario delivers to the customer. As shown in Figure 1-9, SYMPHONY is superior to the other two scenarios in many respects by providing better customer choice, increasing reliability and resilience to improving safety and streamlining business processes. It goes without saying that those benefits will extend beyond the AMP period, which is why we believe SYMPHONY can deliver far superior value to our customers.

However, due to existing legacy regulatory constraints we will focus the remainder of this AMP on the POP scenario, but we hope to engage further with regulatory and policy bodies, as well as our customers, to future-proof and facilitate the future by deploying SYMPHONY.

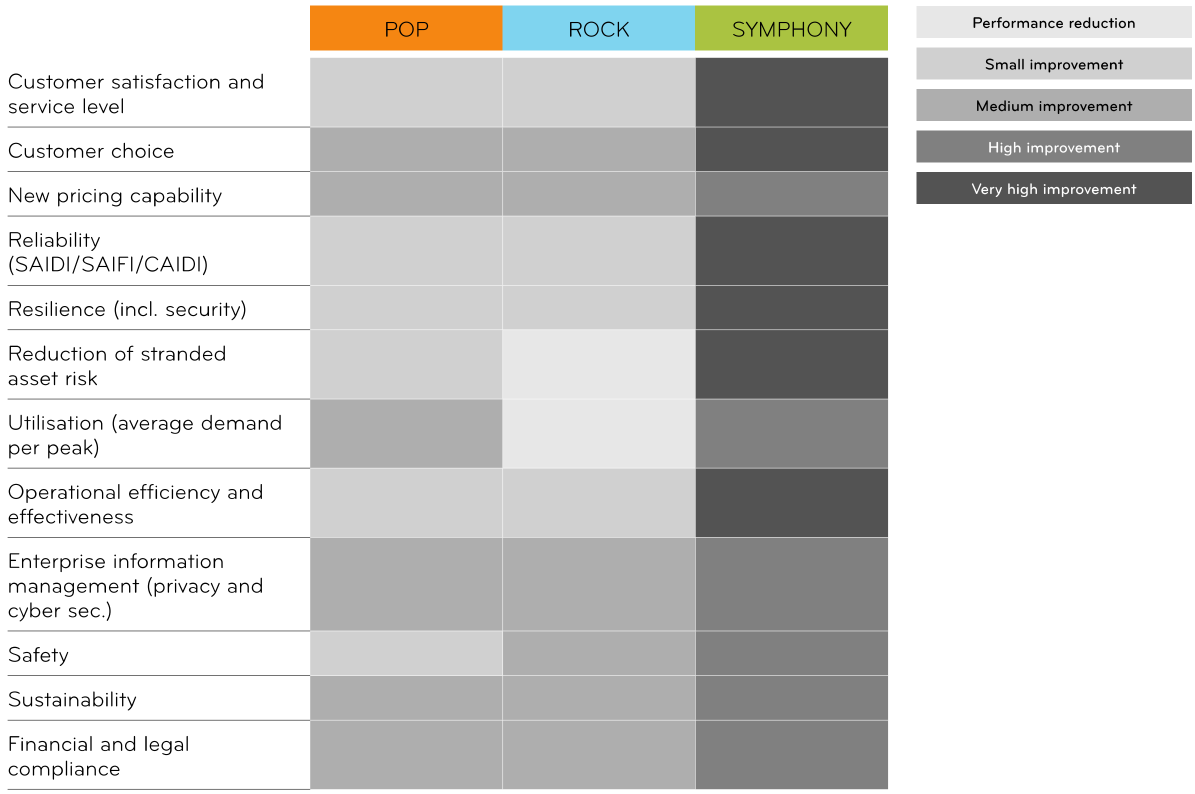

Figure 1-9 Benefits of the different AMP demand modelling scenarios

1.10 AMP STRUCTURE

Vector's 2018 AMP has been developed in accordance with good asset management principles. We have structured and simplified our AMP to tell the story of how Vector is maintaining customer service levels and creating a new energy future. There are six primary sections and supporting details in the appendices that contribute to our asset management story. As described in Table 1-7, the six primary sections of the AMP include:

SECTION	OVERVIEW
1 – Introduction	• Provides the context and summaries for the AMP; • Presents an overview of Vector; who we are, what we do, our vision and mission; and • Considers the purpose, objectives and the operating environment that shapes the AMP.
2 – Customers, Stakeholders and Service Levels	• Identifies Vector's primary stakeholder's interest; • Presents the service level metrics and sets our performance targets to meet their interests; and • Discusses the performance of our network against these service level metrics, along with the primary causes of performance deviation from the service level targets.
3 – Asset Management System	• Provides insight into Vector's asset management practices; • The asset management objectives, scope and governance are presented here; and • Discusses how Vector intends to improve its asset management practices over time.
4 – Our Assets	• Presents an overview and lifecycle management strategies of our electricity distribution assets; • Provide insights in to the types, volumes and functional role of assets we manage in the network; and • Summarises our primary asset management strategies that inform and/or drive our expenditure.
5 – Managing Our Asset's Lifecycle	• Provides an overview by asset category, of the plans we have to manage our distribution network assets over the 2018-2028 planning horizon.

6 – Delivering Our Plan	• Outlines how we develop an optimal portfolio of works from our plans and how we will deliver these works to maintain service levels, and deliver our strategic outcomes; • Provide insights into how prioritisation of the plans presented in SECTION 5 results in a work portfolio that optimises the outcomes from our network investment; and • Presents a summary of the CAPEX and OPEX required to deliver our electricity network AMP for the 2018-2028 period.
7 – Appendices	• Contains supporting and supplementary information for Sections 1 to 6; • Lists the key standards that inform our asset management practices; and • Presents a compliance table showing how our AMP meets the Commerce Commission's Information Disclosure requierments.

Table 1-7 Overview of AMP structure

SECTION

02.

STAKEHOLDERS AND SERVICE LEVELS

SECTION 2. CUSTOMERS, STAKEHOLDERS AND SERVICE LEVELS

Stakeholder requirements form the basis of Vector's asset management practices. They define the level of service required of Vector's assets which go beyond current industry standards of using aggregate reliability indicators such as System Average Interruption Duration Index (SAIDI)/System Average Interruption Frequency Index (SAIFI) indicators. Our engagement with customers to best determine how we meet their expectations informs our plans set out in this AMP, we are continually improving our engagement with customers to ensure we are well informed on customer expectations and are providing the level of services they require. We invest in our network to ensure that we continue to meet our customers' expectations today, whilst preparing the network for our customers in the future.

In this section, the primary stakeholders and their requirements are identified from an asset management perspective. Service level metrics and target performance levels are defined and the performance of Vector's assets against the service level metrics is summarised. Where actual or expected performance gaps are found, consideration is given to the underlying root causes that then inform the development of potential investments required to prevent or correct asset performance, and meet or maintain our stakeholder's service level requirements. SECTION 5 sets out our plans to manage asset performance.

2.1 STAKEHOLDER REQUIREMENTS

The essential nature of the services provided by Vector's electricity distribution network, and its importance to the Auckland community and economy, creates considerable interest in Vector's asset management practices, and there are a large number of stakeholders. Figure 2-1 identifies the primary stakeholders that have an interest in how Vector manages its assets.

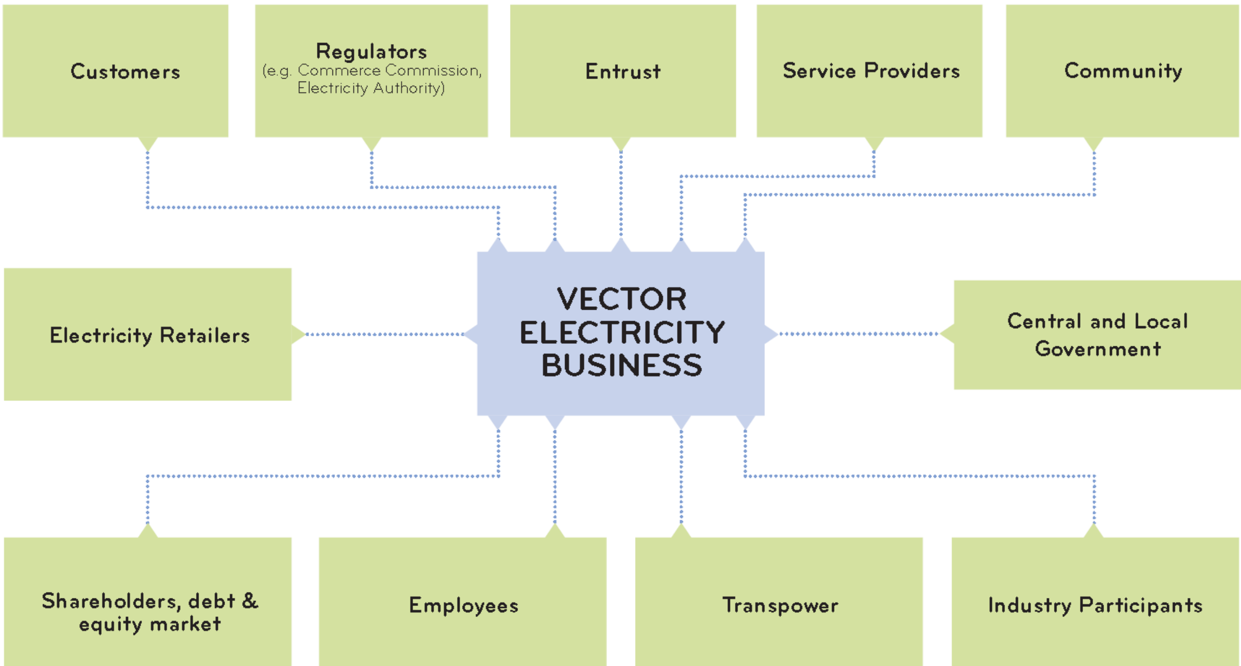

Figure 2-1 Primary stakeholders

To ascertain the service metrics and performance targets that are relevant to managing our electricity assets, Vector engages with its stakeholders through a range of channels. These include meetings, discussion forums, political engagement and direct liaison to understand stakeholder needs. Other means of interacting with stakeholders includes surveys, working group memberships, media and publication monitoring, as well as active engagement in the legislative and regulatory consultation processes.

Vector's stakeholders have a broad range of requirements. Table 2-1 provides some insight into some of the stakeholder requirements that impact our business operations. As relevant, Vector's board and management translate our stakeholders' requirements into specific business requirements that influence asset management practice through guiding values, shaping objectives and informing service level requirements. This includes the need to make the call on the higher priority or trade-offs as required when differing stakeholder requirements conflict.

Public and worker health and safety risk management	Confidence in board and management	Participation in policy proposals, and regulatory issues
Sound management of customer issues and information including timely outage management	Good governance, reputation, and ethical behaviour	Ensure service providers have stable forward work volumes, and construction standards.
Quality, security, and reliability of supply of electricity	Maintain legal and regulatory compliance	Maintain effective relationships and ensure ease of doing business
Sustainability and environmental	Prudent risk management	Work with stakeholders to Influence regulators and government
Timely network connections and asset relocations	Develop and maintain a clear strategic direction	Sharing experience and learning with the industry
Engage with community and stakeholders on relevant issues	Return on investment and sustainable growth	Ensure effective coordination of planning and operations with other utilities and stakeholders
Provide cost effective and efficient operations	Accurate and timely information and reporting	Ensure transmission network interface is well maintained

Table 2-1 Examples of the broad set of stakeholder requirements

From an asset management perspective, stakeholder requirements are translated into objectives that guide asset management practice and into required asset service levels that inform the investment required needed to meet these requirements. Vector has assessed our stakeholder's requirements and formed a set of asset management objectives that are the basis of our asset management policy. SECTION 3 sets out these objectives and provides insight into how they inform our asset management governance and practices.

We have also assessed our stakeholders' requirements and defined a set of service level metrics and associated performance targets that reflect our stakeholders' requirements for the performance of our assets. These metrics have been developed to be meaningful to our stakeholders in terms of the services our assets provide, appropriate to managing our assets and relevant to the investments required to meet and maintain service level performance. Section 2.2 provides details of the service level metrics that we use to assess asset performance and establishes the performance targets.

Vector also uses a wide range of asset management metrics that inform our asset experts about the detailed behaviour and performance of various types and populations of network equipment.

2.2 SERVICE LEVELS

The service level metrics that Vector uses to assess performance of the network against the asset management objectives are described in this section. The service levels include those that are required for regulatory purposes in the DPP, these being the SAIDI and SAIFI indices. Further service levels are also measured that inform Vector's asset management practices and we also report to the Vector Board our service level performance with a specific focus on any corrective and remediation activities to address potential deviations from our service level targets.

The following sections detail each service level metric, the methodology of measurement and where applicable, the target level set.

2.2.1 NUMBER OF CUSTOMER CONNECTIONS

DEFINITION

This service level metric is used to detail the number of new customer connections on the Vector network in the RY. It includes both actual historical customer connections and forecast numbers for the next 5 years.

MEASUREMENT

The actual number of customer connections in each year is recorded in Gentrack[8]. The forecast number of gross customer connections is aligned with the Auckland Forecasting Network, a Crown/Auckland Council partnership aligning data and forecasting for Auckland. Long-term projections align with those produced by this group with some short-term adjustments to take into account latest actual connection data. In order to arrive at the net connection figure, any network movements are considered, such as decommissioned ICPs, reconnections, disconnections and movements to embedded networks, and subtracted from the forecast dataset. Further detail on the calculation of customer connections is described in Schedule 12c (Appendix 10).

As well as determining the connections that need to be designed and executed by the Field Service Providers (FSP), this metric is a critical factor in the network planning process.

TARGET

Figure 2-2 in Section 2.3.1 shows the forecast for number of customer connections for the planning period.

2.2.2 NUMBER OF CUSTOMER RELOCATIONS

DEFINITION

This service level metric captures the number of relocations requested by customers in the RY. The relocation projects included in this metric are commercial and residential subdivisions, overhead to underground conversions and minor asset relocations. As with customer connections, this metric includes both actual customer relocations and forecast number for a further 5 years.

MEASUREMENT

The actual number of customer relocations is recorded in Siebel[9]. Relocation projects are managed by Vector's Customer Excellence team. The forecast number of customer relocations is based on an average of the historic relocations; this is because a small percentage of projects are identified in advance, the majority of projects are identified in the year they commence.

TARGET

Figure 2-3 in Section 2.3.2 shows the forecast for number of customer relocations for the planning period.

2.2.3 SYSTEM AVERAGE INTERRUPTION DURATION INDEX

DEFINITION

The SAIDI index measures the average duration of outages per customer per RY, the value expressed in minutes. This is one of the key metrics used to assess the reliability of the network. It is calculated as the sum of the duration of all customer duration interruptions divided by the total number of customers served, where interruptions are for a period of 1 minute or longer i.e.

$$SAIDI = \frac{total\ interruption\ minutes}{average\ number\ of\ customers}$$

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8 Gentrack is Vector's billing and revenue system.

9 Siebel is Vector's Customer Relationship Management (CRM) system.

SAIDI only measures outages caused by an event on the High Voltage (HV) network and does not include the LV network.

The SAIDI dataset is normalised using a process defined by the Commerce Commission in the DPP. This process reduces planned interruptions by 50% as it is considered that customers are less impacted by interruptions that are planned. It also limits unplanned SAIDI on days where a major event has occurred (e.g. storms) to prevent these extreme events distorting the overall SAIDI data. The following formula is used:

$$SAIDI_{Normalised} = \left(0.5\ x\ SAIDI_{planned}\right) + SAIDI_{unplanned}$$

Where:

$SAIDI_{planned}$ is the sum of daily planned SAIDI values in the assessment period; and

$SAIDI_{unplanned}$ is the sum of daily unplanned SAIDI values in the assessment period, where if any daily value of unplanned SAIDI is greater than the SAIDI Unplanned Boundary Value then the daily value equals the SAIDI Unplanned Boundary Value[10].

The SAIDI Unplanned Boundary Value is calculated in accordance with the Commerce Commission process. This limit is set to 3.37 minutes per day for the current regulatory period (1 April 2015 to 31 March 2020).

MEASUREMENT

All of Vector's interruption data is held in our HV Spec database which is used to calculate and report on SAIDI performance. Supply interruptions are identified by the Supervisory Control and Data Acquisition System (SCADA) or through calls to the Customer Excellence team. Once faults have been resolved by the FSP, details of interruptions are logged in HV Spec. The customer interruptions are updated as supply is restored, with SAIDI calculated for each step in the restoration process. Where faults are identified through the Customer Excellence team, details are also captured in Siebel and linked back to HV Spec.

SAIDI is measured on a monthly and annual basis to inform asset management practises. For regulation purposes, SAIDI is reported to the Commerce Commission on an annual basis. SAIDI reporting to the Commerce Commission is subject to an external audit.

TARGET

The SAIDI target is set by the Commerce Commission's regulatory determination every 5 years. It is largely based on the average SAIDI performance over a 10-year historical reference period. The process for setting this target is specified in the DPP.

For the Regulatory Period (1 April 2015 to 31 March 2020) Vector's SAIDI target has been set at 96.0364 minutes (refer to DPP).

Since 2015, several changes to the operating environment in which Vector operates have meant the regulatory SAIDI target is increasingly unrealistic to achieve. Consequently, until a longer-term solution is determined, Vector has developed in-house SAIDI reports adjusted for these factors to ensure ongoing effective management of the assets and ensuring inherent network performance issues are not hidden. We are in discussions with the Commerce Commission to amend our regulated reliability targets for these changes in the operational environment one of which is the introduction of the Health and Safety at Work Act (HSWA) where as a result Vector has moved to doing most work de-energised resulting in an increase in both SAIDI and SAIFI. The SAIDI forecast in Schedule 12d does not reflect our ongoing engagement with

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10 The SAIDI Unplanned Boundary Value is the 23rd highest daily unplanned SAIDI value from the Reference Dataset. For this Regulatory Period this reference data is from 1 April 2004 to 31 March 2014 and is set within the Electricity Distribution Services Default Price-Quality Path Determination 2015.

the Commission on a possible amendment to the target. Therefore the Schedule 12d forecast just reports Vector's current regulatory SAIDI target.

2.2.4 SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX

DEFINITION

SAIFI measures the average number of outages per customer per RY, the value expressed in number of interruptions. This is one of the key metrics used to assess the reliability of the network. It is calculated as the total number of customer interruptions divided by the total number of customers served, where interruptions are for a period of 1 minute or longer i.e.

$$SAIFI = \frac{total\ number\ of\ interruptions}{average\ number\ of\ customers}$$

Like SAIDI, SAIFI only measures outages caused by an event on the HV network and does not include the LV network.

The SAIFI dataset is normalised using a process defined by the Commerce Commission in the DPP. This process reduces planned interruptions by 50% as it is considered that customers are less impacted by interruptions that are planned. It also limits unplanned SAIFI on days where a major event has occurred (e.g. storms), to prevent these extreme events distorting the overall SAIFI data. The following formula is used:

$$SAIFI_{Normalised} = \left(0.5\ x\ SAIFI_{planned}\right) + SAIFI_{unplanned}$$

Where:

- $SAIFI_{planned}$ is the sum of daily planned SAIFI values in the assessment period; and
- $SAIDI_{unplanned}$ is the sum of daily unplanned SAIFI values in the assessment period, where if any daily value of unplanned SAIFI is greater than the SAIFI Unplanned Boundary Value then the daily value equals the SAIFI Unplanned Boundary Value[11].

The SAIFI Unplanned Boundary Value is calculated in accordance with the Commerce Commission process. This limit is set to 0.039 for the current regulatory period (1 April 2015 to 31 March 2020).

MEASUREMENT

All of Vector's interruption data is held in our HV Spec database which is used to calculate and report on SAIFI performance. SAIFI is measured on a monthly and annual basis to inform asset management practises. For regulation purposes, SAIFI is reported to the Commerce Commission on an annual basis. SAIFI reporting to the Commerce Commission is subject to an external audit.

TARGET

The SAIFI target is set by the Commerce Commission's regulatory determination every 5 years. It is largely based on the average SAIFI performance over a 10-year historical reference period. The process for setting this target is specified in the DPP.

For the Regulatory Period (1 April 2015 to 31 March 2020) Vector's SAIFI target has been set at 1.2914 (refer to DPP).

Since 2015, several changes to the operating environment in which Vector operates have meant the regulatory SAIFI target is increasingly unrealistic to achieve. Consequently, until a longer-term solution is determined, Vector has developed in-house SAIFI reports adjusted for these factors to ensure ongoing effective management of the assets, ensuring inherent network performance issues are not hidden. As stated above in Section 2.2.3, we are in discussions with the

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11 The SAIFI Unplanned Boundary Value is the 23rd highest daily unplanned SAIFI value in the Reference Dataset. For this Regulatory Period this reference data is from 1 April 2004 to 31 March 2014 and is set within the Electricity Distribution Services Default Price-Quality Path Determination 2015.

Commerce Commission to amend our regulated reliability targets for these changes in the operational environment one of which is the introduction of the HSWA where as a result Vector has moved to doing most work de-energised, resulting in an increase in both SAIDI and SAIFI. The SAIFI forecast in Schedule 12d does not reflect our ongoing engagement with the Commerce Commission on a possible amendment to the target. Therefore Schedule 12d forecast just reports Vector's current regulatory SAIDI target.

2.2.5 CUSTOMER INTERRUPTIONS STANDARD

DEFINITION

This service level measures the number of unplanned supply interruptions experienced by customers on Vector's distribution network. It differs from SAIFI as it is the actual number of interruptions that a customer experiences rather than the average across the network. As with SAIFI, the interruptions are those of 1 minute duration or greater.

At this stage, this metric only includes outages on the HV network due to limitations in data on the LV network. It is Vector's intention to improve the data on the LV network to allow LV to be included in the future.

MEASUREMENT

All of Vector's interruption data is held in the HV Spec system, which is used to calculate and report on the number of customer interruptions performance. This metric is measured on an annual basis.

TARGET

The Use of System Agreements between Vector and energy retailers and Vector's Service Standards for Residential and Business & Commercial Electricity Consumers[12] define the standard for customer interruptions. The standard states the number of interruptions, longer than 1 minute, that a consumer experiences per year should not exceed:

- 4 interruptions per annum in the CBD and urban areas; and
- 10 interruptions per annum in rural areas.

Vector's overall target level performance is to meet or exceed 99% compliance. The target is based on the historical average for reference period RY10-RY14, which aligns with the reference period used in the DPP to set SAIDI and SAIFI performance targets.

2.2.6 SECURITY OF SUPPLY

DEFINITION

The Security of Supply Standard (SoSS) sets out Vector's performance expectations in relation to restoration targets following planned and unplanned equipment outages. Vector prepares a demand forecast that is used to assess the performance of the network against the SoSS service level. The SoSS performance assessment in Section 2.3.6 is based on the demand forecast for the 'POP' scenario described in Section 1.9. Section 3.5 provides an overview of Vector's demand forecasting practice and Appendix 10 sets out the forecast for RY18 onwards. Based on this demand forecast, Vector anticipates the implication on the network Security of Supply, by essentially comparing asset capacity against demand and determining risks and shortfalls in the network. The approach to this assessment is described in Section 3.5.

SoSSs are defined in terms of N-x where x is the number of coincident outages that can occur during times of high demand without extended loss of supply to customers. Security levels are also defined by the time allowed to restore supply after an asset failure. The security of supply strategy and standards aim to provide customers with an acceptable reliability of supply at an acceptable cost. This means balancing economic and service level risks appropriately.

SoSSs and restoration targets are categorised by the particular asset failure (e.g. zone substations, distribution feeders), the load at risk and by the asset location (e.g. CBD and urban).

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12 https://vectorwebstoreprd.blob.core.windows.net/blob/vector/media/vector/15-08-16-vector_service_standard_doc_res.pdf
https://vectorwebstoreprd.blob.core.windows.net/blob/vector/media/vector/15-08-16-vector_service_standard_doc_bus.pdf

This service level metric captures the number of breaches of the SoSS. It is another key metric used to establish the reliability and availability of the network, and is used to justify expenditure on the network as part of the annual planning cycle (see SECTION 5.1).

MEASUREMENT

Vector works with Auckland City Council to understand the Unitary Plan and future demographic trends thus forecasting and planning the network several years ahead to identify security issues before they occur. Due to the uncertainty around electricity demand, Vector has harnessed scenario planning to develop network strategies for different future scenarios. The methods used in the scenario modelling is described further in Section 1.9. As mentioned above the demand forecast used in this AMP is based on the 'POP' scenario, where customers and network steadily transition to support future demand. The demand forecast is used to assess the performance of our network against the SoSS service level.

Section 3.5 provides an overview of Vector's demand forecast practice and Appendix 10 sets out our 2018 demand forecast. The number of SoSS breaches are forecast on an annual basis.

TARGET

The current target levels in the SoSS are defined in Table 2-2.

CLAUSE	DEMAND	CATEGORY	STANDARD
1	Any	Single events incurring greater than 4 SAIDI minutes	>4 SAIDI minutes: investment evaluated using a risk-based approach <4 SAIDI minutes: assessment as below
2	Any	CBD substation and subtransmission	N-1: 100% demand (no interruption) N-2: 100% demand restored in 2 hours
3	Any	Zone substations (non-CBD)	N-1: 100% demand restored in 2.5 hours (urban), 4.5 hours (rural). This requirement to be met for 95% of the year for primarily residential substations and 98% of the year for primarily commercial substations
	Any	CBD distribution feeders, 11 kilovolt (kV) or 22 kV	Demand restored to all but a single distribution substation in 2.0 hours. Remainder restored in repair time
4	Any	Distribution feeders (non-CBD), 11 kV or 22 kV	Primarily underground: demand restored to all but 800 Kilovolt Ampere (kVA) in 2.0 hours (CBD), 2.5 hours (urban). Remainder restored in repair time Primarily overhead: demand restored to all but 2.5 Megavolt Ampere (MVA) in 2.0 hours (CBD), 2.5 hours (urban). Remainder restored in repair time
5	Any	Distribution substations (11 kV/400 Volt (V))	Restored within repair time
6	Any	Distribution feeders (400 V)	Restored within repair time
7	Any	All subtransmission	Maximum of one month on reduced security
8	Any	Subtransmission and zone substations	Spatial separation of primary network assets sufficient to avoid common mode failure

Table 2-2 SoSS

2.2.7 POWER QUALITY

DEFINITION

This service level measures power quality issues. The metric is presented as a percentage of the number of customers on Vector's network, for each RY. Complaints that relate to power flicker, power fluctuations, voltage magnitude (high / low) and phase unbalance are included. Any issues relating to customer internal faults are excluded.

Power quality is expected to become increasingly important in the industry due to the increase in distributed generation or storage technologies at a customer level. The power quality issues relate to the aspects of electricity supply that could impact on the performance and potential life expectancy of electrical equipment. While measuring the number of complaints does not necessarily give an accurate picture of power quality issues on the network, it helps to monitor whether the issue is becoming more pronounced. Vector can then assess if / when more targeted monitoring or mitigation activities are required.

MEASUREMENT

Power quality complaints are received by Vector's Customer Service team and stored in Siebel. The number of complaints is reviewed on an annual basis.

TARGET

Vector's overall target level performance is to meet or exceed 99.3% compliance. The target is based on the historical average for reference period RY10-RY14, which aligns with the reference period used in the DPP to set SAIDI and SAIFI performance targets.

2.2.8 ASSET SAFETY INCIDENT RATE

DEFINITION

The asset safety incident rate is a count of incidents that resulted in harm to personnel, members of the public or to property, resulting from a deficiency or failure in any equipment on Vector's electricity distribution network. It is measured on a monthly basis and then summed for each RY.

MEASUREMENT

The asset safety incident rate is measured by identifying the number of asset safety incidents in Vector's Risk and Incident Management System (RIMS) which have caused harm or damage to people or property.

TARGET

With safety always being Vector's highest priority, we strive to achieve no asset safety related incidents causing harm to employees, contractors, and the public. Asset related incidents are a subset of the overall safety incidences.

2.2.9 ENVIRONMENTAL BREACHES

DEFINITION

The environmental breach metric is an annual count of the number of environmental non-compliances, prosecutions, fines, or breach of any specific local requirements, regional council requirements, or environmental regulations or requirements. It includes breaches related to exceeding noise limits and the release of oil or Sulphur Hexafluoride (SF_6) gas into the environment, from Vector's electricity distribution network.

MEASUREMENT

Compliance breaches are captured, processed and reported in Vector's legal compliance reports. The metric is measured and reported monthly and summed for each RY.

TARGET

The performance target value is for no environmental breaches.

Vector's environmental target is full compliance with the requirements of all local and regional councils, to have no prosecutions or fines based on breaches, and to have full compliance with environmental regulations or requirements.

2.3 SERVICE LEVEL PERFORMANCE

The following sections shows the analysis of the network assets historical performance against the service level metrics set out in Section 2.2. As per the definitions, it should be noted that performance against all service level metrics is measured in RYs.

2.3.1 NUMBER OF CUSTOMER CONNECTIONS

Figure 2-2 shows the historical and forecast number of customer connections as defined in Section 2.2.1.

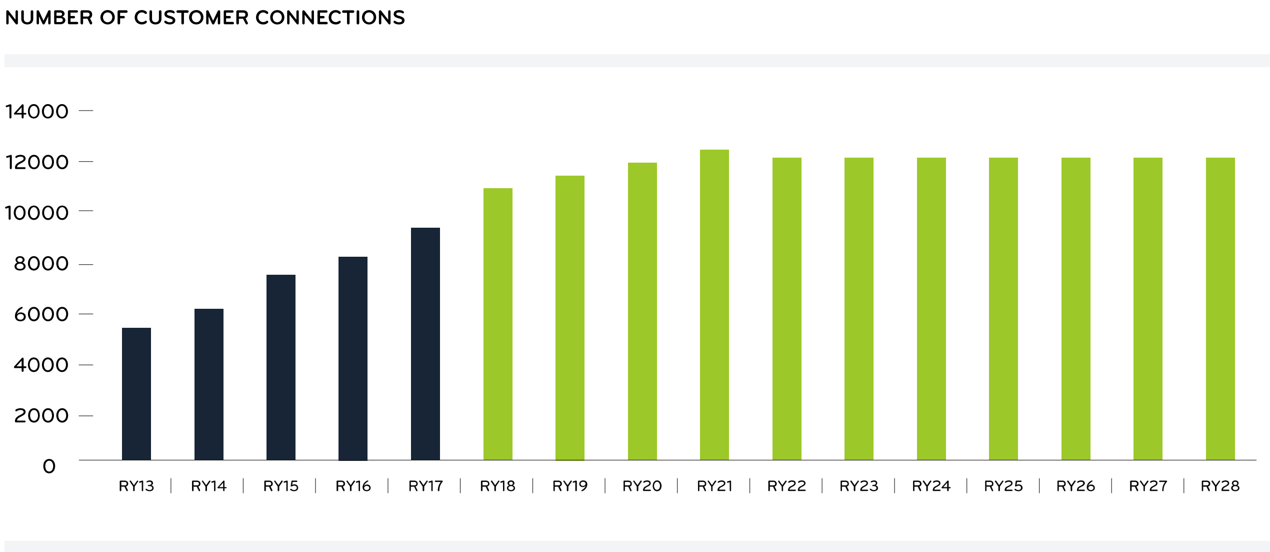

Figure 2-2 Number of customer connections

The number of customer connections has consistently increased since RY13. This trend is anticipated to continue during the planning period and is in line with growth experienced in the Auckland region, as described in Section 1.5. As mentioned in Section 2.2.1, the number of customer connections are based on various forecast economic inputs along with actual connection data. The number of customer connections is assumed to be the same in each of the different scenarios presented in Section 1.9.

2.3.2 NUMBER OF CUSTOMER RELOCATIONS

Figure 2-3 shows the historical and forecast number of customer relocations as defined in Section 2.2.1.

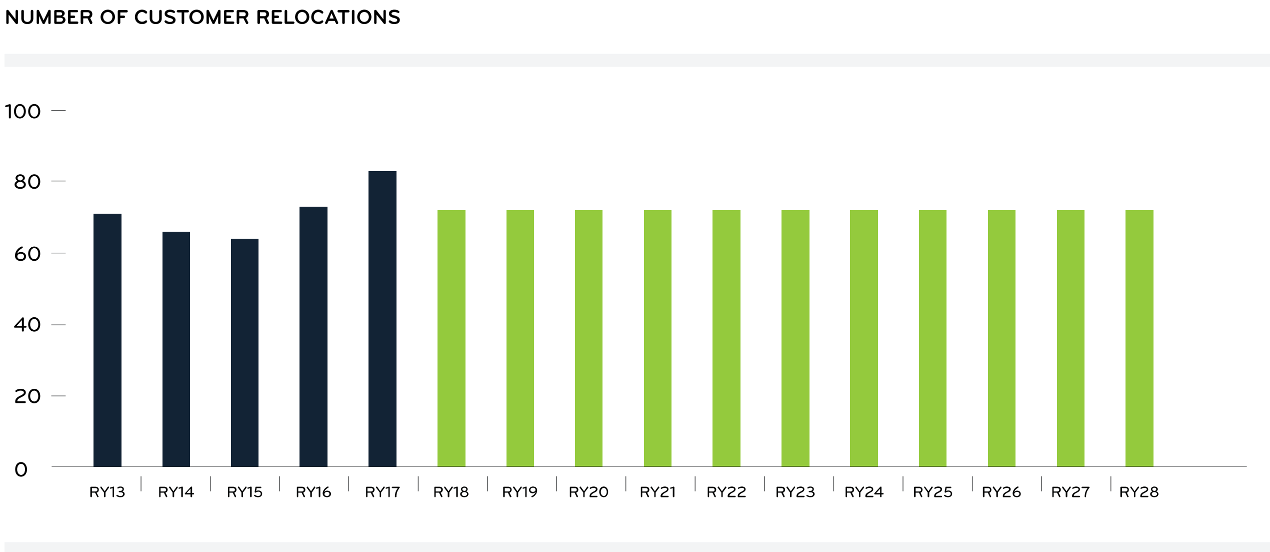

Figure 2-3 Number of customer relocations

The number of customer relocations has increased since RY15, with over 80 relocations in 2017. More recently, there has been an increase in the number of asset relocation projects for road extensions, motorway extensions and subdivision works. However, it is anticipated that future customer relocations will remain constant.

Reference should be made to the AMPs in Section 5.1 for details of customer relocation projects.

2.3.3 SYSTEM AVERAGE INTERRUPTION DURATION INDEX

Figure 2-4 shows the normalised SAIDI performance for the entire Vector network, this includes both planned and unplanned SAIDI in accordance with the definition of this service level metric (see Section 2.2.3). Since RY13, the SAIDI performance has been declining (i.e. increasing SAIDI minutes) and in RY15, RY16 & RY17, the SAIDI performance has consistently been above the regulatory target.

Since RY16, the introduction of Vector's De-energised Work and Isolation Policy has been a significant contributing factor in the increase and duration in interruptions. This policy introduced the rule of no live line work, with lines needing to be isolated during works and therefore the associated number of customers without power increased for both planned and unplanned works. The policy also includes 'Isolation for Safety' measures, where lines are isolated remotely following a customer report on lines being down or low. Fault investigations have shown that the majority of reported lines down are telecommunications or customer owned (service line) assets and not Vector's network assets. Interruptions due to Isolation for Safety are specifically categorised and are set out below. For further background on the De-energised Work and Isolation Policy refer to Section 4.2.7.

TOTAL NETWORK NORMALISED SAIDI

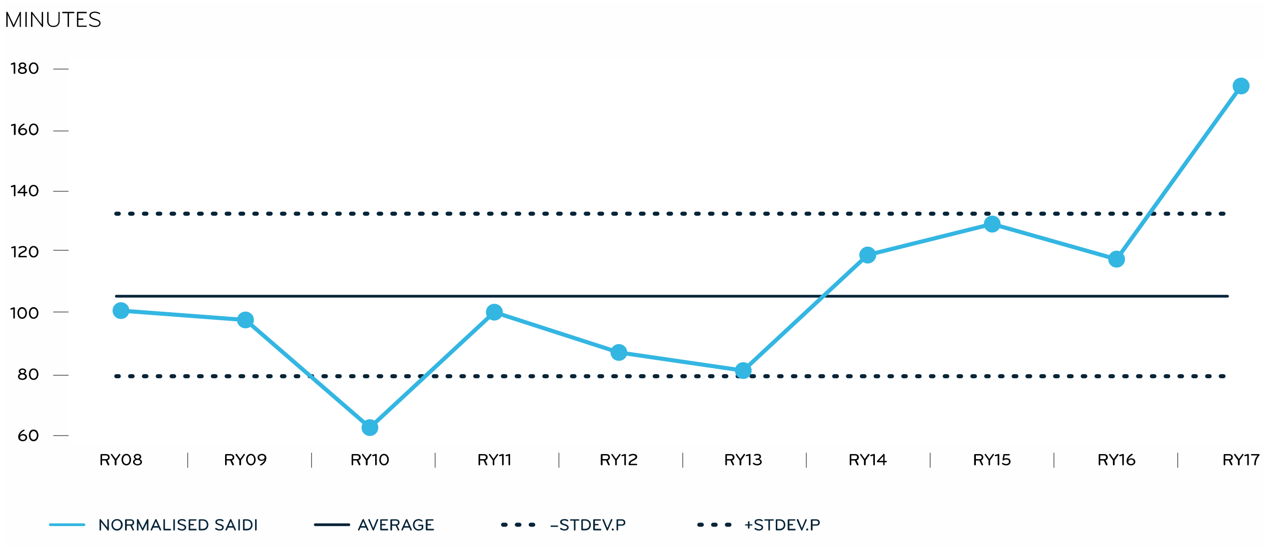

Figure 2-4 Total network SAIDI RY08-RY17

The breakdown of SAIDI performance for RY17 is shown in Figure 2-5 (a). This shows that the largest contributors of SAIDI during RY17 was unplanned distribution feeders outages (72%) and planned outages (21%). Zone substation and subtransmission unplanned outages contribute less to the overall SAIDI because they generally have N-1 security. It is important to note that SAIDI is a combination of three factors:

1. Number of events;
2. Customers affected per event; and
3. Duration of event (referred to as Customer Average Interruption Duration Index (CAIDI)).

Vector continues to invest in automated devices on the distribution network to provide enhanced network resilience. Section 5 provides full details of the planned investments to improve SAIDI. In terms of SAIDI, these devices will mean less customers are affected per outage, or are affected for a much shorter duration. The increase in SAIDI is much greater than the change seen in number of events.

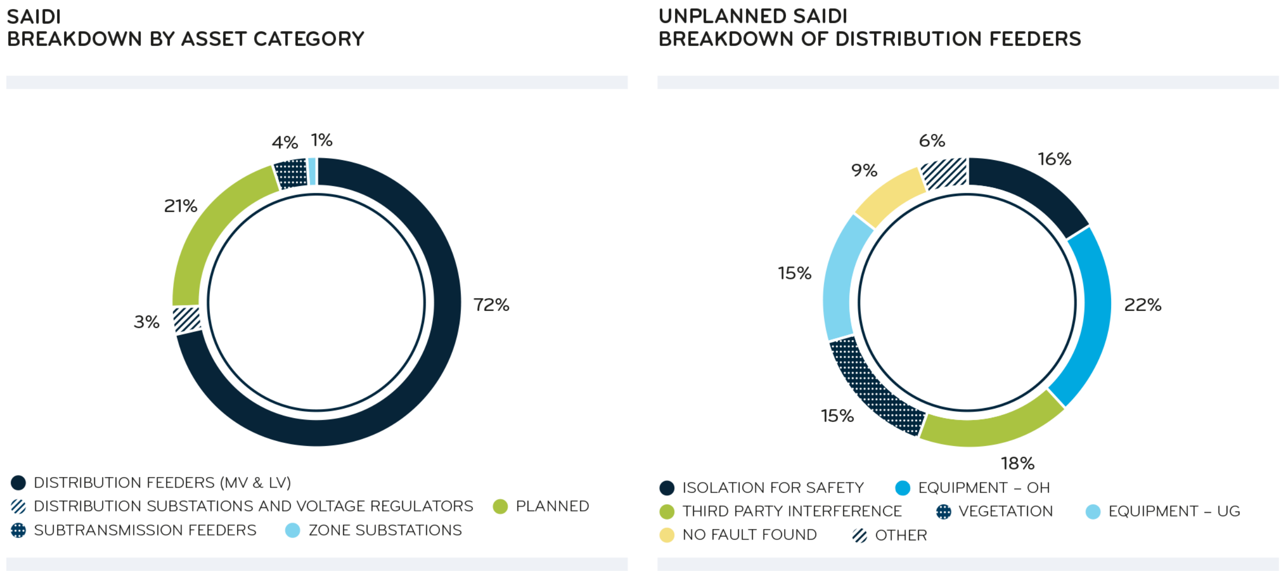

Figure 2-5 Breakdown of RY17 SAIDI by (a) asset category and (b) unplanned distribution feeders

Planned outages are a significant contributor of SAIDI, and have seen a notable increase with the introduction of the De-energised Work and Isolation Policy in RY16 (see comments above).

Of the 72% of SAIDI contributed by unplanned distribution feeders, Figure 2-5 (b) shows the contributing factors. The largest contributors include:

- Isolation for safety contributes 16% of distribution feeders SAIDI and has seen the biggest increase since the introduction of this policy in RY16;
- Third party interference contributes 18% of distribution feeders SAIDI which is predominantly due to cars colliding with poles, also included are third party cable strikes. Both have shown an increasing trend in event count, which are likely linked to Auckland growth and increased traffic congestion (see Section 1.5);
- Vegetation faults contribute 15% of distribution feeders SAIDI and are caused by trees or debris contacting Vector's network. The impact of vegetation is managed through Vector's Vegetation Management strategy (see Section 4.2.8). Analysis has shown that the majority of trees causing events are outside of the growth limit zone as defined by the tree regulations [13], and can cause up to 70% of all events during periods of high winds. This has prompted a change to the vegetation management strategy to include proactive work on trees other than those in the growth limit zone (see Section 4.2.8);
- Underground equipment contributes 15% of distribution feeders SAIDI mainly due to failure of aged cable and cable termination. as shown in Figure 2-6 (b); and
- Overhead equipment contributes 22%, which is the result of deteriorating conductors, crossarms, connectors and insulator failures (as shown in Figure 2-6 (a)).

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13 Electricity (Hazards from Trees) Regulations 2003

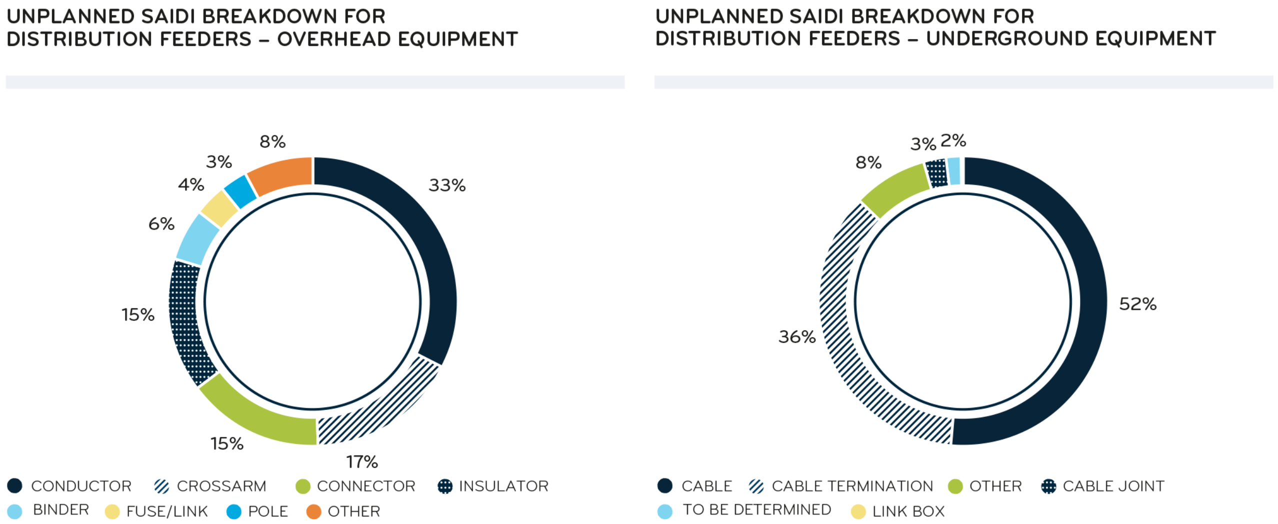

Figure 2-6 Breakdown of RY17 SAIDI for (a) Overhead and (b) Underground Equipment

From an asset management perspective, this analysis shows that the primary equipment related contributors to the SAIDI performance gap identified above are associated with conductors, crossarms, connector and insulator failures, as well as cable and cable termination failures.

The majority of conductor SAIDI is attributed to the failure of aging copper conductors. However, there has also been an increasing trend in the failure rate of ground mounted oil distribution switchgear which requires attention since they will have a significant impact on SAIDI.

Reference should be made to the AMPs in SECTION 5 for details of Vector's response to these causes of the service level performance gaps identified in this analysis.

2.3.4 SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX

Figure 2-7 shows the normalised SAIFI performance for Vector's network, which includes both planned and unplanned SAIFI, in accordance with the service level definition metric in Section 2.2.4. The SAIFI performance, in general, has been volatile and has been above the target level of 1.2914 set for the current regulatory period for 2 out of the last 3 RYs (see Section 2.2.4). In Financial Year (FY) 17, the introduction of Vector's De-energised Work and Isolation Policy in RY16 has had a significant impact on the number of interruptions (see Section 2.3.3).

TOTAL NETWORK NORMALISED SAIFI

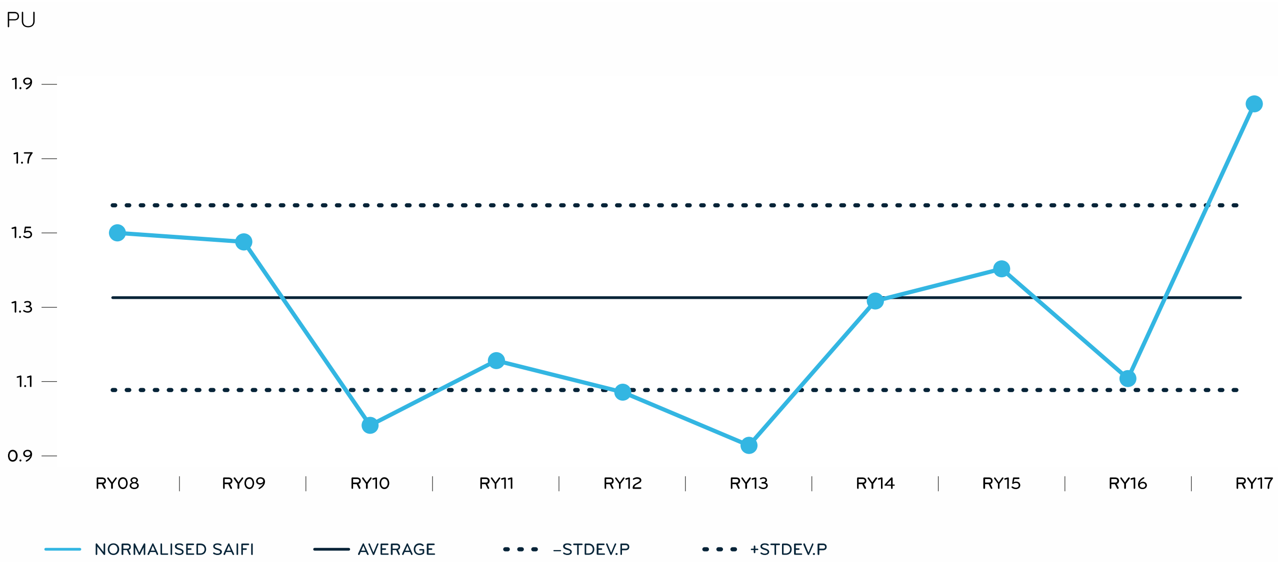

Figure 2-7 Total network SAIFI RY08-RY17

The breakdown of SAIFI performance for FY17 is shown in Figure 2-8 (a). This shows that, as with SAIDI, unplanned distribution feeder outages are the predominant contributor to network SAIFI, accounting for around 78% of total, with planned outages making the second largest contribution of 10%. Zone substation and subtransmission outages contribute less to the overall SAIFI figure because they generally have N-1 security.

It is important to note that SAIFI is a combination of two factors:

1. Number of events; and
2. Customers affected per event.

Vector continues to invest in devices on the distribution network to provide enhanced network resilience. In terms of SAIFI, these devices will mean less customers are affected per outage.

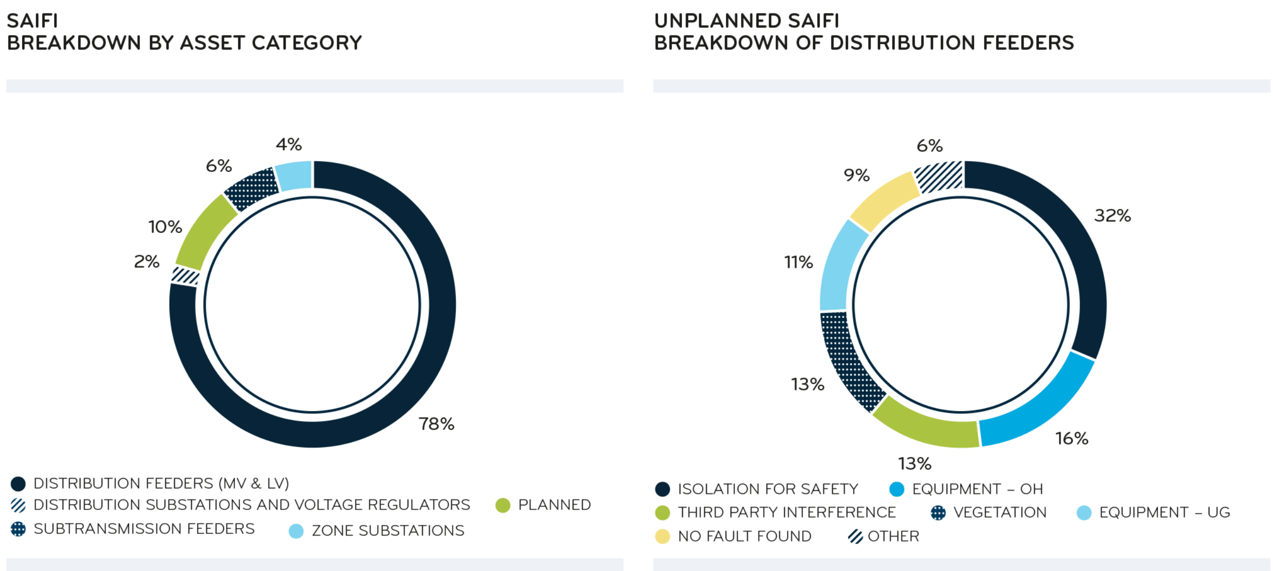

Figure 2-8 Breakdown of RY17 SAIFI by (a) asset category and (b) unplanned distribution feeders

Of the 78% of SAIFI contributed by distribution feeders, Figure 2-8 (b) shows the contributing factors. The largest contributors include:

- Isolation for safety contributes 32% of distribution feeders SAIFI and has seen the biggest increase since the introduction of the De-energised Work and Isolation Policy in 2016;
- Third party interference contributes 13% of distribution feeders SAIFI which is predominantly due to cars colliding with poles, but also includes third party cable strikes. Both have shown an increasing trend in event count;
- Vegetation faults contributes 13% of distribution feeders SAIFI and are caused by trees or debris contacting Vector's network. The impact of vegetation is managed through Vector's Vegetation Management strategy (see Section 4.2.8); Analysis has shown that the majority of trees causing events are outside of the growth limit zone as defined by the tree regulations. This has prompted a change to the vegetation management strategy as mentioned in Section 2.3.3;
- Underground equipment contributes 11% of distribution feeder SAIFI. Theses outages are primarily due to cable and cable termination failures as shown in Figure 2-9 (b);
- Overhead equipment contributes 16% of distribution feeders SAIFI, which is the result of deteriorating conductors, crossarms, connectors and insulator failures as shown in Figure 2-9 (a).

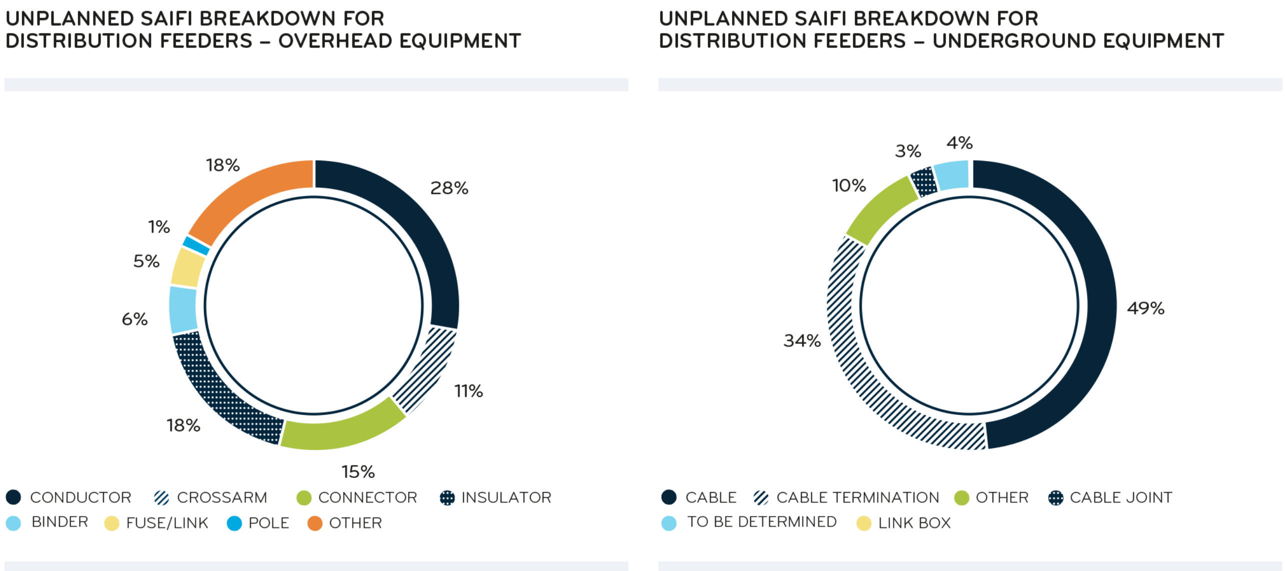

Figure 2-9 Breakdown of RY17 SAIFI related to (a) overhead (b) underground Equipment

From an asset management perspective, this analysis shows that the primary equipment related contributors to the SAIFI performance gap identified above are consistent with those influencing SAIDI.

As per SAIDI, the majority of the conductor SAIFI can be attributed to the failure of aging copper conductor. The increase in failure rate of aging ground mounted oil distribution switchgear which requires attention since they will have a significant impact on SAIDI.

Reference should be made to the AMPs in SECTION 5 for details of Vector's response to these causes of the service level performance gap identified in this analysis.

2.3.5 CUSTOMER INTERRUPTIONS

Figure 2-10 shows the historical performance for the percentage of customers meeting the interruptions standard, defined in Section 2.2.5, against the target of 99% of customers. Figure 2-11 shows the number of interruptions that customers have experienced in RY17.

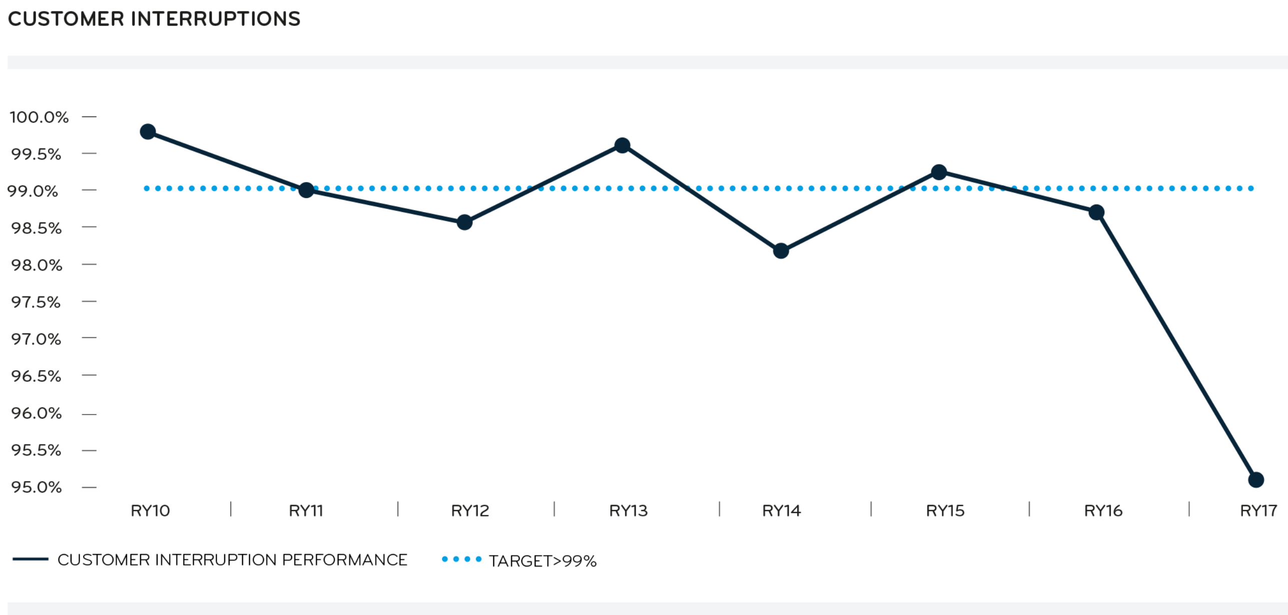

Figure 2-10 Percentage of customers meeting interruptions standard

NUMBER OF CUSTOMER INTERRUPTIONS 2017

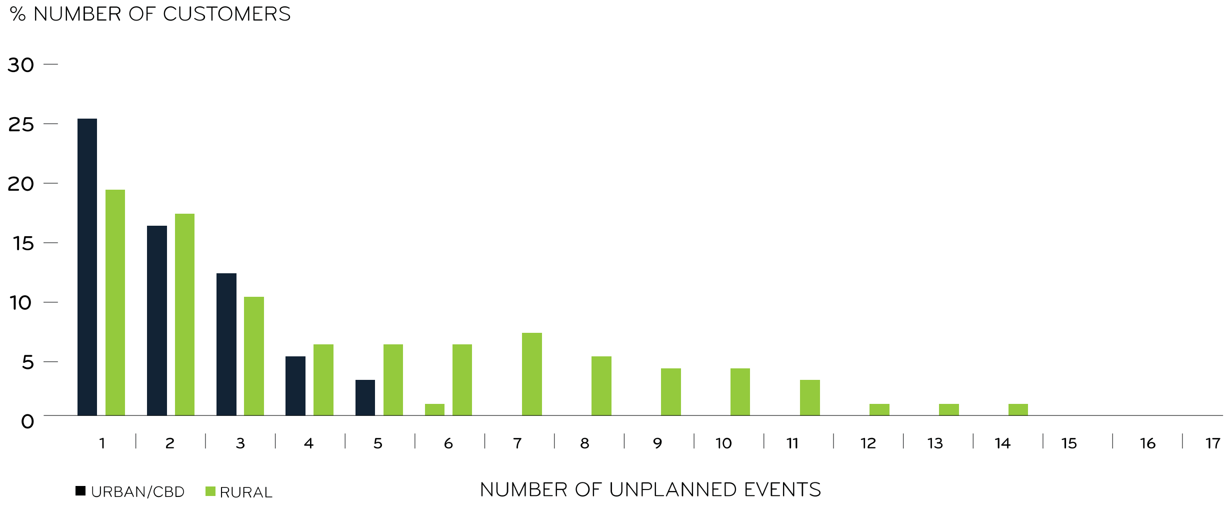

Figure 2-11 Number of customer interruption breaches in 2017

The number of CBD and urban interruptions have increased over the past year with changes in the HSWA playing a role in this increase. In general, the cause of these interruptions is comparable to the reasons for increasing SAIFI (see Figure 2-8 and Figure 2-9). That is, an increase in the frequency of interruptions, results in more customers exceeding Vector's minimum number of interruptions target. Equipment related contributors being associated with conductors, crossarms, connectors and insulator failures, and cable and cable termination failures. As with SAIFI, changes to safe working practices, which has led to whole feeders and larger sections of the network requiring isolation during unplanned events, as required by the De-energised Work and Isolation Policy, will also have impacted on the number of interruptions experienced by customers.

As noted in Section 2.2.5, the effects of LV interruptions are not currently included in the number of interruption breaches due to data limitations. Going forward Vector intends to resolve these data issues and report on both HV and LV in this metric.

2.3.6 SECURITY OF SUPPLY

Table 2-3 shows the forecast number of security of supply breaches in accordance with the definitions of this service level metric (see Section 2.2.6), should no investment be made. It should be noted that for SoSS clause 6 (distribution feeder breaches), the forecast number of breaches is only accurate to FY21 as 11 kV reinforcements projects are only identified one or two years in advance.

Section 5.1 lists the projects needed to mitigate the security of supply breaches. These projects may address more than one breach.

CLAUSE	RY19	RY20	RY21	RY22	RY23	RY24	RY25	RY26	RY27	RY28
Single events incurring greater than 4 SAIDI minutes				1						
CBD substation and subtransmission	2						1	1		

Zone substation and substransmission (non-CBD)	5	11	4	4	2	6	5	5	6	8
Distribution feeders (11 kV or 22 kV)	13	7	6	5	5	3	5		5	10
Total	20	18	10	10	7	9	11	6	11	18

Table 2-3 Security of supply breaches forecast should no investment be made

2.3.7 POWER QUALITY

Figure 2-12 shows the historical power quality performance in accordance with the definition of this service level metric (see Section 2.2.7). Power quality performance has improved since RY14.

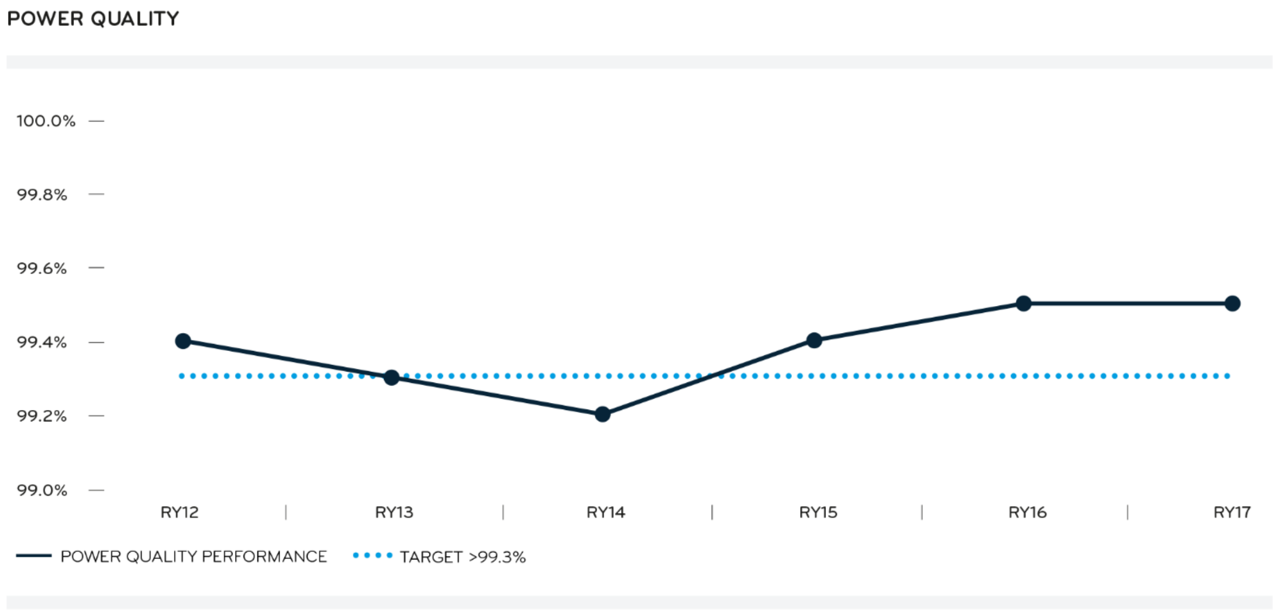

Figure 2-12 Percentage of customers meeting power quality standard

In recent years, Vector has been more actively monitoring power quality related complaints. As mentioned in Section 2.2.7, the number of complaints does not necessarily provide an accurate picture of power quality on the electricity network. However, it does provide a useful monitor to determine if power quality issues are becoming more pronounced.

Power quality is currently only measured at zone substations and not in the LV network. However, smart meters have the potential to provide this information at the LV level (see Section 4.2.9 for Power Quality Strategy). In general, power quality improvements are achieved through planned reinforcement projects, such as new transformers and larger LV conductors (see Section 5.1).

2.3.8 ASSET SAFETY INCIDENT RATE

Table 2-4 shows the asset safety incident performance in accordance with the definition of this service level metric (See Section 2.2.8). In 3 out of the last 6 years the asset safety incident rate has been above the target level of zero incidents.

	RY12	RY13	RY14	RY15	RY16	RY17
Asset safety incident rate	0	0	1	0	2	1

Table 2-4 Asset safety incident rate

Distribution feeder assets have accounted for all asset safety incident events. Analysis shows that the primary contributors are associated with failures of fuses, pillar boxes, stay wires or connectors. The impact of these asset failures is managed through Vector's Health, Safety and Environment Management System's Incident Management Standard (HSEMS 09) and Key Requirements (HSEMS KR 9.1 – 9.4).

Without continued effective maintenance practices, there is an increased risk for the safety incident rate to increase. It is expected that going forward the Maintenance Strategy (Section 4.2.6) and the Safety in Design Strategy (see Section 4.2.11) will contribute to the target of achieving no asset related safety incidents.

2.3.9 ENVIRONMENTAL BREACHES

Vector has not breached the Environmental target of no environmental breaches, which is defined in Section 2.2.9. Achieving this target requires consistent and effective environmental management. It is expected that provided asset maintenance continues as per their respective maintenance standards, which ensures compliance with our asset management objective, that there won't be any environmental breaches.

SECTION

03.

ASSET MANAGEMENT SYSTEM

SECTION 3. ASSET MANAGEMENT SYSTEM

This section provides insight into Vector's asset management practice. The objectives and scope of asset management practice are presented along with an outline of the governance arrangements that we apply. An overview of Vector's asset management practices is also provided in this section and the primary policies, standards, information systems and data that support and enable our practice are identified. An assessment of the maturity of our asset management practice is presented along with consideration of how Vector intends to improve its practice over the timeframe of this AMP.

Vector's asset management is a multi-utility practice that includes both gas and electricity distribution assets. While these practices have much in common, the specific nature of each asset type requires differing approaches for some aspects of asset management. In this section, and throughout this AMP, the scope of asset management is limited to Vector's electricity distribution network. Vector is continually improving its asset management practice, and accordingly, the way asset management practice is described in this AMP differs from previous AMPs. Service levels governed by Regulatory obligations are measured and inform Vector's asset management practices, and are recorded in Vector's risk management system. We also report to the Vector Board our service level performance with a specific focus on any corrective and remediation activities to address potential deviations from our service level targets.

3.1 ASSET MANAGEMENT VALUES AND OBJECTIVES

Vector's asset management policy is the overarching governance document that defines the principles and objectives that guide all aspects of our asset management practice. These principles and objectives accord with our corporate values and align with our corporate vision and mission.

Vector is committed to ensuring safe, reliable and cost effective electricity services for the benefit of all our customers. This commitment is demonstrated through the principles and objectives that we apply in managing our network assets.

- Safety is our highest priority, and we strive to achieve zero harm to employees, contractors and the public through the management of our assets over their entire lifecycle;
- We strive to serve our customers by managing our assets to provide a reliable, sustainable, resilient, and efficient distribution network that meets our customer's present and future service expectations;
- Delivering value to our customers and shareholders is at the core of our business and we maximise the value that our assets deliver across their entire lifecycle through good practice asset management, risk management and sound asset investment decisions;
- Our asset management is fact based, drawing on analysis of data to drive understanding and underpin the creative management of our assets in the long-term interests of our customers;
- We care for our natural environment, and so we manage our assets and work with our suppliers to improve energy efficiency, reduce greenhouse gases and minimise the environmental footprint of our distribution network assets;
- We create sustainable value through a long term strategic focus that we leverage to drive an innovative approach to asset management that aligns with Vector's corporate vision and goals as a multi-utility asset manager; and
- As a regulated provider of distribution network services, we aim to comply with all applicable statutory and regulatory obligations and draw on good asset management practice to achieve and maintain this compliance.

In addition to these principles and objectives, Vector's asset management practice seeks to accord with the principles of ISO 55001 and reflects a whole of lifecycle approach.

3.2 ASSET MANAGEMENT SCOPE

Throughout this AMP, the scope of asset management is limited to Vector's electricity distribution network, while the scope of our plans covers the period from 1 April 2018 to 31 March 2028. Consistent with Information Disclosure requirements, a greater level of planning detail is provided for the first five years of this period.

The primary asset within this scope is Vector's electricity distribution network. This asset is an interconnected network that operates as a geographically distributed machine with many interdependent elements as shown in Figure 3-1. However, for the purposes of this AMP, we have defined asset categories that correspond to the major functional elements of our network. Table 3-1 shows the asset categories we have adopted in this AMP and compares them to the Information Disclosure asset categories,[14] while Table 3-1 shows how the AMP asset categories and the Information Disclosure asset categories relate in terms of the network topology.

SCHEDULE 11A(III) ASSET CATEGORIES	AMP ASSET CATEGORIES
Subtransmission	Subtransmission feeders
Zone substations	Zone substations
Distribution and LV lines	Distribution feeders (HV & LV)
Distribution and LV cables	
Distribution substations and transformers	Distribution substations and voltage regulators
Distribution switchgear	
Other network assets	Secondary systems and other network assets

Table 3-1 Asset category relationships

14 Commerce Commission, Electricity Distribution Information Disclosure Determination 2012 (consolidated in 2015) 24 March 2015, Clause 4.5.1.

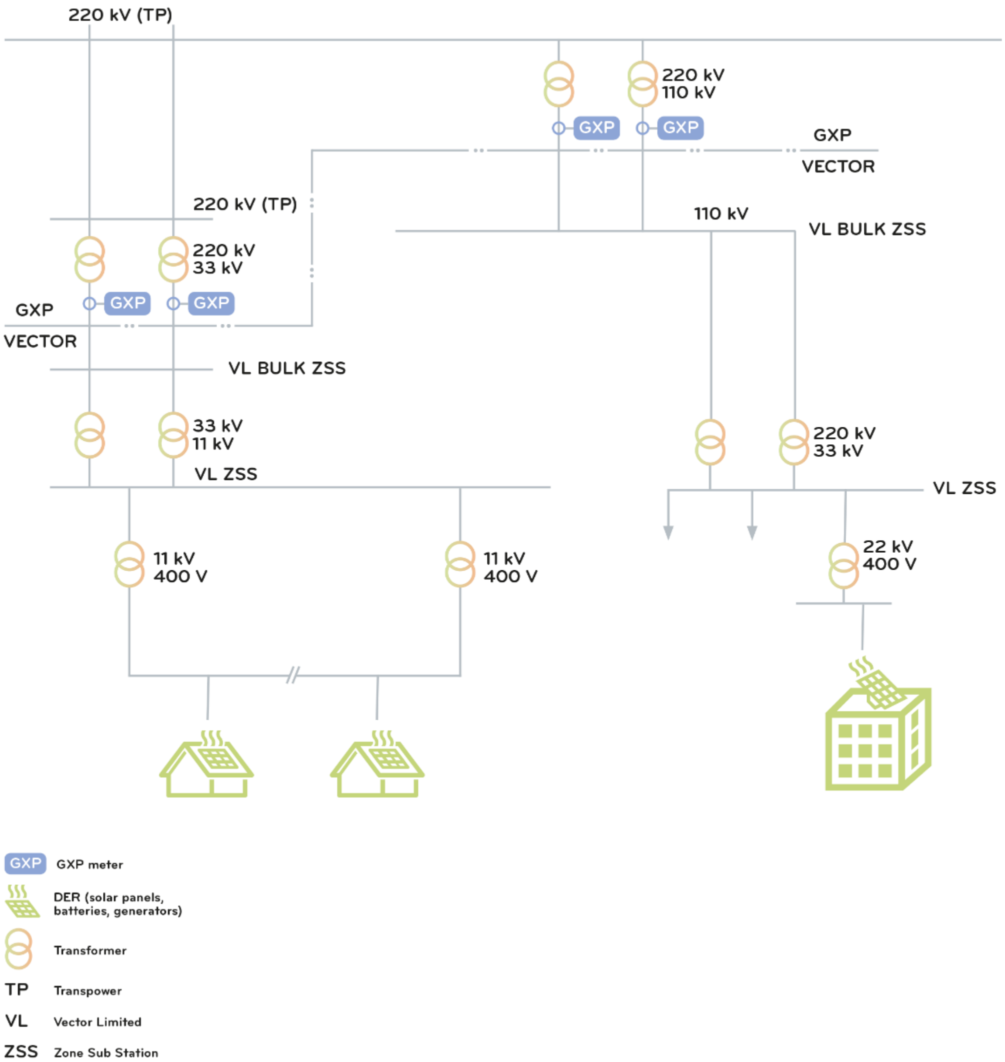

Figure 3-1 Network topology diagram

While Section 4.1 and Appendix 6 provide details that align with the Information Disclosure asset categories, Vector's broader AMP is developed in terms of the AMP asset categories shown in Table 3-1. Vector has developed its AMP based on these asset categories as they better reflect how our network operates (i.e. its topology), and it focuses on customer service that is mostly related to distribution feeders (HV & LV). Importantly, for future network development this structure also better captures the network implications of new technology. Specifically, capacity stranding and the related thinning of the network will mostly impact subtransmission feeders first and progressively zone substations, while DER will influence the function and operation of distribution feeders (HV & LV) as bidirectional power flows start to impact. The functional capability of distribution substations will also alter as DER changes power flows and impacts on customers' service needs. As these implications become clearer, specific strategies will need to be established that reflects the impact of new technology on these major functional elements of our network. Similarly, Vector's network vision has specific implications for each of the major functional elements listed in Table 3-1 as our AMP asset categories.

Further details of Vector's electricity distribution network assets, how they are defined and key statistics, is provided in SECTION 4.

3.3 ASSET MANAGEMENT ORGANISATION AND GOVERNANCE

Vector's asset management organisation and our governance structure is shown in Figure 3-2. This structure provides oversight and controls all aspects of our asset management practice. An overview of the asset management responsibilities and governance roles within this structure are set out below.

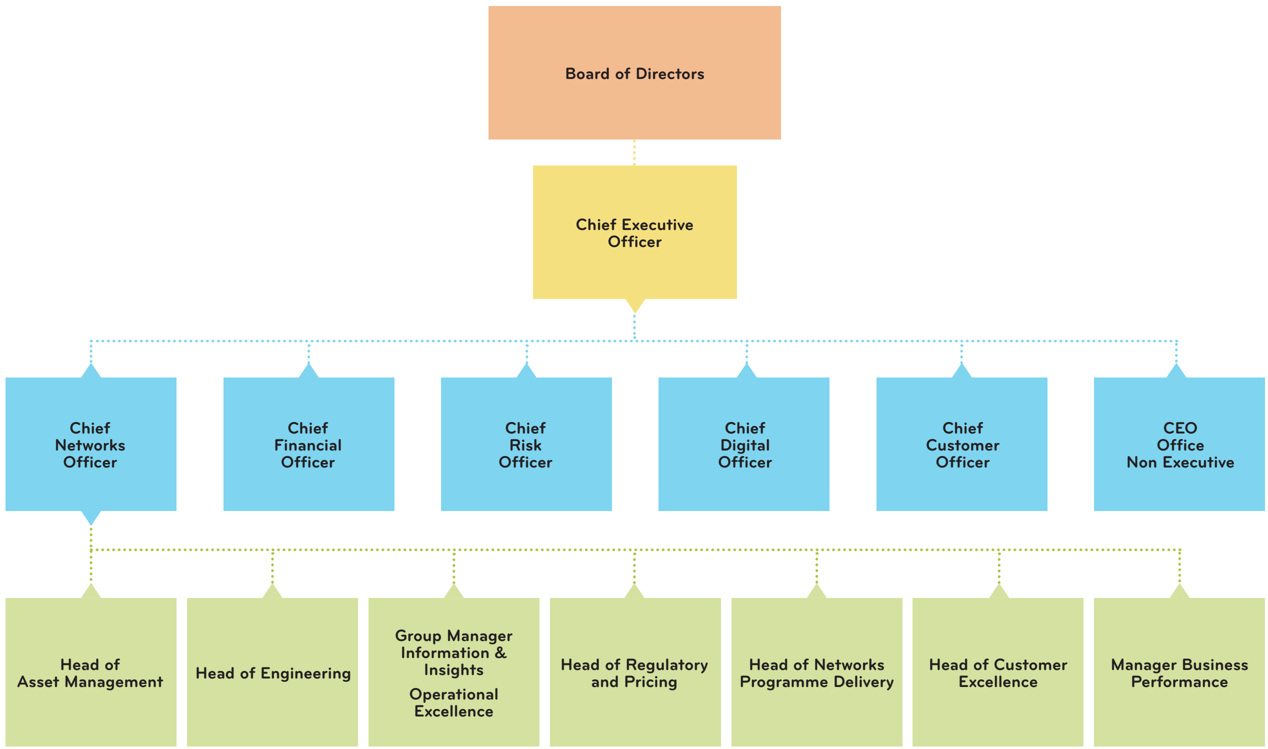

Figure 3-2 Asset management governance structure

3.3.1 BOARD OF DIRECTORS

At the highest level, the Board of Directors operates under the Board Charter, and provides governance over all aspects of Vector's asset management practices on behalf of Vector's owners and the broader stakeholder community. While taking advice from Vector's management, the board exercises oversight of the objectives of asset management, its strategic direction, investment approvals and the customer service level outcomes achieved by Vector's electricity distribution network. Overall budgets, significant expenditures and asset investments are reviewed and approved at the board level.

Vector's Board of Directors maintains its asset management oversight through the implementation of governing policy, a delegated authorities' framework, management reporting and periodic reviews including internal and external operational audits. The Board also receives performance reporting which among other things include reporting against key service levels and regulatory reliability targets.

Vector is committed to maintaining the highest standards of corporate governance, ensuring transparency and fairness, and recognising the interests of our shareholders and other stakeholders. Full details of Vector's board members, the executive leadership team and our corporate governance structure are provided in our Annual Report.

3.3.2 GROUP CHIEF EXECUTIVE

Under the delegated authorities' framework, the approved strategic plan, approved annual budgets and the day to day operation of the business is the responsibility of the Group Chief Executive (GCE). The GCE maintains oversight of Vector's asset management practices, including service level outcomes, strategic direction and investment approvals. To assist with this oversight the GCE receives performance reporting against key metrics and service levels which include reporting against regulatory reliability targets.

All Vector's activities are governed through the delegated authorities' framework which links approved budgets to the authority to authorise or commit expenditure. Under this structure, the GCE has delegated responsibility for asset management to the Chief Networks Officer (CNO).

3.3.3 CHIEF NETWORKS OFFICER

Under delegation from the Board and GCE, the CNO also has full responsibility for Vector's electricity asset management practice. This includes the establishment and enforcement of Vector's Asset Management Policy, the overall performance of Vector's electricity distribution network, development and implementation of the approved AMP, and budgetary control with the delegated authorities' framework.

Within the asset management context, the CNO is supported by the Chief Financial Officer, Chief Risk Officer, Chief Customer Officer and the Chief Digital Officer in ensuring that appropriate systems, policies and procedures are in place that support and enable asset management, as well as implementation of the management and governance practices required by the Board of Directors and GCE. The CNO role is responsible for compliance with the requirements of Vector's risk management framework, delegated financial authorities, and in conjunction with the Chief Digital Officer, for ensuring that Vector's Digital Strategy meets the needs of our asset management practice and enables our network vision (see Section 5.3.1).

3.3.4 HEAD OF ASSET MANAGEMENT

The Head of Asset Management reports to the CNO and has responsibility for the day to day operation of Vector's asset management practice. This position is responsible for ensuring that Vector's Asset Management Policy is implemented, for monitoring the service level performance of our assets, for the development of asset strategy, for the development of Vector's AMPs (including maintenance standards) and for developing asset management practice. This role also has limited budgetary control within the delegated authorities' framework.

3.3.5 HEAD OF ENGINEERING

The Head of Engineering reports to the CNO and is responsible for Network Planning, Engineering and Design Standards, as well as development and integration of new technology options. The primary focus of this role is planning and development of the assets to meet the required service levels and to achieve Vector's network vision. In particular, the Head of Engineering is responsible for the service levels associated with the SoSS, quality of supply and for new connection demand associated with large or unusual connections, as well as demand for significant asset relocations (see Section 2.2).

3.3.6 OTHER SENIOR POSITIONS THAT SUPPORT ASSET MANAGEMENT

There are several other senior roles that provide critical support to the CNO role, the Head of Asset Management and the Head of Engineering. Specifically:

- **Head of Customer Excellence:** this role is responsible for ensuring customer expectations are met through the Call Centre Management and Customer Initiated Projects processes. The Head of Customer Excellence also champions the voice of our customers within Vector's asset management practice.
- **Group Manager Information & Insights:** this role is responsible for Networks Analytics, Business Intelligence, as well as Networks Risks and Investigations. This function provides analytical support and information that is essential to understanding asset performance, developing and evaluating asset strategy and managing asset risks.
- **Head of Networks Programme Delivery:** this role manages the day to day networks operations and the Electricity Operations Centre (EOC) as well as delivery of the approved CAPEX and OPEX works programme under Vector's Multi Utility Service Agreement (MUSA) with our FSPs. The works programme is delivered through our Project Delivery Framework (PDF) that ensures compliance with Vector's requirements and in accordance with the AMP. Section 6.3 provides further details of the PDF.
- **Head of Regulatory and Pricing:** this role ensures that Vector's regulatory activities and pricing is managed appropriately. The Head of Regulatory and Pricing provides regulatory compliance oversight as well as expert regulatory advice and support to Vector's asset management practice.

The governance framework overarching each of these roles is defined by Vector's Delegated Authorities Framework (DAF), the Delegated Financial Authorities Policy (DFA) and position descriptions for each role. Vector's Board has delegated specific authorities to the GCE and authorised delegation of certain authorities to other levels of Vector's management. The limits and rules applied to delegations are prescribed in the DAF documentation and govern the authority to commit to transactions or expose Vector to a risk.

Vector's Enterprise Resource Planning (ERP) System (SAP) is the primary management system used to implement the DAF and DFA. Financial delegations for approvals under the DAF for OPEX and CAPEX are set and managed within Vector's ERP system. Periodic audit of the DAF is undertaken to ensure ongoing compliance. The ERP system also provides control of asset management workflows, as well as the management of information that enables our asset management and project management practices. Further details of Vector's asset management practice and our project management practice are provided in Section 3.5 and Section 6.3 respectively.

3.4 KEY DOCUMENTS

Vector has a robust set of documents that inform our asset management practice. Table 3-2 provides an overview of these governing documents which are used to create 'line-of-sight' in preparing the AMP.

KEY DOCUMENT	DESCRIPTION
Business Plan	The business plan shows Vector's goals and discusses at a strategic level how Vector is going to achieve them. It provides direction to our AMP in managing our assets to achieve the outcome in the business plan.
Organisational Policies and Standards	Vector has many policies and standards that provides a course of action or guidelines for staff. See Section 3.4.1 and 3.4.2 for policies and standards that relates to asset management.
AMP	Vector's AMP is a tactical plan for managing the physical assets to deliver an agreed service levels to achieve the objectives and goals outlined in the business plan.
Operational Programme	The output of the AMP is the operational programme which drives OPEX on Vector's electricity network. It informs the development of asset maintenance plans.
Capital Programme	The outcome of the AMP is the capital programme which drives CAPEX on Vector's electricity network. It informs the business cases prepared for capital investments.

Table 3-2 Key documents that informs asset management

Vector also has a robust set of policies and standards that inform our asset management practice. The following subsections provide insight into these governing documents and how we use them.

3.4.1 MAJOR POLICIES

Vector's major asset management policies are listed in Table 3-3 along with a brief description of how each policy informs our asset management practice.

POLICY DOCUMENT	ROLE IN ASSET MANAGEMENT PRACTICE
Asset management policy	This policy is Vector's formative asset management document. It defines the principles and objectives that guide all aspects of our asset management practice. Further details of our asset management policy is provided in Section 3.1
Delegated financial authorities policy	The DFA has a primary role within Vector governance practices that are defined by Vector's DAF. The DFA governs the level of financial commitment that specific roles can make on behalf of Vector. All decisions within asset management that require expenditure or involve significant risk will be made under this policy and in accordance with Vector's project approval process. Under this policy, projects in the early stages of development are given preliminary approval, while final approval must be provided before expenditure is committed. Further information on Vector's governance practices as they relate to asset management can be found in Section 3.3
Networks risk management process	This document sits under Vector's Corporate Risk Policy and Risk Management Guideline. The Network's Risk Management Process sets out specific requirements for asset risk management including how risk is to be managed, identified, assessed, and reported. Further information on Vector's network risk management practices are provided in Section 3.5
Health and safety policy	This policy sets out Vector's commitments and requirements for health and safety. Vector will conduct its business activities in such a way as to protect the health and safety of all workers of Vector Limited and its related companies ("Vector People"), the public and visitors in its work environment

Environmental policy	This policy sets out Vector's commitment for managing the environmental aspects of its businesses and sets out the standards expected of all workers of Vector Limited and its related companies ("Vector People")
Electricity safety and operating plan	This Safety And Operating Plan has been developed for Vector's electricity network to detail the controls in place to mitigate the risks that have been identified under the hazard and risk assessment processes for minimisation of harm to persons, property, the public and the environment, including emergency response

Table 3-3 Major asset management policies

Appendix 2 provides an overview of other important asset management policies and related documents that inform specific aspects of Vector's asset management practice.

3.4.2 MAJOR STANDARDS

Standards are an integral part of our asset management framework and Vector applies a large number of these standards to the management of our electricity distribution assets. Table 3-4 lists the major standards that support the procurement, supply, commissioning, operation and maintenance of existing, new or replacement assets.

ASSET STANDARD	ROLE IN ASSET MANAGEMENT PRACTICE
Planning standards (ESP and ENS series)	These standards guide the planning and development of Vector's overall distribution network. They work in conjunction with the SoSS service level metric to ensure that the network has sufficient capacity and capability to provide the required service levels, enable customer connections, and accommodate growth. These standards also set requirements that enable appropriate operation of the network in accordance with the Network Operating Standards (see below). Further information is provided in Section 3.5
Maintenance standards (ENI, ENS and ESM series)	Vector has developed a set of maintenance standards for each major class of asset. These detail the required inspection, condition monitoring, maintenance and data capture requirements. Where a cyclic maintenance strategy is applied these standards also set out the maximum maintenance cycle frequency. These standards implement compliance with our asset management policy and ensure our assets continue to operate across their design life to provide the required service levels (see 1.10)
Network operating standards (EOS series)	These standards define protocols and procedures for operating and controlling Vector's electricity network, including contingency plans. They also inform minimum requirements for network planning and design practices
Design and construction standards (ENG, END, EDE, ESE, CND and ESS series)	There are a large number of these standards and they cover the detailed design and installation of Vector's network equipment
Technical specifications (ENS)	Vector has a number of technical specifications which specify the materials and equipment to be used on the electricity network
AS/NZ standards AIEC standards	A large number of Australian and New Zealand standards, as well as International Electrotechnical Commission (IEC) standards are applied in specifying, developing, and maintaining Vector's electricity assets. A full list of these standards is beyond the scope of this AMP

Table 3-4 Major asset standards

Vector uses a range of other standards and related documents in its asset management practice. A listing of some of the more important standards can be found in Appendix 2.

3.5 ASSET MANAGEMENT PRACTICE

The following sections provide an overview of the practices and principles that Vector applies in the management of its electricity distribution assets. These practices are set in the context of our asset management framework that guides implementation, operation and improvement of asset management. Each of the major asset management process elements is described below with attention given to some specialist aspects of our practice.

3.5.1 ASSET MANAGEMENT FRAMEWORK

At the broadest level, Vector's asset management practice reflects an asset lifecycle approach guided by the principles of ISO 55001 and this is reflected in our Asset Management Framework shown in Figure 3-3.

Our framework is grouped into five sections to reflect the major stages of Vector's asset management practice. These five stages are highlighted in Figure 3-3 and described in the following sections.

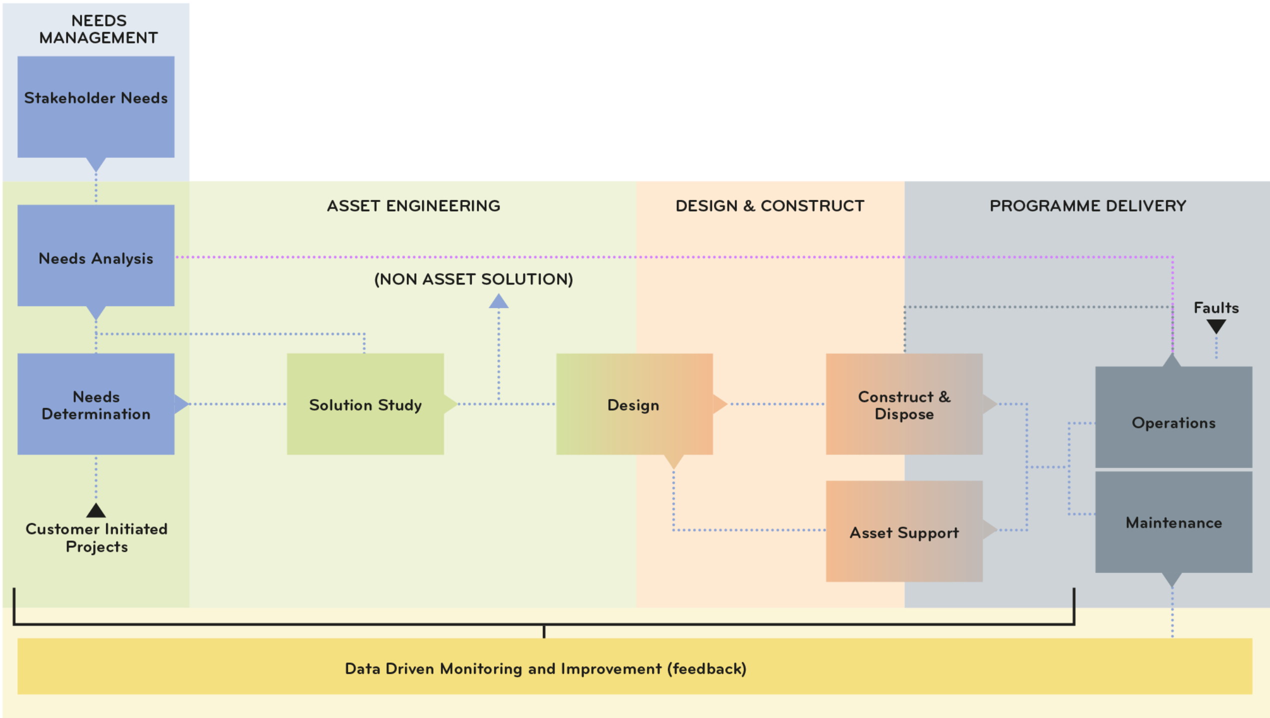

Figure 3-3 Asset management framework

3.5.2 NEEDS MANAGEMENT

This is the formative stage of our asset management practice and involves Stakeholder Needs identification, Needs Analysis and Needs Determination. During this stage, Vector engages with its stakeholders to identify and understand their service needs and requirements. By understanding stakeholders' requirements, Vector is able to develop meaningful service level metrics and associated performance targets that are used to assess asset performance. SECTION 2 provides details of our primary stakeholders and the service levels metrics and targets we use in managing our electricity distribution network assets.

On an annual basis, Vector assesses asset performance against the service level targets defined in Section 2.2. Using asset data from SAP and supported by Vector's data analytics layer, analysis of performance volatility and trends are used to identify any significant systemic performance issues. While focus is placed on understanding the assets' historical performance, Vector also considers our assets expected future performance. Any actual or expected performance gaps are identified, and root cause analysis and risks analysis are undertaken to identify the source and significance of any actual or expected service level breaches. Details of the service level gap analysis, root cause analysis and asset needs analysis are provided in Section 2.3.

The result of this analysis is to identify the need for asset related services and network development, or corrective or preventative interventions, that address actual or expected degradation of service performance outcomes. Project proposals are created to address these needs. These proposals specify the need identified, the options considered to address the need and the preferred option. Project proposals are also created through the network planning process (see below), which is responsible for managing the development of the network through a probabilistic planning approach.

All project proposals are approved by Vector's subject matter experts and are then subjected to a portfolio optimisation process as described in Section 6.1. Through the portfolio optimisation process, any conflicting requirements are addressed by trading off requirements to select the option with the greatest overall benefits and least cost. The project proposals for this AMP are provided in SECTION 5 and the results of trade-off's made through the optimisation process are set out in Section 6.4.

3.5.3 NETWORK PLANNING PRACTICE

Vector's network planning practice forms an important specialist aspect of Needs Management that applies across the segment, focusing on network development. Our network planning practice involves processes to manage network peak demand (organic growth), and need for asset services initiated directly by customers that may have significant network implications (i.e. major connections, unusual loads and major asset relocations).

The need for asset services initiated directly by customers includes network connections and asset relocations. Sections 2.2 and Section 2.3, respectively, describe the service level metrics for connections and asset relocations, and consider the need for these services. In most cases, network connections and asset relocations are managed directly by Vector's FSPs who undertake design, execute project works and maintain associated asset records, in accordance with Vector's standards. Where practical, opportunities to combine network development or asset replacement works with customer initiated works are leveraged to achieve cost savings and other advantages.

Growth in network peak demand (organic growth) is managed under the SoSS service level discussed in Section 2.2.6. Section 2.3.6 analyses the performance of the SoSS service level based on Vector's demand forecast (see Appendix 10). The SoSS service level captures a cost-quality trade-off that reflects the ability of our assets to accommodate electrical demand without breaching quality of supply requirements, and to provide restoration capacity that supports planned and unplanned supply interruption events. Performance against the SoSS service level is managed through an annual network planning cycle that involves:

- Development of Vector's annual network load forecast in accordance with the Electricity Load Forecasting Process. An overview of Vector's load forecasting process is provided later in this section;
- Updating of Vector's network model with asset changes and the latest load forecast in accordance with the Network Modelling Guidelines. To support this practice, data on customer connections is extracted from Gentrack and Smallworld. A specialist data management tool, OSIsoft PI, is also used to extract other network data from Vector's digital systems (see Section 3.6);
- Modelling of the network to identify future capacity or security constraints that breach the SoSS service level requirements. Modelling is undertaken using Digsilent, our network modelling software, and in accordance with the Electricity Network Security Standard. This model includes the capability of modelling both subtransmission and HV distribution networks to ensure adequate capacity under contingency conditions or other nominated scenarios including future loads increases, the impact of investment in additional network capacity and effect of seasonal load and asset ratings to meet SoSS. Details of Vector's primary plant ratings are set out in Appendix 9.
- Where a breach of the SoSS service level is identified, a risk assessment is undertaken and options developed as outlined under Asset Engineering (see above). Any proposal to respond to an expected breach will be developed to address the breach on a just-in-time basis, and are developed in accordance with Vector's corporate and asset strategies and with the System Design: Network Parameters standard.

The SoSS service level is also taken into consideration when reviewing asset replacement options, and any synergies with network development works are investigated. Moreover, not all breaches of the SoSS service level are addressed through network investment, as in some cases non-network solutions are practical and more economical.

Further information regarding the standards used in Vector's network planning practice are provided in Section 3.4 and Appendix 2.

NETWORK LOAD FORECASTING PROCESS

Vector's network planning practice harnesses load forecasts that are informed by a wide range of data inputs and represent the Auckland geographic area with high granularity. The load forecasts are based on scenario planning to capture a variety of future developments in order to capture the uncertainties associated with the impact of the new customer-side technologies. Vector's model, data inputs and scenarios are described in Section 1.9 and the load forecasts can be found in Appendix 10 of this AMP.

As we move forward in time we will closely monitor load development with a focus on studying areas where there is a high penetration of new customer-side technologies to validate and update our model with additional data. The target is to stay, as much as possible, flexible and agile in our physical asset investments so that we can respond to the impact of new technologies and customer demands. As we recognise changes to the demand profile over time, we are defining network strategies to invest ahead of the technology uptake curve to encourage customer choice and enable achievement of network safety, reliability, operational cost reduction and customer service excellence. The SYMPHONY scenario, introduced in Section 1.9, represents such a high-value investment strategy.

3.5.4 NETWORK RISK MANAGEMENT

Risk management is integral to Vector's asset management process. Vector's Risk Management Policy sets out the objectives and rationale for risk management and governs asset risk management practice in line with the global risk management standard ISO 31000:2009 Risk management – Principles and guidelines.

Vector's Network Risk Management Process sets out the framework, criteria and methodologies used for effective enterprise risk management. This framework reflects the nature of our business as a supplier of critical infrastructure, a leading New Zealand-listed company and an operator of high hazard businesses. Accordingly, Vector's network risk management practice is audited and certified to NZS 7901 Electricity and Gas industries – Safety management practice for public safety, and incorporates a risk control audit and assurance programme. Quality service metrics, i.e. SAIDI and SAIFI, governed by Regulatory obligations are recorded in Vector's risk management system. We also report to the Vector Board our service level performance with a specific focus on any corrective and remediation activities to address potential deviations from our service level targets.

Vector's enterprise-wide approach to risk management:

- Provides a single complete view of risk, and ensures a consistent appraisal and treatment is applied across the business;
- Aligns across a number of profiles and contexts (as illustrated in Figure 3-4), to support the achievement of strategic corporate objectives while ensuring key operational activities are appropriately managed and assessed;
- Considers the external trends and drivers which shape Vector's operating environment and creates both risks and opportunities for the business (as outlined in SECTION 1);
- Is integrated into all aspects of our asset management practice; and
- Is managed in line with Vector's data analytics and digital strategy to link network data sets and create tailored user interfaces and reporting.

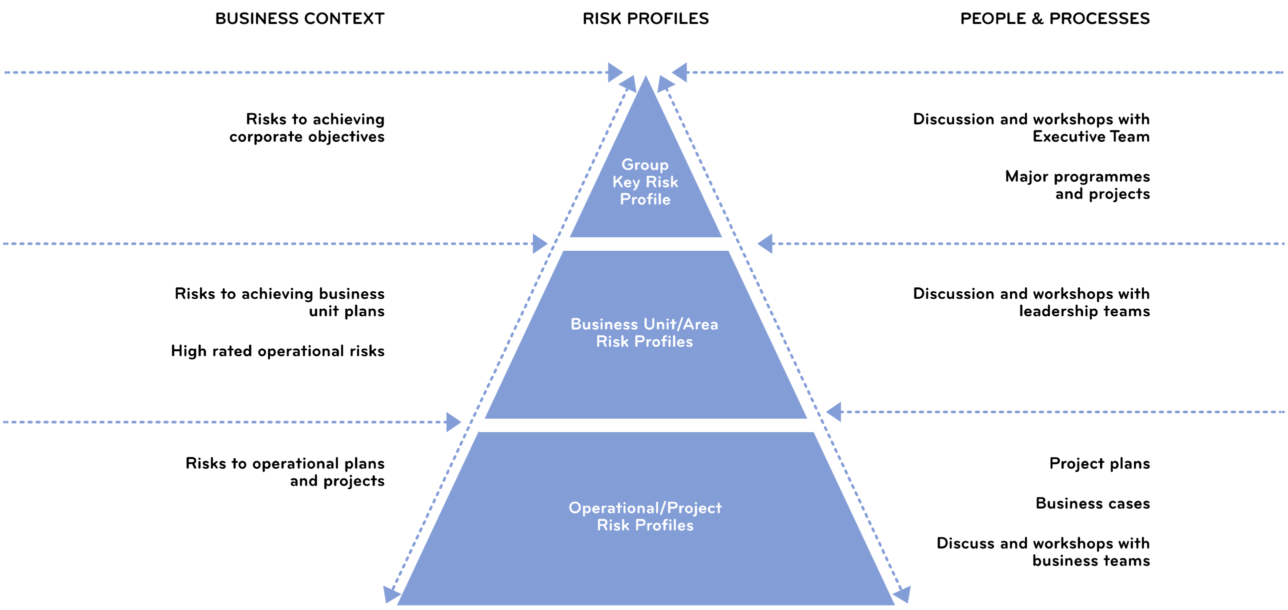

Figure 3-4 Vector's risk profiling structure

Our framework is consistent with the global risk management standard ISO 31000:2009 Risk management – Principles and guidelines and supports organisational performance by identifying, assessing and proactively treating uncertainty using the process in Figure 3-5

Figure 3-5 Vector's enterprise risk management process

Risks are assessed against Vector's risk assessment matrix, which articulates the Board's risk appetite for the business, and enables risks to be evaluated based on both the likelihood of a risk occurring and the potential impact(s) of a risk. The resulting evaluation informs the development and prioritisation of appropriate treatments plans (which supplement existing controls).

Asset risk management is undertaken using a combination of risk and asset reliability models, including a Failure Mode and Effects Analysis (FMEA), to identify maintenance and other proactive controls, while Bow Tie diagrams enable a comprehensive (and visual) assessment of the causes and consequences of an individual risk and the controls in place to manage the risk. The network-related risk assessment includes identifying potential High Impact Low Probability (HILP) events that could adversely affect the state of the network with specific controls and mitigating activities identified to manage and address the potential consequences. Where appropriate, a visual inspection of the network's health is undertaken post-HILP events to confirm the ongoing resilience of the system.

The management and tracking of identified risks and associated treatment plans is undertaken using Vector's enterprise risk management system, Active Risk Manager (ARM).

3.5.5 ASSET ENGINEERING

Asset Engineering involves a Front-End Engineering Design to develop possible options that address the needs identified during Needs Determination. Options may include traditional network solutions such as asset replacement or renewal, accepting the risks of service level breach (do nothing), new technology solutions (e.g. distributed generation, batteries etc.), non-asset solutions or combinations of these options. Each option is developed and a preferred option selected based on the option's economic value, technical feasibility, risk, strategic alignment and on asset management policy considerations.

Where an asset solution is recommended, functional and performance requirements are specified, lifecycle management plans are developed and a project scope is prepared as the basis of the Design and Construct stage. Where appropriate, Vector also assesses non-traditional solution options which may include distributed generation, batteries etc. to meet the functional or performance requirements expected. A combination of these options may be developed to address a particular functional or performance requirement. Where a non-asset solution is recommended, appropriate specialist processes are engaged to progress Vector's response[15]. In some cases, where no technically or economically feasible option is identified, the Front-End Engineering Design may lead to a revaluation of the identified need.

Under Vector's governance practices, approval of the preferred option is required prior to proceeding to the Design and Construct stage or prior to referral to a specialist non-asset solution process. Vector's governance processes are discussed further in Section 3.3.

DESIGN AND CONSTRUCT

During the Design and Construct stage, Vector translates the project scope, functional requirements and performance requirements, developed during the Solution Study, into a set of design specifications and plans. For certain types of projects, Vector manages construction as a design and build operation, design overlaps and integrates with construction. The design processes includes application of design standards, equipment selection and development of a project specific design if required.

In accordance with our asset management policy, life-cycle cost minimisation is undertaken during design to ensure that ownership and acquisition costs are minimised. Vector also undertakes assessment of safety, constructability, standards compliance, reliability (i.e. failure modes effects analysis), design standardisation, sustainability, environmental impact and operability, during design to ensure that assets can be safely and effectively maintained and operated across the lifecycle. In addition, design is undertaken to align with relevant corporate and asset management strategies. These strategies are discussed in Sections 4.2 and Section 4.3.

The outputs of the design process are detailed technical design documentation that is used to guide procurement and construction. During design, essential information is captured in Vector's SAP and Smallworld systems to enable and support the ongoing management of our assets. Section 3.6 provides an overview of the role of these systems in our asset management practice.

Asset Support forms a further essential part of the Design and Construct stage and provides key links with the Programme Delivery stage. Drawing on service level gap and root cause analysis undertaken in the Needs Management stage, Asset Support develops detailed plans for maintenance, spares holding, data systems, finance and resources that maintain asset performance across the lifecycle. All assets are reviewed annually and a comprehensive set of plans are produced that set priorities to maintain asset performance against the required service levels. These plans are approved under Vector's governance practices (see Section 3.3) before being programmed and delivered by Vector's FSPs.

PROGRAMME DELIVERY

Programme Delivery is a process that involves asset acquisition, construction and commissioning, operations, maintenance and disposal. Construct and Dispose links Design and Construct with Programme Delivery. Through this process, the detailed design documentation produced is translated into network assets. Construction of new assets, testing and verification of "as built" assets and disposal of old assets is undertaken through the Construct and Dispose process to ensure compliance with design documentation, and Vector's standards (see Section 3.4 and Appendix 2). Critical asset data records are created or updated in SAP, Smallworld and in other systems during this process (see Section 3.6).

Once in service, Operations & Maintenance manages the asset across the operational phase of its lifecycle. This involves maintaining the assets in accordance with Vector's maintenance standards, under the annual plans produced by Asset Support. Asset inspections are also carried out and inspection data is captured in SAP to inform Vector's asset management practices, service level performance analysis and root cause analysis. This inspection data is also used to identify any network components that require replacement due to an unacceptable failure risk (see risk management below). Operations & Maintenance is also responsible for operating the assets to manage system performance, implement planned changes to the network's static configuration and for providing access to undertake planned or emergency works. Delivery of Operations and Maintenance at Vector is contracted to FSPs and is managed under a contract based performance framework. An overview of Vector's works management practice is provided in Section 6.3.

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15 The nature of the process for non-asset solutions, and some new technology solutions tends to be bespoke and highly dependent on the type of solution recommended. These are not addressed further in this AMP.

3.5.6 DATA DRIVEN MONITORING AND IMPROVEMENT

As shown in Figure 3-3, Data Driven Monitoring and Improvement provides feedback into almost every aspect of Vector's asset management practice. This process involves the capture of a wide array of data from the Operations & Maintenance process (and other processes) into Vector's digital systems, and most notably SAP. A Data Analytics layer provides the critical analysis and reporting capabilities that enable our entire asset management practice, governance processes and project management practices. An overview of Vector's primary systems is provided in Section 3.6.

Process audit and review adds to this feedback by monitoring Programme Delivery compliance and outcomes. This ensures that assets are delivered in accordance with design documentation, that Asset Support annual plans are implemented, and that there is ongoing conformance with Vector's specifications and standards. Any process, practice, technical or performance nonconformities identified are addressed through change management processes, which includes engineering change management, processes change management and strategic review.

3.6 ASSET INFORMATION SYSTEMS

Vector has a suite of information systems that support its asset management practice. These, and other critical systems, are described below.

The primary systems used by Vector to manage the operation and performance of its network assets, and the related financial and project management activities are shown in Section 4.1.7.

PRIMARY SYSTEMS

Many of Vector's information systems operate through an integration layer that extends across these systems and enables the reporting and data analytics that support Vector's asset management processes. Table 3-5 provides an overview of the primary systems and provides insight into how they support asset management.

PRIMARY SYSTEM	FUNCTIONAL OVERVIEW
SAP	SAP is Vector's ERP System. It contains records for all assets and is used for managing the asset lifecycle from procurement and operation, to maintenance and disposal. SAP also provides financial management related to asset management and project management
GE Smallworld	This system provides the geographic, schematic and connectivity information used in managing Vector's network assets
ARC-GIS	This system provides geospatial visualisation and analytics tools
Siebel	Siebel is Vector's Customer Relationship Management system. This system is used for managing customer requests for new connections, quality of supply complaints management, and fault and outage management
Gentrack	Gentrack provides records for all connected ICP's as well as their regulatory and market attributes. It is used to manage energy consumption, revenue assurance and interfaces with the Electricity Authority registry
Data Analytics Layer	This is a bespoke integration layer that provides reporting, monitoring and associated analytics related to network assets. It is a critical source of information for most of Vector's asset management processes
Siemens Power TG	This is Vector's SCADA system and is used to monitor and control operations on the network as well provide data on network loading and other critical asset data
ARM	ARM is Vector's corporate risk management system. Under the Corporate Risk Policy all asset management risks are recorded, prioritised and managed through this system. A supporting system, RIMS is used to record any associated incidents
Stationware	Stationware is Vector's system to record and manage all protection settings in its primary and distribution networks

Table 3-5 Overview of primary information systems

OTHER IMPORTANT SYSTEMS

Vector uses a number of other information systems, computer models and computer based tools in the management of is electricity distribution assets. In particular:

- OSIsoft PI: is a real-time network performance management system that utilises data from various corporate systems (e.g. SCADA – see above), and provides a Microsoft EXCEL link to support analysis. This tool provides a permanent archive of historical network data;
- Forecast Scenario Model: this is bespoke load forecasting model used in Vector's load forecasting practice (see Section 3.5). It is implemented in Microsoft EXCEL and draws data from other corporate systems and databases and third party sources.
- Backstop model: this is a bespoke model implemented in Microsoft EXCEL. It is used in Vector's network planning practice (see Section 3.5) to forecast the ability to backstop a zone substation in the event of failure of the subtransmission supply;
- Digsilent: is a network modelling tool that provides network power flow and fault levels analysis. It uses information from Gentrack and Smallworld to maintain its network model;
- CymeCap: is a software tool that calculates cable ratings based on ground thermal conductivity test results and standardised cable installation practices. It is used to set the ratings of all subtransmission cables;
- HV Spec: is Vector's system of record for all outage information, including fault interruption and duration data. This system is used to calculate and report on Vector's reliability measures such as SAIDI and SAIFI.
- Rating Datasheets: this is a Microsoft EXCEL based database that contains summer and winter ratings for subtransmission plant and considers network pinch points. It is manually updated on an annual basis; and
- Zone Substation Equipment Ratings: this is a Microsoft EXCEL based database that contains details of the ratings of primary plant in our zone substations and in GXPs. It considers N-1 ratings for winter and summer conditions and identifies points of constraint. It is manually updated on an annual basis.

3.7 ASSET MANAGEMENT IMPROVEMENT

Periodically, Vector reviews its asset management practices using the Commerce Commission's Asset Management Maturity Assessment Tool (AMMAT). In addition, Entrust, Vector's majority shareholder (see Section 2.1), biennially conducts an independent review of the state of Vector's network that includes an assessment of asset management. Vector uses these reviews to inform our plans to improve our asset management practice.

At an overall level, Vector's asset management maturity compares well with generally accepted New Zealand electricity asset management practices to ensure the ongoing safe and efficient operation of the electricity network. Appendix 12 provides details of Vector's latest AMMAT self assessment. However, this review also suggests areas where improvement is needed for Vector to achieve our target score of three on each AMMAT rating criteria. Set out below is an overview of the primary areas where improvement of our asset management practice is being considered or implemented.

3.7.1 ADOPTING AN ISO 55001 FRAMEWORK

Vector has more recently been consolidating its asset management practice as a basis for improvement. The next step is to revise our key processes so they better accord with an ISO 55001 framework. This will involve further development of our asset management framework, assessment and amendment of some of Vector's asset management processes, training (currently underway) and some documentation redevelopment. The 2018 AMP is a step in this direction.

It is expected that this initiative will provide benefits through improved skills and more effective and efficient asset management practices. Improvements should become apparent through progressive increases in Vector's self-assessment against the AMMAT model.

3.7.2 ENHANCING STRATEGIC ASSET MANAGEMENT PRACTICE

Adopting an ISO 55001 framework highlights strategic asset management as a core practice. While Vector has a range of asset strategies, their effectiveness can be enhanced through the development of a formal strategy framework that improves their alignment and relationship with service level metrics. This initiative involves the review and mapping of current strategies, service levels and corporate strategies, and the development of an appropriate strategic framework. Development and redevelopment of several asset management strategies may also be required. Further staff training in aspects of strategic asset management will also be undertaken.

This improvement initiative will provide benefits through more effective and efficient asset management practices and greater alignment of asset investment. This will be evidenced through progressive increases in Vector's self-assessment against the AMMAT model.

3.7.3 DEVELOPING DATA AND ANALYTICS

Vector's asset management relies on a wide range of data captured and managed through Vector's Data Driven Monitoring and Improvement practices (see Figure 3-3), and stored, processed and reported on through our primary systems (see above). At the heart of Vector's data and analytics programme is a strong focus on ensuring that appropriate security and governance frameworks are in place and actively monitored to ensure that Vector meets its legal, commercial and ethical obligations with respect to the data that it collects and uses to optimise the business. Vector has established an Information Governance Council who is accountable for setting and enforcing the Information Policy which governs the collection and use of data. The Information Governance Council reports to the Chief Executive Officer and is comprised of the heads of Cyber Security, Information Management, Privacy, Legal, Risk, Regulation and Policy and Digital Architecture.

Vector has created a centre of excellence to combine all data related functions to ensure that the capture, storage and ability to use data meets the business needs now and into the future as the volume and variety of data explodes. Enterprise Information Management, Data Platforms and Business Intellegence and Advanced Analytics have been centralised into a single group called Information and Insights. This team works with the business to ensure that the data collected meets a minimum set of standards, is quality assured and is available via appropriate platforms for self-service and for more advanced applications such as advanced analytics and machine learning.

While Vector's asset data management practices are relatively mature, and meet the requirements of asset management, there are areas where improved understanding of our assets is required to improve our asset management practices. Specifically:

- Data defining the state and condition of Vector's distribution feeder assets has limitations relating to LV components and there is a lack of asset age data for some parts of the LV network. While LV has been historically of less concern, the impact of new technologies and the requirements of Vector's network vision place greater emphasis on the capability of the LV network. Vector's commitment to sustainability will also require improved LV network data. Improving LV data will require enhancements to our asset inspection and data capture practices and forms part of our Future Networks Strategy (see Section 4.2.3). Vector has specifically developed the LV Reinforcements programme to address this improved data need (see Section 5.1.16). For further information on Vector's network vision, the implications of new technology on our network and our sustainability commitments refer to SECTION 1;
- As the party that engages with and manages consumer queries over the network (connections, disconnections, relocations, power quality) or faults, Vector collects and holds information regarding consumers and their connections. For the bulk of our residential customers retailers only provide aggregated monthly usage data. This is insufficient to determine coincident peak usage for planning purposes – something that will become increasingly important as customers elect to take up new technology that changes the way energy flows and is utilised through the network. Retailers are currently unsupportive of allowing customers to provide Vector with their usage data for the purposes of network planning and management. From recent work completed with a partial set of residential half hourly data (acquired from some retailers under protest) Vector has shown that access to residential consumer half hourly data (in the same way we receive half hourly commercial customer data) is critical to ensuring that we not only optimise the capital spend on the network but also ensuring that the network supports changing consumer preferences such as the shift to EVs and more self generation through technology such as solar and batteries. Vector has a range of customer data that meets traditional network asset management needs. However, in the face of technological change and increasing customer choice, customer information and greater customer insight is becoming critical. To enable Vector to meet the changing needs of our customers and achieve our network vision, we have developed a customer insight strategy. Under this strategy, and supported by the corporate Digital Strategy (see Section 4.2.12), Vector will capture a much larger set of customer data and undertake a broader range of customer sensitivity analysis. This will inform and directly enable development of our network topology trial (see Section 4.2.3), HV feeder automation (see Section 5.1.16), and micro grid initiatives (see Sections 5.1.1 and 5.1.2 for micro grid projects). These initiatives, and our customer insight strategy will comply with Vector's privacy and contractual obligations as well as further support our corporate sustainability commitment; and
- There is a range of other more ad-hoc data improvement needs that Vector is also intending to address. In particular, there is a need to improve modelling of the overall condition and risk associated with asset populations. This will require enhanced incident data (i.e. fault and failure records) and improved asset inspection records, to support improvements

to our Condition Based Asset Risk Management (CBARM) methods, and enable asset health indices and remnant life model development. Vector is currently developing its CBARM models for the different asset classes.

Vector's corporate Digital Strategy is a core enabler of developing our data and analytics to support asset management practices. Section 4.2.12 and Section 5.3 provide further details of the key features of our Digital Strategy.

3.7.4 DEVELOPING AN ASSET CARBON REDUCTION STRATEGY

To demonstrate its commitment to sustainability and environmental performance, Vector has committed to achieving zero emissions from its operations by 2030. To achieve this commitment, Vector is implementing a carbon reduction strategy that includes setting annual reduction targets; reviewing opportunities relating to transmission losses, business travel, electricity consumption, waste minimisation and possible investment in New Zealand based carbon offsets.

Vector's carbon emissions are collated by our Environmental team using a software tool 'BraveGen.' Performance is reported to business units on a monthly basis. The most significant carbon emissions relating to Vector's network assets are defined as Scope 2 emissions (in accordance with the Greenhouse Gas Protocol). These are Indirect emissions from purchased electricity consumed by Vector, and transmission losses associated with our electrical distribution network (i.e. technical loss).

The Scope 2 emissions totalled 31,163 tonnes of carbon dioxide equivalent for our baseline year (FY17).

Vector intends to introduce a service level to assess performance of the network against the asset carbon reduction strategy.

3.8 EMERGENCY RESPONSE AND CONTINGENCY PLANS

Vector as a "lifeline utility" under the Civil Defence and Emergency Management (CDEM) Act 2002 is required to be able to function to the fullest possible extent, even if this may be at a reduced level, during and after an emergency. In line with its obligations, Vector has a range of plans governing how it will function during and after an emergency. These plans (detailed in Table 3-6) are reviewed and updated regularly. Vector actively participates in the development of a CDEM strategy and is a member of:

- The Auckland Lifelines Group ;
- The National Engineering Lifelines Committee; and
- Various lifeline groups throughout New Zealand.

TITLE	DESCRIPTION

Business Continuity Management Policy	• Formal representation of Vector's commitment to business continuity management, which forms an essential part of Vector's enterprise risk management framework;
	• Defines key business continuity management roles, responsibilities, accountabilities and reporting requirements;
	• Approved by the Board, it is consistent with the following Standards; and
	  • Australian/New Zealand Standard AS/NZ 5050:2010 "Business Continuity - Managing disruption-related risk"
	  • ISO 22313:2013 "Societal security - Business continuity management systems - Guidance";
	  • SAA/SNZ HB 221:2004: "Business Continuity Management"
	  AS/NZS ISO 31000:2009 "Risk management - Principles and guidelines.

Crisis Management Plan	• Provides the enterprise-wide framework and structure to assess and respond to any crisis-level incident or event affecting Vector, its customers and/or it employees, contractors and other stakeholders; • Includes the Incident Management Guideline, which provides direction on how to categorise incidents - this categorisation determines the appropriate response team, response plan and escalation hierarchy; and • Annual crisis management exercises and regular plan reviews are undertaken to ensure usability and understanding and support continuous improvement of the plan.

Issue / Crisis Communications Plan	• Standalone plan governing the communications and external relations approach and processes during a crisis, emergency or business continuity events.
Business Continuity Plans / Incident Response Plans	• Individual business unit / team plans outlining the procedures for responding to any disruptive events or incident (below crisis level) within a specific business area.
Emergency Response Plan	• Ensures Vector is prepared for, and responds quickly to, any major incident that occurs or may occur on the electricity network; • Describes the roles and responsibilities for staff during a major incident; and • Reviewed annually to ensure continuous improvements and standardised approach to all operational incidents.
EOC Emergency Evacuation Plan	• Ensures Vector's EOC is prepared for, and responds quickly to, any incident that requires the short, medium or long-term evacuation of the EOC; • Vector's network control centre has a fully operational disaster recovery site; and • Regular evacuation exercises are held to ensure evacuation of the control centre can proceed smoothly.
Switching Plans	• Restoration switching plans developed for each zone substation at a feeder level.
Emergency Load Shedding Obligations	• Vector is required under the Electricity Industry Participation Code (2010) to provide emergency load-shedding by way of Automatic Under-frequency Load Shedding; and • The purpose is to maintain the electricity security of the grid and to avoid cascade tripping under emergency conditions.
Participant Outage Plan	• Vector is a specified participant under the System Operator Rolling Outage Plan (part of the Electricity Industry Participation Code 2010); and • Specifies the actions that would be taken to reduce electricity consumption.

Table 3-6 Overview of emergency response and contingency plans

SECTION

04.

OUR ASSETS

SECTION 4. OUR ASSETS

This section of the AMP sets out Vector's electricity distribution assets; the types and volumes of assets, their functional role and key statistics. The asset management strategies are summarised both at a network wide level and for specific asset classes. These strategies inform when we act and what actions are taken in managing the lifecycles of our network assets. It is these asset management strategies that inform or drive the plans set out in SECTION 5.

4.1 OVERVIEW

Vector's electricity network supply area is centred on the Auckland isthmus and extends north to Mangawhai Heads, south to Franklin, west as far as South Head and Tapora on the Kaipara flats, east to Waiheke Island and south to Papakura. Vector also supplies electricity to a network remote from Auckland outside the network franchise, namely the Fonterra dairy factory at Lichfield in the Waikato. The Vector Auckland supply area is shown in Figure 4-1.

Figure 4-1 Vector's electricity supply region

4.1.1 ASSET OVERVIEW

Vector's network is made up of three main network components: the subtransmission network operated at 110 kV, 33 kV and 22 kV, the HV distribution network operated at 22 kV and 11 kV and the LV distribution network operated at 400/230 V. Our network connects to the Transpower grid at 15 Grid Exit Points (GXP)s from where our subtransmission network conveys electricity to zone substations. Typical load profiles of the network and a list of Vector's large customers that have an impact on network operations, can be found in Appendix 3. A single line diagram of the subtransmission network can be made available on request.

Key statistics of Vector's network are given in Table 4-1.

Customer connections	551,728
Overhead circuit network length (km)	8,354
Underground circuit network length (km)	10,101
No of poles	119,583
No of GXPs	15
No of zone substations	111
No of distribution substations	24,201
Maximum coincident GXP demand - Megawatt (MW)	1,684.5
Energy delivered through GXPs (GWh)	8,511.5

Table 4-1 Key statistics for RY17

4.1.2 SUBTRANSMISSION FEEDERS

The function of the subtransmission network is to transfer electrical energy from GXPs to bulk supply substations and zone substations.

110 KV SUBTRANSMISSION

The 110 kV subtransmission network emanates from Transpower 110 kV GXPs to connect to Vector owned bulk supply substations in the Auckland CBD, Kingsland and Wairau Valley on the North Shore. The 110 kV subtransmission network consists of cables in the Penrose to CBD tunnel, cables buried in ducts in the ground and overhead lines. The 110 kV subtransmission network is configured as a mesh system with a mix of 33 kV and 22 kV circuits providing backstop to the 110 kV nodes. Key statistics of the 110 kV subtransmission feeder assets are shown in Table 4-2.

Number of 110 kV underground subtransmission circuits	9
Length of 110 kV underground subtransmission circuits (km)	47
Number of 110 kV overhead subtransmission circuits	3
Length of 110 kV overhead subtransmission circuits (km)	27
Number of overhead support structures for 110 kV subtransmission circuits	294

Table 4-2 Key statistics for 110 kV subtransmission network

33 KV AND 22 KV SUBTRANSMISSION

33 kV and 22 kV subtransmission circuits run from Vector's bulk supply substations and Transpower GXPs to Vector's zone substations. The 33 kV and 22 kV subtransmission network consists of a mix of underground cables and overhead lines. In the Northern network the subtransmission system is configured as a meshed system. In the Auckland network the subtransmission system is configured mostly as radial line-transformer feeders that can be paralleled at the 11 kV busbars.

Vector's overhead subtransmission circuits also accommodate 11 kV and 400 V circuits on the same support structures in many instances. Key statistics of the 33 kV subtransmission assets are shown in Table 4-3.

Number of 33 kV underground subtransmission circuits	166
Number of 33 kV overhead subtransmission circuits	86
Length of 33 kV underground subtransmission circuits (km)	416
Length of 33 kV overhead subtransmission circuits (km)	369
Number of overhead support structures for 33 kV subtransmission circuits	1316
Length of 33 kV oil-filled cable (km)	119
Length of 33 kV paper insulated lead cable (PILC) (km)	17
Length of 33 kV cross-linked polyethylene (XLPE) cable (km)	280

Table 4-3 Key statistics for 33 kV subtransmission network

Figure 4-2 below depicts the age profile of our 33 kV subtransmission cables.

33 KV SUBTRANSMISSION CABLES AGE PROFILE

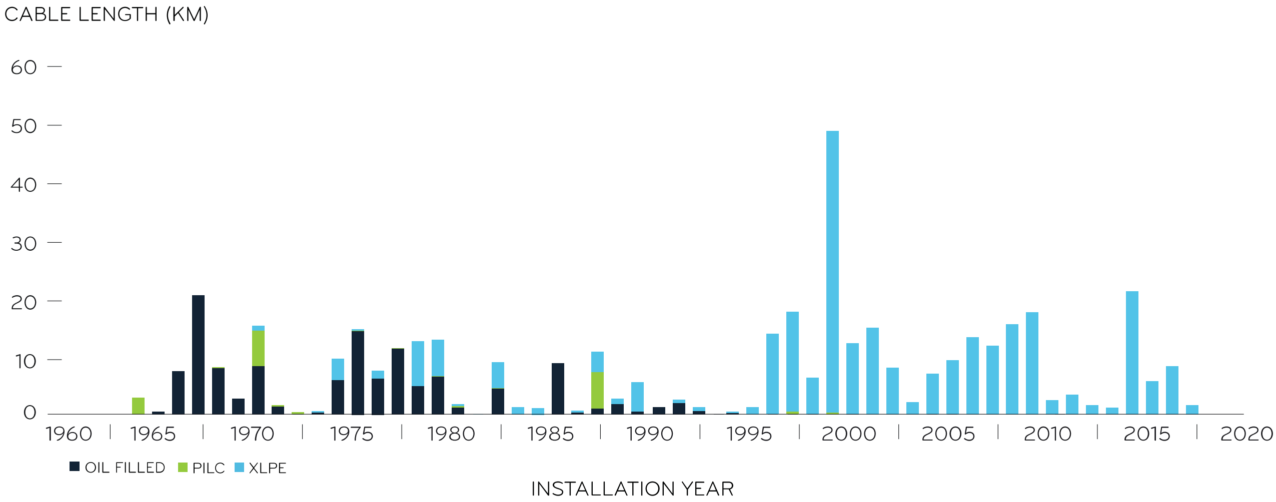

Figure 4-2 Age profile for subtransmission cables

Key statistics of the 22 kV subtransmission assets are given in Table 4-4 below.

Number of 22 kV overhead subtransmission circuits	1
Length of 22 kV overhead subtransmission circuits (km)	2.9
Number of overhead support structures for 22 kV subtransmission circuits	21
Length of 22 kV gas-filled cable (km)	2.4
Length of 22 kV oil-filled cable (km)	27
Length of 22 kV PILC cable (km)	44
Length of 22 kV XLPE cable (km)	65

Table 4-4 Key statistics 22 kV subtransmission network

Figure 4-3 below depicts the age profile of Vector's 22 kV subtransmission cables.

22 KV SUBTRANSMISSION CABLES AGE PROFILE

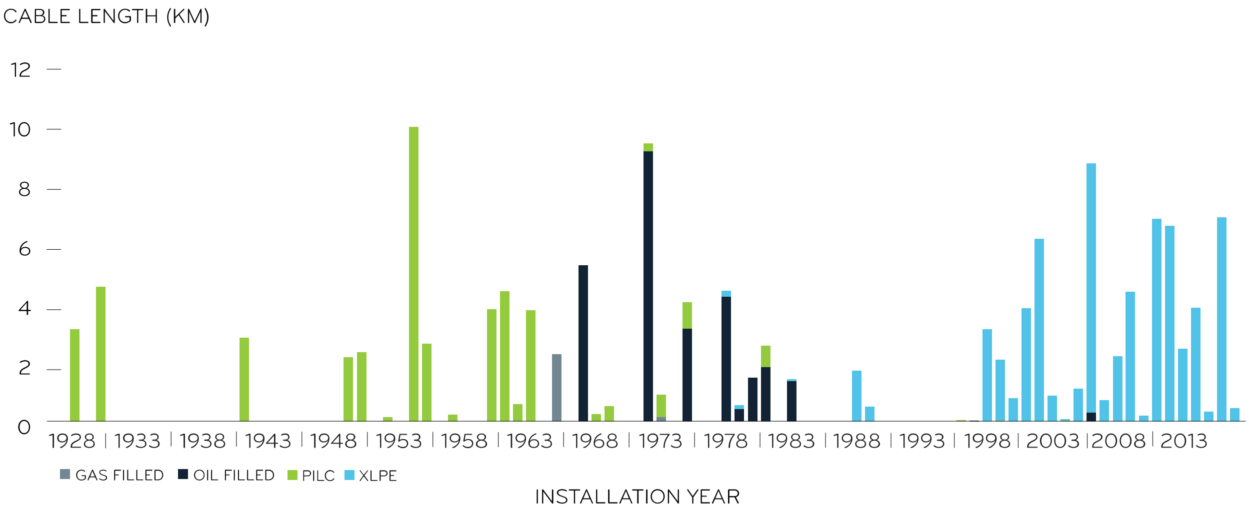

Figure 4-3 Age profile for subtransmission cables

4.1.3 ZONE SUBSTATIONS

OVERVIEW

Zone substations are the electrical nodes from which the 22 kV or 11 kV distribution network emanate into Vector's supply areas. Zone substations contain the subtransmission switchgear (33 kV or 22 kV and in some cases 110 kV) and power transformers (33 kV/11 kV or 22 kV/11 kV and in some cases 110 kV/22 kV). They also contain 11 kV distribution switchgear, ripple plant, local supply transformer and auxiliary systems e.g. Direct Current (DC) systems, SCADA systems and network communications connection equipment, that allow Vector to control, protect and manage its distribution network.

Vector also has a transportable 11 kV switchboard that can be moved to different locations as a substitute switchboard when a zone substation is out of service for project work or when a failure occurs at a zone substation. The transportable unit contains 11 kV switchgear and auxiliary systems similar to those found in our fixed zone substations.

Key statistics of zone substations are summarised in Table 4-5. Schedule 12b in Appendix 9 shows the peak loading, capacity and constraints statistics of all Vector's zone substations.

Number of 110 kV zone substations[16]	7
Number of 33 kV zone substations	84
Number of 22 kV zone substations[17]	18

—

16 Lichfield, Liverpool, Hobson, Quay Street, Kingsland, Pacific Steel

17 Highbrook has been included in the list although this is a 22 kV switching station

Number of operational BESS zone substations	1
Number of transportable 11 kV switchboard	1
Number of transportable transformers[18]	2

Table 4-5 Key statistics for bulk and zone substations

POWER TRANSFORMERS

Power transformers are used to transform one voltage to another. They are installed either indoors or outdoors. To protect the environment, outdoor transformers exist in a bund complete with an oil/water separation system[19] that separate oil from rainwater when there is an oil spill. Indoor transformers are installed in bunded enclosures thus negating the need for oil/water separation systems.

In the Auckland region, zone substations have two and in some instances more power transformers, with most of the transformers radially supplied from a bulk supply substation or GXP. Interconnection at the subtransmission level between zone substations is thus limited. The exception in the Auckland region is Highbrook zone substation that is fitted with 22 kV switchgear but no power transformers, i.e. it is solely a 22 kV switching station but is regarded and grouped under zone substation assets.

Vector has 214 power transformers in operation. They are a mix of Dyn11 and Dyn1 vector groups. The exception is the two transformers at Lichfield zone substation that are Ynyn vector group. The age profile of Vector's power transformers in zone substations is given in Figure 4-4 below.

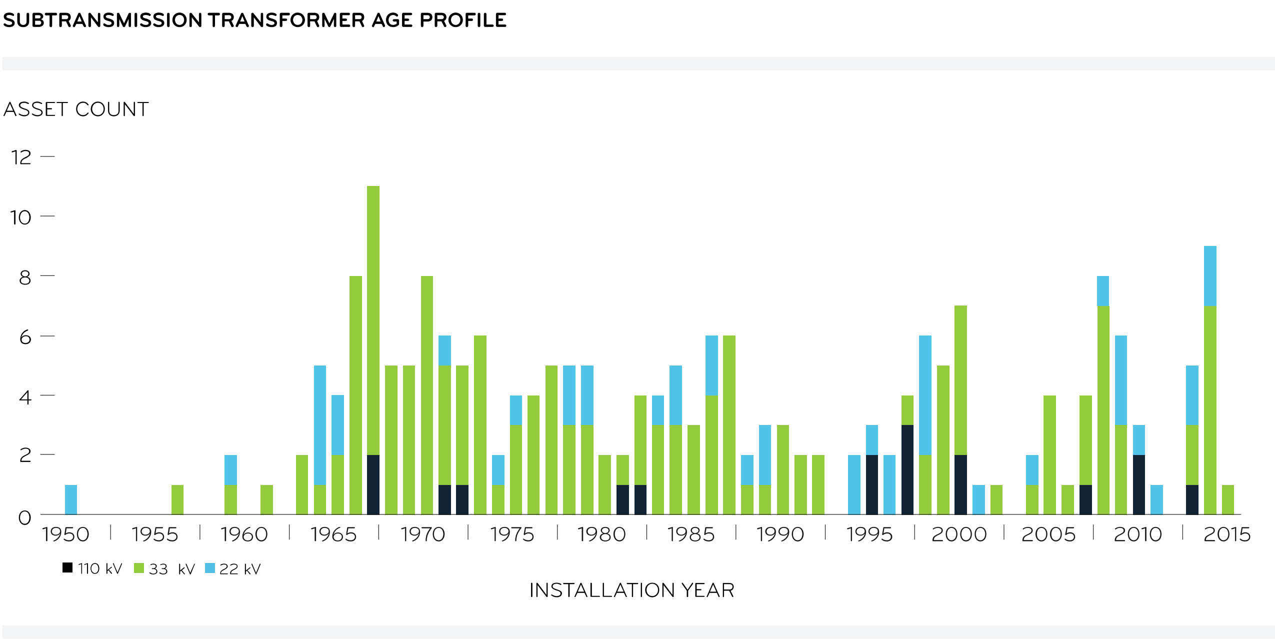

Figure 4-4 Age profile of power transformers

SWITCHGEAR

The 22 kV bulk supply substations in Auckland's CBD are interconnected with 22 kV interconnectors and 22 kV distribution feeders to provide N-2 security of supply.

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18 2.5 MVA 400 V/11 kV transformer for the connection of temporary generation

19 Also known as a SEPA system

In the Northern area, zone substations are fitted with 33 kV switchgear and the subtransmission network is highly interconnected. In the Northern region, many zone substations are equipped with a single transformer but N-1 security is then supplied from neighbouring zone substations via the 11 kV distribution network.

Vector's 33 kV switchgear is a mix of outdoor and indoor types. Outdoor 33 kV switchgear is bulk oil type switchgear mostly of late 1960s to 1970s vintage although there are outdoor Circuit Breakers (CB) that have been replaced with new generation SF_6 outdoor VOX CBs. Indoor 33 kV CBs are all SF_6 insulated switchgear. Older zone substations are fitted with first generation SF_6 insulated switchgear.

All 11 kV switchgear in zone substations in both the Northern and Auckland regions are installed indoors. Where two or more power transformers exist, the 11 kV switchgear consists of two or more bus-sections with incomer CBs to match the number of transformers.

Table 4-6 below provides key statistics of CBs in zone substations (this excludes CBs in distribution substations).

Number of 33 kV outdoor CBs	134
Number of 33 kV indoor CBs	149
Number of 22 kV indoor CBs	125
Number of 11 kV indoor CBs	1350

Table 4-6 Key statistics for CBs in zone substations

CAPACITOR BANKS AND STATIC COMPENSATORS

GXPs, from which Vector's zone substations are supplied, are equipped with capacitor banks or static compensators to support voltage. Capacitor banks also exist at 27 of Vector's zone substations to maintain power factor as defined in Connection Agreements with Transpower to be not less than 0.95 lagging in the case where reactive power is drawn off grid assets or 0.95 leading where reactive power is being injected into the grid.

DISTRIBUTED ENERGY RESOURCES

Glen Innes zone substation is Vector's first substation with a large-scale BESS, rated 1MW (2.3 MWh). The second BESS (2 MW) zone substation is under construction in Warkworth South (2 MW). The 3rd BESS zone substation will be constructed at Snells Beach (3 MW) and a BESS will be installed at Kawakawa Bay (0.6 MW). Both these projects are in the detailed design stage at the time of writing. Installation of a fifth BESS (1 MW) will soon commence at the new Hobsonville Point zone substation.

SECONDARY SYSTEMS

Each zone substation is equipped with secondary systems such as DC systems, SCADA panels with routers and network switches to connect protection and measuring gear to the Wide Area Network (WAN) and back to SCADA. These are described in more detail further below in Section 4.1.6.

RIPPLE CONTROL (HOT WATER AND STREET LIGHT CONTROL)

Hot water and street light control systems are also located in zone substations. These secondary systems are described in more detail in Section 4.1.6.

4.1.4 DISTRIBUTION FEEDERS (HV AND LV)

OVERVIEW

Vector's HV distribution network is for the larger part operated at 11 kV. In the Northern supply area, the HV distribution network is predominantly overhead but in new subdivisions HV networks are installed underground. The underground HV network is extensively interconnected via distribution substations. In the Auckland supply area, the HV distribution network is predominantly 11 kV underground but there are pockets of overhead supply most notably the lengthy rural supply to Maraetai and further south to Kawakawa Bay. In the Auckland CBD and in the Highbrook industrial estate, 22 kV networks are utilised for distribution.

Key statistics of the HV distribution network are given in Table 4-7 (see Section 4.1.2 for details of the 22 kV network).

Number of 11 kV overhead distribution feeders	600
Route length 11 kV overhead distribution feeders (km)	3,802
Route length overhead aluminium conductors (all types used for 11 kV) (km)	2,727
Route length overhead copper conductors - all sizes and types used for 11 kV (km)	1,075
Route length 11 kV underground feeders (km)	3,341
Number of support structures for 11 kV overhead distribution feeders	69,458
Number of 11 kV pole mounted reclosers	123
Number of 11 kV pole mounted sectionalisers	128
Number of 11 kV pole mounted gas load breaking switches	525
Number of 11 kV pole mounted air break switches	136
Number of 11 kV rocking-post type air break switches	715

Table 4-7 Key statistics for HV distribution

All HV CBs in zone substations that feed the distribution network can be controlled remotely via SCADA. Overhead air break switches and gas-filled overhead switches that can be remote controlled via SCADA exist in strategic locations in the overhead distribution networks. This allows the EOC to quickly and effectively control the network to limit SAIDI and SAIFI during switching after a fault to restore supply or for planned works.

Vector has a small number of 11 kV distribution Ring Main Unit (RMU) switches that can be controlled remotely in its network. Automation, that is smart switching or self-healing, has not historically been applied to Vector's distribution network due to the fact that there were no reliability issues, although our network development strategy evolves the network over the next 10 years and beyond towards our network vision and towards an automated network platform.

In urban areas, support structures for overhead distribution circuits are predominantly pre-stressed concrete with timber crossarms. About 8% of poles in rural distribution feeders are treated softwood timber poles with only a few hardwood poles in the network. Timber poles are extensively used as support structures for connections to customers. Concrete poles in the Auckland region are about 40% as strong as new prestressed concrete poles. Any upgrade or refurbishment of overhead lines utilises pre-stressed concrete poles.

Due to historical legacy issues, there are deficiencies in the information of the ages of poles for certain areas in the Auckland region. Figure 4-5 below summarises the age profile of poles in our network.

11 KV POLE AGE PROFILE

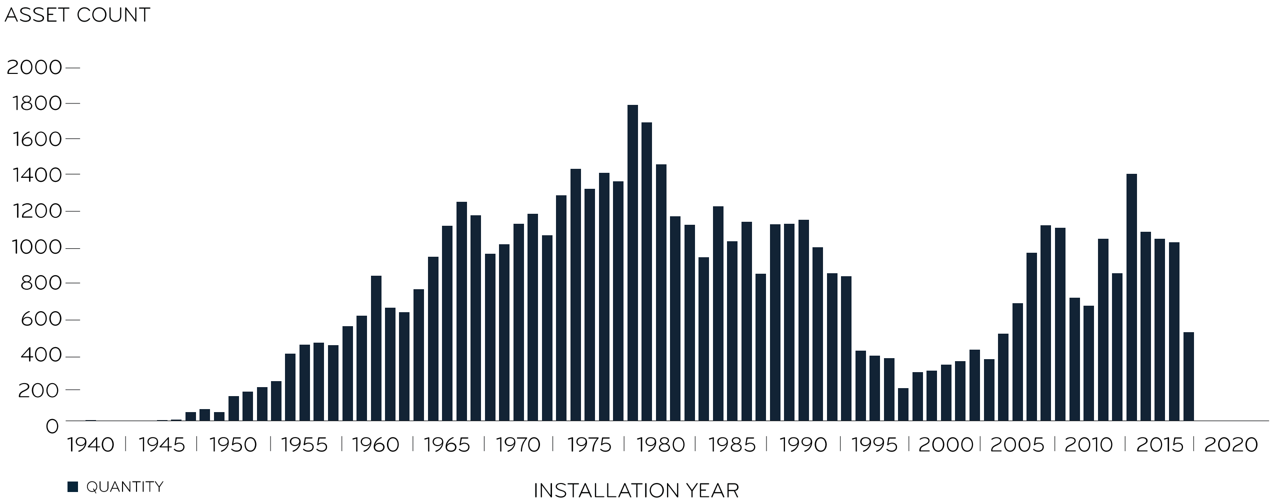

Figure 4-5 Age profile of 11 kV distribution poles

The overhead conductor types and sizes vary across the overhead network and are predominantly copper, all aluminium conductors (AAC) or aluminium conductor steel reinforced (ACSR) conductors. A smaller quantity of all aluminium alloy conductor (AAAC) are being utilised for new line construction.

Figure 4-6 below summarises the age profile of 11 kV conductors in our network.

11 KV CONDUCTOR AGE PROFILE

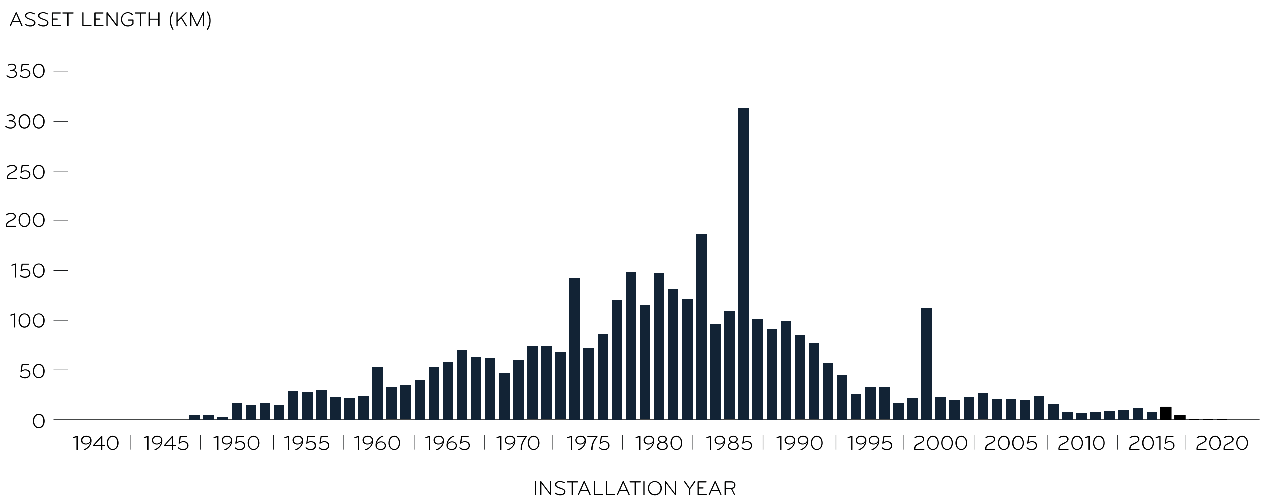

Figure 4-6 Age profile of 11 kV conductors

Copper conductors installed in the 1940s through to 1960s are showing an increasing trend of failure. Figure 4-7 below summarises the age of 11 kV copper conductors.

11 KV COPPER CONDUCTOR AGE PROFILE

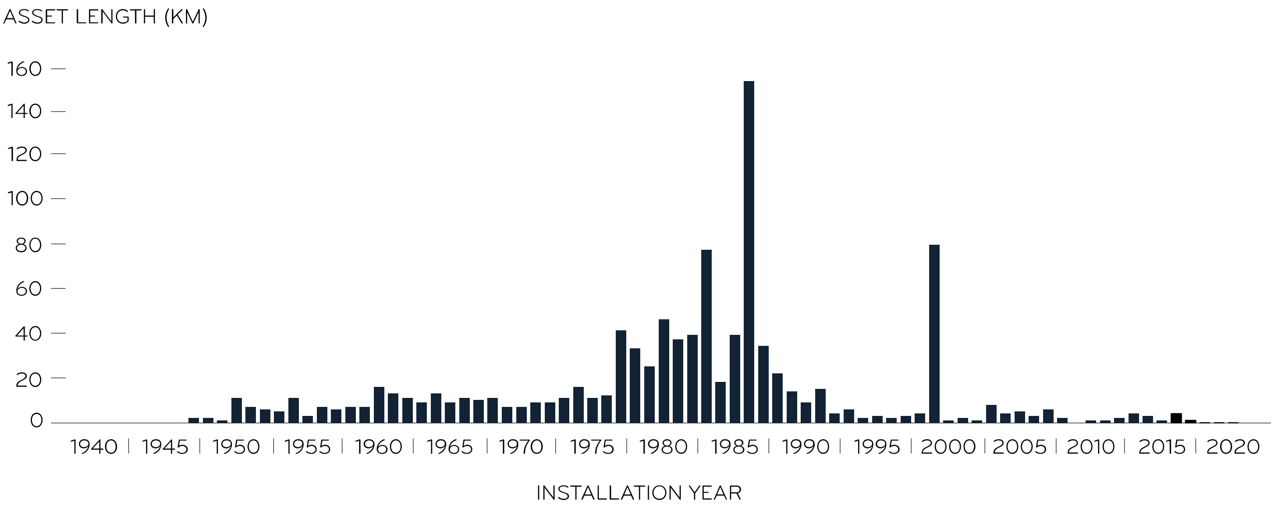

Figure 4-7 Age profile 11 kV copper conductors

DISTRIBUTION FEEDERS (LV)

Vector's LV operates and maintains a multiple earthed neutral LV network that operates at 400 V/230 V. The LV network is predominantly overhead in the Northern region and consists of bare conductors. The LV network shares HV support structures for extensive parts of the network and on many routes subtransmission circuits exist on the same support structures. Glenfield on the North Shore is a notable example where 110 kV, 33 kV, 11 kV and LV circuits exist on many of the same support structures. In newer subdivisions, the LV network is all underground.

Historically, overhead conductors have moved from copper, to AAC and ACSR, through to AAAC. Vector has a large number of different sized conductor with some bare and some PolyVinyl Chloride (PVC) covered, some greased and some not greased.

The larger part of the LV network in the Auckland region is underground but ~30% of the LV network remains an overhead network. In the Northern region, LV overhead networks share support structures with HV and subtransmission circuits on many circuit routes.

Key statistics of the LV distribution network are stated in Table 4-8 below.

Length of LV overhead distribution feeders (km)	4,158
Number of dedicated LV overhead support structures	45,629
Number of shared LV overhead support structures (sharing with HV)	53,195
Length of LV underground distribution (km)	5,897
Number of buried LV distribution pits	45,939
Number of above ground LV distribution pillars	94,120

Table 4-8 Key statistics for LV distribution network

A mixture of above ground pillars and buried service pits are used to tap off to customer connections from our LV underground networks.

The fact that the Auckland CBD utilises two primary voltages, 22 kV and 11 kV, the LV network is supplied by both 22 kV/0.4/0.231 kV and 11/0.4/0.231 kV transformers. Notwithstanding the LV networks are supplied from two HV networks with different voltages, the LV networks can be paralleled if required because Dzn transformers are used in the 22 kV network to bring its LV system in phase with the LV systems supplied from Dyn11 transformers.

For the larger part of the LV network, circuits have limited interconnections and in some cases are not designed for full backstopping if an adjacent distribution transformer should fail. A significant challenge with regard to the LV fleet is that network data is less visible and Vector's geospatial information system does not provide an up to date view of the LV network.

4.1.5 DISTRIBUTION SUBSTATIONS AND VOLTAGE REGULATORS

The Distribution substation fleet consists of a variety of substations:

- Pole mounted transformers (transformers for pole mounting are limited to 300 kVA in size);
- Ground mounted compact kiosk substations complete with HV RMU and LV panel;
- Ground mounted mini-substations and "tin-can" substations[20] (no HV switchgear), either with or without an LV panel;
- "Open top" (i.e. not fully enclosed) chamber substations with transformer, RMU and LV panel; and
- Completely enclosed chamber substations that house HV switchgear (either CBs or RMU), DC system, transformer(s) and LV panels.

Key statistics of our distribution substations and voltage regulators assets are given in Table 4-9.

Total number of distribution substations of all types	24,201
Number of compact kiosk package substations	1,473
Number of mini-substations including "tin-can" substations	7,855
Number of "open top" (i.e. not fully enclosed - no roof) chamber substations	902
Number of chamber (fully enclosed) buildings	754
Number of pole mounted transformers	7,650
Number of distribution substations with oil-filled switchgear	4,174
Number of distribution substations with gas-filled (SF_6) switchgear	1,400
Number of voltage regulators	6

Table 4-9 Key statistics for distribution substations

DISTRIBUTION SWITCHGEAR

Vector's distribution switchgear comprises oil-filled, SF_6 and resin insulated equipment of varying ages and brands. The arc-quenching mediums used in the equipment are air, oil, SF_6 and vacuum. The majority of distribution switchgear is rated at 11 kV but 22 kV units are used in Auckland's CBD and in Highbrook Business Park.

Vector has 1,291 Andelect Series 1, 11 kV switchgear units in service. The series 1 switchgear has very small internal clearances to earth and of particular interest is the use of laminated wood and lexan material in the barrier walls between adjacent phase fuses in the fuse carriers. Over time the condition of the laminated wood/lexan material deteriorates and

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20 An older type of mini-substation that will be phased out over time

becomes brittle after being submerged in oil for a long period of time and this degradation has led to an arc being drawn during switching operations and caused equipment failure. Due to the inherent poor design and material defect associated with the Series 1 switchgear, a full ban on live switching operations on all Series 1 switchgear was introduced by Vector in 2012.

Vector worked with Linak, an actuator designer, to develop a remote actuator that allows operators to carry out switching operations remotely on Series 1 switches at a safe distance away from the switchgear. This eliminates the risk of the switching operator being injured if the switchgear fails during switching.

Vector has 3,164 Long and Crawford 11 kV oil-filled switchgear of various models in service. There have been two failures of the T4GF3 model in the past two years and similar to the Andelect series 1 switchgear, the Long and Crawford switchgear has been identified as having an increasing risk of failure.

Table 4-10 shows the key statistics for Andelect and Long and Crawford switchgear.

Number of Andelect SD series 1, 11 kV oil-filled switchgear	1,291
Total number of Long and Crawford 11 kV oil-filled switchgear (all models)	3,164
Number of Long and Crawford T4GF3 11 kV oil-filled switchgear	340

Table 4-10 Key statistics for Andelect and Long and Crawford distribution switchgear

DISTRIBUTION TRANSFORMERS

Distribution transformers convert distribution voltage levels (typically 22 kV and 11 kV) to customer voltage levels (400 V three phase and/or 230 V single phase). The units are generally constructed with an off-load tap changer which enables the LV voltage to be raised or lowered depending on system requirements. Vector's distribution transformer population is given in Table 4-11 .

Number of pole mounted transformers	7,651
Number of ground mounted transformers (all types of substations)	13,980

Table 4-11 Key statistics for distribution transformers

Figure 4-8 summarises the age of distribution transformers.

DISTRIBUTION TRANSFORMER TYPE AGE PROFILE

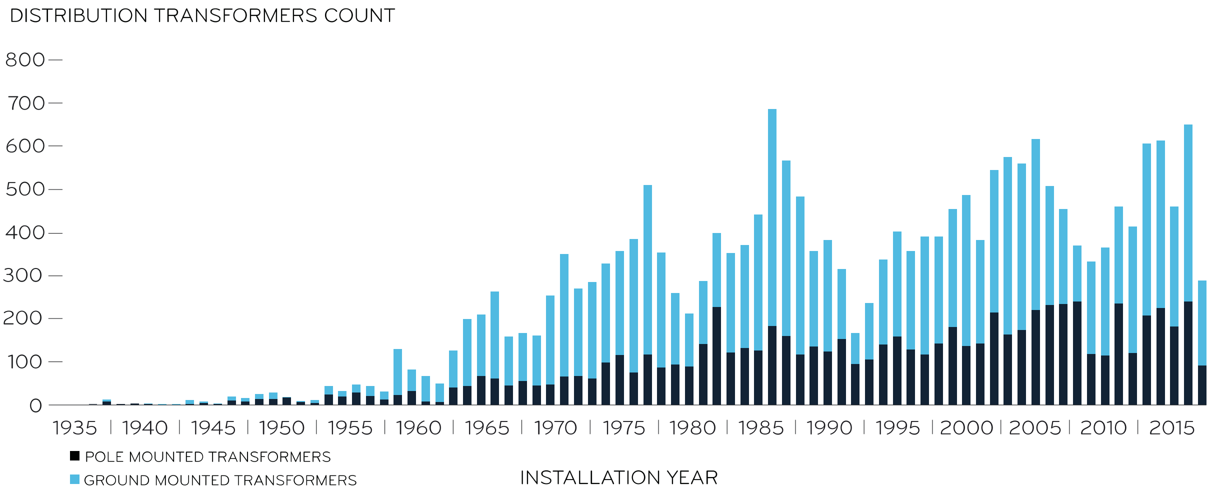

Figure 4-8 Age profile of distribution transformers

Pole mounted substations are used extensively in areas with overhead HV reticulation, but there are numerous ground mounted substations supplied via HV cabling from overhead HV distribution feeders. Pole mounted transformers are protected by drop out fuses, but for lengthy cables from overhead lines to ground mounted transformers, 3-pole switches are installed to reduce the risk of ferro resonance during switching.

For the majority of distribution transformers currently in service, the windings, insulated with paper insulation, are contained in a tank of mineral insulating oil. For a very small number of transformers the windings are contained in a tank of synthetic organic ester. These transformers are used in situations where fire safety or protection of the environment (where other containment measures are not practical) are primary considerations, e.g. close to waterways.

New distribution transformers are supplied in compliance with Vector's procurement standard ENS-0093 and have ratings that range from 5 kVA to 1.5 MVA for industrial customers.

In general, the Auckland network utilises transformers rated higher than the Northern network, as it is a dense urban area, with the majority of transformers rated higher than 300 kVA. The rural nature of the Northern network means that a large number of pole mounted transformers of a comparatively lower rating have been installed. A large number of 100 kVA and 200 kVA ground mounted transformers exist in the Northern network.

Pole mounted transformers are installed on either single or double poles depending on its kVA rating. Ground mounted transformers are either stand-alone, enclosed in metal or fibreglass canopies, installed in open chambers or chambers with roofs.

VOLTAGE REGULATORS

Voltage regulators are normally used in long feeders (usually in remote rural feeders) to boost the voltage. Essentially, they are tap-changing autotransformers that maintain network voltage within desired limits and they automatically produce a regulated output voltage from a varying input voltage. Vector has a limited number of voltage regulators in its network: two exist in the Auckland network and four in the Northern network.

A micro grid BESS will be installed on the lengthy Kawakawa rural feeder south-east of Auckland (see Section 5.1.12) and this installation will include a new 22 kV/22 kV voltage regulator to improve voltage regulation.

4.1.6 SECONDARY SYSTEMS AND OTHER NETWORK ASSETS OVERVIEW

Vector has the following secondary systems and other network assets:

- Protection systems;
- Transformer Management Systems (TMS);
- Power Quality Meters (PQM);
- Local Area Networks (LANs) and Remote Terminal Units (RTUs);
- DC supplies;
- Communications and network systems;
- Copper and fibre optic pilot communications channels;
- Earthing systems; and
- Ripple Control Systems.

We have also installed PV systems combined with batteries at a number of our zone substations to provide local building service power requirements.

Vector's data for the age of certain secondary systems are lacking for certain items of plant. Data issues will be resolved as assets are replaced at end of life.

PROTECTION SYSTEMS

Protection schemes detect and isolate the electrical network from faults that could damage network assets and also protect operating personnel and keep the public from harm. Vector's protection relays are a mix of electro-mechanical, electronic, and numerical relays, also referred to as Intelligent Electronic Devices (IEDs). Table 4-12 provides a breakdown of the 2,610 relays on Vectors Network.

RELAY TYPE	QUANTITY	AVERAGE AGE	% OF TOTAL
Electro-mechanical relays	900	39	35%
Static (electronic) relays	140	23	5%
Numerical IEDs – first generation	170	17	6%
Numerical IEDs – later generations	1,400	7	54%

Table 4-12 Key statistics for protection relays

TRANSFORMER MANAGEMENT SYSTEMS

Power transformers are a vital part of the electrical distribution network, but they are also large and expensive assets usually without spares readily available and with a very long lead time for replacement. As result of this, monitoring and diagnostic technologies focused on power transformers, are essential to provide a means to monitor transformers, predict failures, and proactively manage their performance. Transformers, like any other asset, have a finite life that can be shortened through abuse or prolonged with care by monitoring their condition and acting in a timely manner. By monitoring their condition, it is possible to change from time-based maintenance to condition based maintenance, and thus significantly reduce maintenance costs.

Table 4-13 provides a breakdown of the TMS' in service on Vector's power transformers.

TMS TYPE	QUANTITY	% OF TOTAL
Electro-mechanical	85	41%
Programmable logic controller (PLC) type	20	10%
Numerical IED type	101	49%

Table 4-13 Key statistics for transformer management systems

POWER QUALITY METERS

Power quality assets assess the quality of power, identify the causes of any problems and check the effectiveness of remedial measures. Power quality is defined by a group of performance attributes. Four main functions are used to check power quality;

- Monitoring of harmonics;
- Detections of voltage sags and swells;
- Detection of transients; and
- Electricity supply compliance checking.

In addition, Vector utilises power quality metering system as a check of revenue meters at GXPs and zone substations. Vector employs several intelligent revenue class energy and PQMs installed at GXPs and zone substations. The PQMs also provide full analytical capability to analyse faults and provide data to a separate PQM server at Vector SCADA. Table 4-14 provides key statistics of PQM metering.

PQM METER TYPE	QUANTITY	AVERAGE AGE	% OF TOTAL
Dranetz PQM	1	17	1%
GE PQM	4	15	4%
ION7330 PQM	6	7	6%
ION7350 PQM	6	8	6%
ION7500 PQM	6	15	6%
ION7600 PQM	7	13	6%
ION7650 PQM	63	6	58%
ION7700 PQM	10	15	9%
PQM Lichfield	4	17	4%
PQM PM8243	1	Unknown	1%
PQM PM8244	1	Unknown	1%

Table 4-14 Key statistics for PQM meters

ZONE SUBSTATION AUTOMATION SYSTEMS

LAN and RTUs are used to remotely control CBs and other plant from Vector's EOC. The LANs and RTUs also provide visibility to the control centre of the network and is used to gather and transmit data to the control centre. All of this happens via the WAN.

The LANs in Vector's zone substations are based on a redundant optical ethernet architecture and complies with the IEC 61850 standard. The IEC 61850 LAN enables the co-ordination of protection, automation, monitoring, metering and control functions through the use of network switches and allows the use of media converters to facilitate optic fibre to copper cable connections and communications.

Vector has a different range of RTUs of which key statistics are provided in Table 4-15.

RTU TYPE	QUANTITY	% OF TOTAL
Foxboro	71	18%
SEL	266	67%
Siemens	7	2%
Unknown brand	29	7%

Table 4-15 Key statistics for RTUs

DC SUPPLIES

DC auxiliary systems provide supply to the protection, automation, communication, control and metering systems, including power supply to the primary equipment motor driven mechanisms in zone substations. All new DC systems comply with Vector engineering standard ESE601, DC systems and consist of a dual string of batteries, a battery charger, a number of DC/DC converters and a battery monitoring system.

Table 4-16 shows the key statistics for DC systems.

BATTERY CHARGER TYPE	QUANTITY	% OF TOTAL
240 V DC chargers	1	0.3%
110 V DC chargers	138	45.8%
48 V DC chargers	10	3.3%
30 V DC chargers	60	19.9%
24 V DC chargers	92	30.6%

Table 4-16 Key statistics for DC systems

The battery chargers simultaneously supply 110 V DC to the zone substation protection and control systems and float charging to the 110 V DC station battery bank(s), (aka 'strings'). For an alternating current (AC) failure event of the battery charger the battery banks provide an un-switched 110 V DC supply to the protection and control systems, i.e. as an uninterruptable DC supply.

Battery monitoring is essential to ensure battery systems continue to have the capacity to operate equipment during a supply outage and to enable restoration of supply once any contingency has been rectified. Battery voltages are alarmed to Vector's SCADA system to alert the EOC to low battery voltage.

COMMUNICATIONS NETWORKS

Vector operates an open communications architecture based on industry standards. The deployed technologies range from copper based buried cables to first generation optical fibre multiplex systems, to modern digital microwave systems and Ethernet based optical fibre networks. Vector's communications network also consists of differing architectures and technologies, some of which are based on proprietary solutions.

The physical network infrastructure consists of a mix of optical fibre, copper wire telephone type pilot cables and third party radio communication systems.

Several digital microwave radio links were installed about 10 years ago to extend Vector's internet protocol (IP) operational WAN to zone substations in the Northern region. The expected life for digital mobile radio equipment is about 10 years.

For communication to distribution substations Vector uses commercial cellular 2G/3G networks. Each distribution substation is equipped with an IP based layer 3 wireless router.

Vector's Northern region legacy radio system is based on 6 base stations and one repeater to cover most of the area. It is used for voice, data communication and demand side management applications.

In the Auckland region, a similar radio network was installed which consists of two base stations and three repeaters. One zone substation and five distribution substations are connected to the master station via this radio network. The system is performing satisfactorily but is obsolete and is to be retired in the next 5 years.

In the Northern network, around 70% of the pilot cables used for operational communications are installed overhead and are prone to damage by the environment and lightning. They are generally not in good condition and Vector has been migrating operational communication services to optical fibre IP based network since 2006. This programme of works will continue.

The mostly copper pilot cables in the Auckland region are all installed underground. They are used for operational communication services and differential protection and alarms. The copper pilot cables are 50 plus years old and are showing an increasing trend of failures. They have gradually been phased out with migration to optical fibres and IP based communication network and this programme of work will continue.

LOAD MANAGEMENT SYSTEMS

Vector uses demand-side load management systems on its distribution network as a customer-centric service to reduce peak demand to limit transmission charges for customers or to help with network congestion. At all other times this load is offered into the wholesale electricity market as instantaneous reserve.

Due to the separate legacy power board network philosophies at the time of installation, two signalling systems exist: 'ripple injection' over power lines in the Auckland network, and in the Northern network ripple injection and a 'pilot wire' system. For customers signed up to a 'controlled' (lesser cost) tariff, these signal customer's hot water cylinders to switch on or off, shifting Vector's network demand peaks for up to three hours continuously within a 24-hour period. The signalling equipment also switches some streetlights on and off at dusk and dawn on behalf of Auckland Transport.

The Auckland network ripple system continues to provide a load management service. The Northern network load management systems have been discontinued due to the unreliability of the aged and end of life pilot wire system and the poor condition and lack of technical support for the GEC and Zellweger ripple plant. System capability is now reduced to ensuring hot water cylinders are always on.

Table 4-17 below provides key statistics of our ripple plant.

RIPPLE CONTROL PLANT TYPE	QUANTITY	AVERAGE AGE	% OF TOTAL
GEC Cyclocontrol	2	37	6%
GPT	5	26	16%
SFU-G 120	6	25	19%
SFU-G 200	1	26	3%

SFU-G 30	1	25	3%
SFU-K 203	1	15	3%
SFU-K 503	7	11	22%
Zellweger 1050 Hertz	9	55	28%

Table 4-17 Key statistics for ripple plant

The asset strategy for the future-use or replacement of the load management system is under review. The systems on both networks are end-of-life, increasingly unreliable, are incurring increasing maintenance provisions, and require upgrading and/or replacement. Assisting any replacement strategy is the transfer of Vector's management of streetlights to Auckland Transport as they migrate these to LED luminaries with a new radio-based switching technology. This Auckland Transport programme began in 2014 is planned for completion in five years (2023). The same Vector systems that manage streetlights are used to manage hot water cylinders and so must be retained pending a cost-effective alternative, of which several are being investigated by Vector.

EARTHING SYSTEMS

Earthing systems are required to minimise the risk of electric shock, limit earthing system related over-voltages on the network, ensure the operation of protection and carry earth fault currents safely.

All asset installations with conductive equipment have their own independent earthing systems. In general, the earthing systems comprise a set or sets of pins (electrodes) driven into the earth connected together via bare copper conductor. Copper is both an excellent electrical conductor and mechanically resistant to in-ground corrosion.

The nature of the surrounding soil and surface covering play an integral part in the performance of the earthing system. The effects of local soil resistivity and covering (e.g. metal chip and asphalt) must be included in the overall analysis of earth system performance and are covered by step and touch voltage measurement.

4.1.7 NON-NETWORK ASSETS

Vector implements and manages its information systems and their related infrastructure components according to an overall digital technical reference model. This ensures that each component has clear boundaries, which ensures that the technology used to support these components are "fit-for-purpose". It also helps ensure that Vector's information systems environment maintains a "separation of concerns" between its information systems and infrastructure. The technical reference model is shown in Figure 4-9.

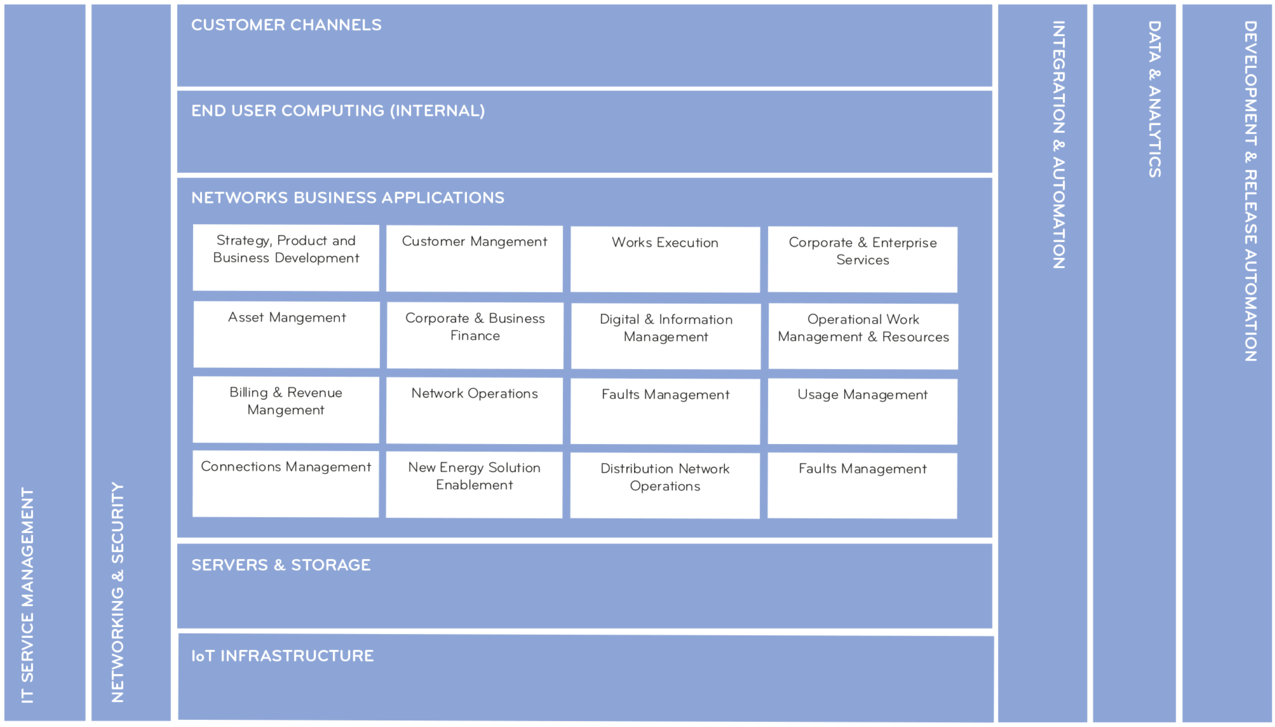

Figure 4-9 Vector's digital technical reference model

Vector's core network and supporting network information systems are used to manage data that is necessary for the effective day-to-day operation of its network and customer assets and the ongoing planning activities relating to those assets.

Figure 4-10 illustrates the relationship between Vector's business functions and processes, referred to as business process domains, and its core network related applications.

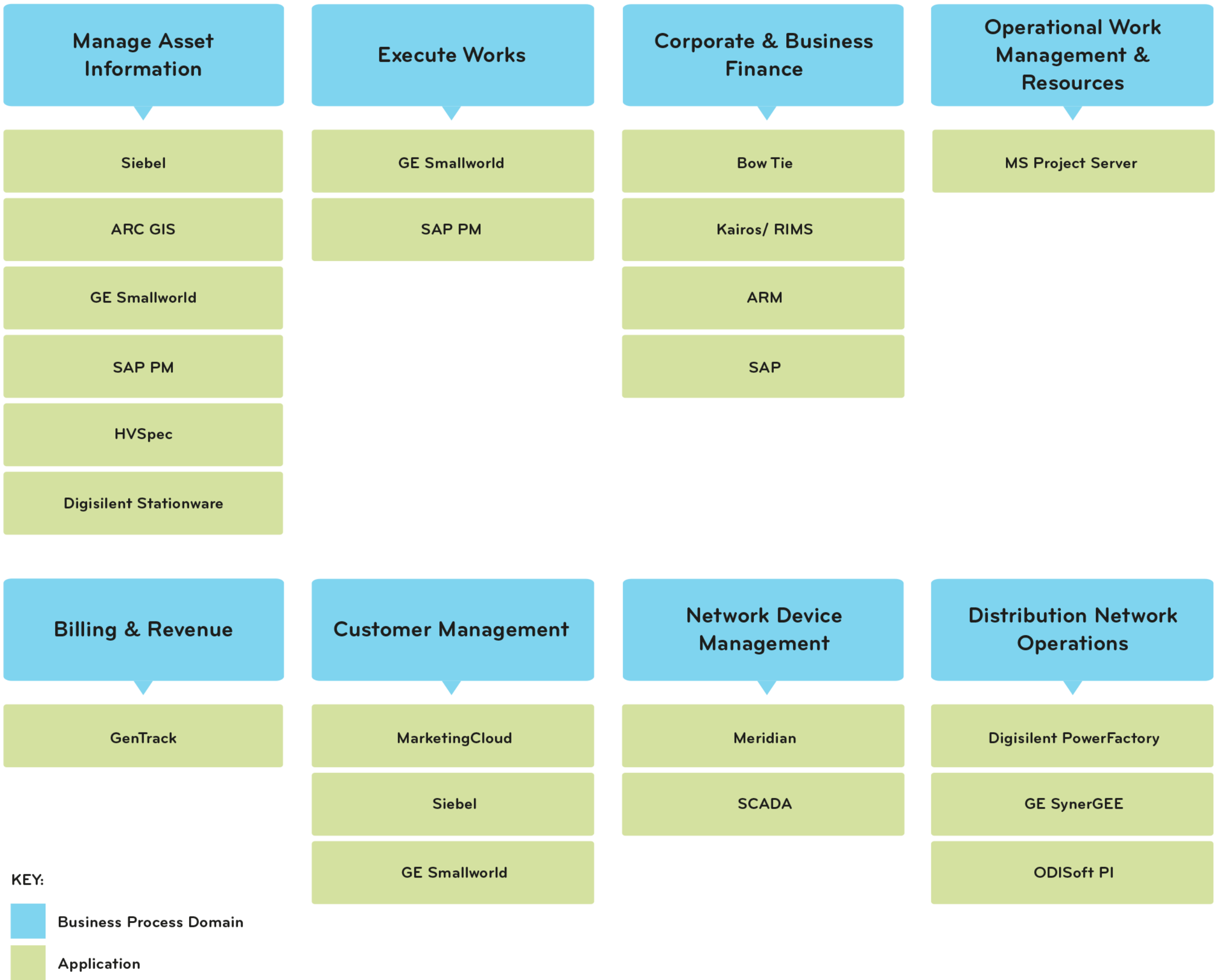

Figure 4-10 Business process domain and core network related systems (non-exhaustive)

INFORMATION AND DATA

Vectors information systems are used to manage data that is necessary for the effective day-to-day operation of its network assets and the ongoing planning activities relating to those assets. The information can be divided into several entities as shown below.

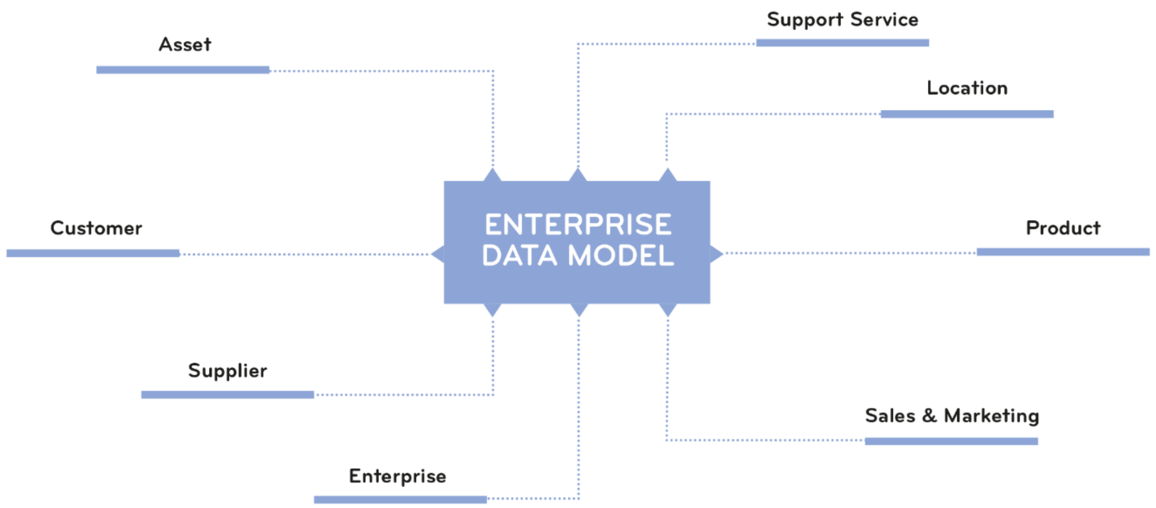

Figure 4-11 Enterprise data model

The information entities above consist of multiple attributes and stored in source systems. The Entity->Attribute->Source System mapping is captured in Vector's Enterprise Data Model.

4.2 MANAGEMENT STRATEGY

4.2.1 OVERVIEW

Management of Vector's network is undertaken in accordance with Vector's asset strategies. These strategies are focused on meeting service level targets. To this end, Vector's assets are managed over their full lifecycle to avoid failures that pose a hazard to staff, public safety or harm the environment and minimise interruptions of supply to our customers. Strategies are also aligned with statutory and regulatory requirements and design and maintenance standards. A list of key asset strategy documents, design and maintenance standards are provided in Appendix 2.

This section describes the asset management strategies that are in place at Vector that span across all asset classes. These include planning, operation and maintenance strategies as well as specific strategies relating to service level performance i.e. reliability, power quality, environmental and safety. Asset specific strategies are described in Vector's asset strategy documents (see Appendix 2) but have been summarised in Section 4.3.

4.2.2 NETWORK PLANNING STRATEGY

The planning strategy ensures the network assets can continue to achieve Vector's SoSS and other service level obligations at optimal life cycle cost.

Demand for new customer connections outside existing network boundaries is typically supplied through the development of new zone substations and feeders. Where forecast demand within an existing network supply area is expected to exceed the nominal capacity of an asset, resulting in a breach of the SoSS, then the capacity constraints are addressed. The timing of this is aligned with expected timeframes in which the capacity in a geographical area or the capacity of the existing substation is expected to be exceeded.

In addressing constraints, Vector considers traditional assets i.e. expanding zone substations, upgrading feeder lines, but also considers alternative technology. Distributed generation, DERs, smarter distribution technology and advanced analytics give us access to new options and choices to plan the network and have been and will continue to be used to defer investment in, for example zone substations, to a more optimal time frame.

Vector also accepts a marginally lower level of security for certain parts of the network reflecting our probabilistic planning philosophy, such that supply cannot be maintained at all times following a fault (for a very small proportion of the time, during peak demand periods). This allowance is captured in Vector's SoSS, as set out in Section 2.2.6. The purpose of this probabilistic approach is to support more efficient network reinforcement investments.

The combination of maximum demand and security standards set the design threshold that triggers the need for network reinforcement. By accepting the small risk not supporting supply should a fault occur exactly at peak times, the design maximum demand can be materially reduced. However, as only a minority of the substations are fully loaded at peak times, the probability of an outage at peak times through the adoption of this security of supply approach is further lessened. The benefits of not having to invest for the highest substation demand peaks provides not only an improved asset utilisation but a more efficient use of reinforcement capital.

4.2.3 FUTURE NETWORKS STRATEGY

As set out in Section 1.6, the future of distribution of electricity will be driven by new infrastructure that will see true on-demand energy delivered in new ways. Unprecedented integration of generation and storage capacities will redefine how customers generate, source, store and trade energy. This Future Networks strategy is focused on ensuring Vector's assets will be better able to support the future network changes and allow Vector to move towards our network vision (see Section 1.4). Vector's decisions are ultimately based on integrated environmental and socially responsible views that are agile enough to meet quarterly demands and yet strong enough to prepare the business for the long term.

Some of Vector's future network strategies are:

- Investing in automation, that is smart switching or self-healing, which has not historically been applied to Vector's distribution network. Vector's ability to quickly switch and control the network will become more important to enable Vector's vision of a new energy future (see Section 1.4);
- Improving visibility of the status and condition of the LV network. Considering the increased importance that will be placed on the LV network, this will be an important focus of the future;
- Committing to planning, designing, managing and maintaining the network to allow integration of storage, micro-generation and load management. This may include trialling network topology arrangements where DERs are more pronounced and looking to increase LV meshing capability; and
- Consider non-traditional network solutions as alternatives or in conjunction with network investments. Evolving technologies and economies of scale are making these solutions more practical and cost effective. For example, in some parts of our network it would be more cost-effective to install a BESS to a remote area to provide backup during outages than to construct a lengthy backup HV overhead line. BESS and their associated inverters give the option to provide network voltage support, respite during outages and the ability to shave peaks and have been implemented with success in Vector's network.

The majority of these strategies are supported by the Digital Strategy set out in Section 4.2.12.

4.2.4 NETWORK DEMAND STRATEGY

Vector will continue to use hot water load control for peak management where practicable and economical. In the Northern network, Vector will continue to investigate new technology systems to replace the existing end-of-life hot water management systems and its associated pilot wires. A number of new technology solutions are being trialled.

Within the Auckland network, the implementation of an alternative system is an extensive programme that will take a number of years to complete, and so Vector will continue planned maintenance to keep the existing systems operational. This includes regular tuning of ripple plants so they perform as optimally as practicable. This retains the maximum reach of the ripple signal, improving the reliability of signal propagation and thus the volume of managed load.

Load control management is still required in areas where intensification and/or growth is not forecast, in these areas the existing ripple plants will have to be retained, maintained or even replaced until Vector attains new cost-effective technology to displace it. Furthermore, for the Auckland network with its active load management system, Vector plans to procure a mobile ripple plant that can be deployed when an ageing zone substation ripple plant should fail[21], for both demand management and streetlight control.

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21 Under an agreement with Auckland Transport Vector is obliged to reinstate ripple signal within 24 hours to enable street-lights to be controlled

Vector and Auckland Transport are conjointly continuing to transfer from Vector to Auckland Transport the control of their street lighting. Auckland Transport plans to have this programme completed within five years over which time Vector's existing systems must continue to provide street light control.

4.2.5 REFURBISHMENT AND REPLACEMENT STRATEGY

Assets that are no longer able to deliver the level of service that customers require in a safe, efficient and economical way, will be replaced or refurbished. In dealing with distribution assets, where Vector has large populations of low cost assets and associated components, the optimal investment options to repair, replace or refurbish are relatively limited and are readily evaluated.

For the more critical distribution and subtransmission assets where replacement costs are typically high, the optimal investment options to repair, replace or refurbish will require more complex multi-criteria evaluation and business case justification. Factors that may be considered include:

- Maintenance costs over the remaining life of the asset will exceed that of replacement;
- The asset has become obsolete, component fabrication is expensive, the asset may be the last of its kind and inefficient to continue operation and maintain;
- Low cost retrofit replacements are available with enhanced ratings and safety features; and
- Associated risk and asset performance history.

Economic asset refurbishment is generally restricted to subtransmission transformers and certain size of distribution transformers. This is an efficient way of extending asset life.

The choice to refurbish assets is based on the condition of the assets, its age, history of faults, known issues, criticality of the asset and the cost of refurbishment. The availability of assets and the safety of assets also play an important part to elect whether refurbishment is an option.

Vector is moving towards implementing the CBARM model for asset replacement and this will replace the cyclical inspection regime in the longer term;

4.2.6 MAINTENANCE STRATEGY

Vector's assets are maintained over their whole lifecycle to avoid failures that pose a hazard to staff or public safety. The core that underpins the maintenance strategy is scheduled inspections for equipment in accordance with maintenance standards for each class. Maintenance inspections are used to perform minor maintenance tasks, minor repairs and identify and record any non-compliances as defined by the maintenance standards. All completed tasks, or requests for follow-up corrective work, are recorded against the asset in the asset system of record. All outstanding requests for corrective work are held in a work pool, and are prioritised based on risk.

Vector has a comprehensive suite of in-house developed maintenance standards that define asset inspections, condition testing and associated maintenance tasks by primary asset category. In general, Vector's philosophy is to keep its assets in use for as long as they can be operated safely, technically and economically. The maintenance standards support this goal to ensure optimal performance. Corrective maintenance for non-compliances will then be undertaken within specified time frames, as stipulated in the maintenance standards.

Each maintenance standard addresses the purpose, content, frequency, record requirements and associated treatment criteria. The treatment criteria and resulting actions generally direct field staff, to repair, refurbish or replace components, replace the entire asset and for some assets refurbish the entire asset off-site or refurbish in-situ.

Real time monitoring using SCADA exists for all plant in zone substations and bulk supply substations. These record key parameters such as transformer temperature, status of switches, DC system voltage levels, switchgear gas levels, voltage and current levels, trip alarms and fault alarms.

PQM meters (see Section 4.2.9) provide the ability to analyse faults in depth, that is, they keep record of fault currents, time of faults, fault duration and phase relationships, and magnitudes during the fault. The systems at zone substations are well developed and mature.

The following forms Vector's maintenance strategy

- Migration of the asset management system of our Auckland FSP into Vector's asset management system which is currently SAP;
- We have already developed the capability to track asset failures in SAP but there is further work to be done to refine the quality of data; and
- Increase the deployment of remote condition monitoring equipment at strategic locations;
- Using the criticality information developed for CBARM, we intend to move to a risk based prioritisation of maintenance approach.

Vector will also increase corrective maintenance. This will involve continuing with current planned maintenance practices of routine inspections, testing and servicing, in accordance with Vector's maintenance standards and current reactive maintenance practices, that respond to asset failures. Corrective maintenance practices will however be altered to adopt increased works volumes to target the root causes of identified service level gaps.

Spending on corrective maintenance will increase, including for associated asset replacement (see SECTION 5 for details of the programs of work and investment summaries). As service level performance returns to target in future years, Vector will reduce corrective maintenance to accord with historical work volumes. Preventative and reactive maintenance will remain consistent with historical work volumes, although an allowance for network growth has been assumed to apply to the reactive maintenance programme. Consideration of the impact of Auckland's growth was discussed in Section 1.5

4.2.7 RELIABILITY AND RESILIENCE STRATEGY

Section 9 of the DPP specifies an EDB must comply with SAIDI and SAIFI values defined by the Commission for the assessment period or have complied with the assessed SAIDI and SAIFI values for the two previous years.

For the 2015-2020 Determination, the defined SAIDI and SAIFI values were derived by the Commission using a 10-year historical view to define the SAIDI and SAIFI limits for the assessed values. Vector notes this historical view does not address any changes to the operating environment affecting the capability to meet the defined SAIDI and SAIFI values.

In this respect the enactment of the HSWA in September 2015, following the recommendations of the Royal Commission into the Pike River Mine tragedy and the Taskforce on Workplace Health and Safety has created more onerous obligations around ensuring the safety of staff, contractors and sub-contractors. To comply with this legislation Vector has developed new policies for technicians working on or near lines as a "reasonably practicable" means of eliminating the risk posed by live electrical equipment. Vector also introduced a new policy of remotely de-energising public reported downed lines before an on-site investigation has been conducted. These new safety policies are collectively referred to as the 'De-energised Work and Isolation Policy'.

The new policies create significant challenges to meet SAIDI and SAIFI values defined by historic performance when polices such as restricted live line work were not in place (see Section 2.3.3).

Nonetheless, Vector monitors its performance to SAIDI and SAIFI reliability indices, together with the number of customer interruptions metric (see Section 2.2), which are key indicators for Vector on the performance of the network. Our current objective from a reliability point of view is to reduce SAIDI, SAIFI and number of customer interruptions, to work back towards targets.

For SAIDI-SAIFI we have constructed a model that predicts the SAIDI-SAIFI performance of the network based on fault rates, network restoration times and network topology. Vector recognises that SAIDI performance is a function of these three variables and an optimised balance needs to be struck between them in order to deliver the required SAIDI-SAIFI performance. Based on our models, Vector is able to define the required balance by setting targets for network restoration times, tolerable fault rates and identify network topology changes required to improve overall SAIDI-SAIFI performance. These targets then inform the prioritisation of maintenance and investment plans.

Vector has a comprehensive set of network performance reporting tools (including dashboards) that are used to monitor to the required targets and we also report to the Vector Board our service level performance with a specific focus on any corrective and remediation activities to address potential deviations from our service level targets.

The strategy to reduce or maintain customer interruptions as per Vector's Service Standards, reduce interruption durations and reduce interrupted areas, will continue. We take compliance with regulatory SAIDI and SAIFI targets very seriously. There is extensive reporting on performance against these targets. This reporting includes daily updates to the GCE and monthly reports to the Board of Directors

4.2.8 VEGETATION MANAGEMENT STRATEGY

Effective vegetation management practice is essential in ensuring the safe and reliable operation of the network, and furthermore Vector has obligations to comply with the Tree Regulations. Vector undertakes a full review of significant events to identify any improvements that can be made to its responses to future events.

Gap analysis between service level performance and target performance levels has identified outages caused by vegetation contribute 15% of SAIDI and 13% of SAIFI on distribution feeders (see Section 2.3.3 and Section 2.3.4). This in turn adversely impacts the service level for Customer Interruption Breaches (see Section 2.3.5). While Asset Safety Incidents have not occurred in relation to vegetation, having physical contact between network assets and vegetation poses a significant risk to safety as well as the potential to cause fires.

Recent storm events shows the vegetation problem is greatly magnified when high winds are present. During such events, just under half of all events are confirmed as being caused by vegetation, whereas almost another quarter is suspected vegetation contact due to no permanent network fault being found. During these events, vegetation issues arise not only from trees within the 'growth limit zone' (as defined in the Tree Regulations), but also falling trees, or trees shedding debris from many metres, sometimes hundreds of metres, from the network.

A routine programme exists to survey the overhead sections of both subtransmission and overhead distribution feeders. This primarily identify trees that encroach the 'growth limit zone', which are then addressed either as a 'first cut'[22], trimmed at Vector's cost, or passed to the tree owner for their action and cost. However, a reliability and safety focused vegetation programme completed over FY16 and FY17 surveyed approximately 20% of the overhead network to risk assess vegetation that could impact the performance of the associated distribution feeders. Of the sites identified, two thirds (67%) were trees outside of the growth limit zone – a mixture of trees likely to shed debris onto or fall across the lines, causing an outage or risk to public safety.

The Tree Regulations do not offer Vector any assistance in enforcing the tree owners to take action to mitigate the risk of these out of zone trees, do not give Vector a right of access onto private property in order to complete cuts, nor offer any support in enforcing completion of second cuts for sites where the risk is to network performance as opposed to 'immediate danger to persons or property'. Required second cut remedial works which should be the responsibility of the tree owners, or work on out of zone trees, have to be negotiated each time in order to obtain permission to access the land and obtain permission to work on the tree. Even if permission is given, the works typically have to be completed at Vector's cost. Aside from a proactive approach on the network, Vector is also participating in industry working groups to review the effectiveness of the tree regulations for the future.

In the mean time, Vector is focused on addressing the issue of vegetation through a proactive programme to identify trees that have a high risk of causing an outage and affecting SAIDI, SAIFI or customer interruption service levels, as well as safety of the public. This is documented in the Vegetation Management Strategy and the details of required programme can be found in Section 5.2.

It should be noted that following a successful trial in 2016, Vector embarked on a programme of Light Detection And Ranging surveys (LiDAR) in 2018. Two of the main deliverables of the programme are a series of measurements relating to vegetation:

- Clearances between vegetation and conductors (to monitor growth limit zone encroachment); and
- Height of trees when compared to distance from conductors (to monitor fall hazard).

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22 This component of the works have been completed by Vector

It is expected that once the output data is received back from this programme, this will improve our vegetation plan by giving a full network view of the vegetation problem and enabling us to establishing priority areas based on our criticality models.

4.2.9 POWER QUALITY STRATEGY

Vector provides a nominal voltage of 230 V ±6% for single phase and 400 V ±6% for three phase at the point of supply, except for momentary fluctuations as allowed by the Electricity (Safety) Regulations 2010. Maintaining the network to operate within the permissible range is proving to be increasingly challenging with local distributed generation (e.g. solar/PV) pushing the network voltage beyond the upper levels and winter demand testing the lower threshold. Access to customer smart metering data would offer substantial benefits allowing pro-active identification of voltage issues on the network. Pending access to this data, where Vector is notified of instances of the network operating outside the regulatory voltage range, it will investigate and implement remedial action to address the problem.

Vector has installed PQMs at a number of its zone substations primarily to monitor harmonic levels. While variable speed drives have been in service in the industrial sector for a long time, we are interested in monitoring and understanding the impact of power electronics operating at the residential level, particularly inverters associated with solar/PV and EV/battery charging.

Increasingly we are being approached to assist commercial and industrial customers who have experienced production outages potentially caused by network disturbances. These disturbances may be caused by depressed voltage caused by network faults on adjacent circuits or even Transpower switching events but nonetheless result in loss of production and hence costs to the customer. The data from PQMs are analysed to determine the cause of network disturbances and changes will be implemented as appropriate in the Vector network to improve the performance to within regulatory requirements. There are of course instances where PQM issues are caused by disturbances in the customers' electrical installation, rather than caused by Vector's network, in which case Vector will recommend that the customer undertake steps to investigate, test and take appropriate steps to improve their electrical installation.

4.2.10 ENVIRONMENTAL STRATEGY

Sustainability lies at the heart of creating a new energy future and Vector strives to be an industry leader in Health, Safety and Environmental performance (see Section 1.8). The Environmental Strategy is to provide sufficient competent resources and effective systems at all levels of the organisation to fulfil this objective. Vector has ISO 14001 Environmental Management System certification and will strive to maintain this.

To achieve the above, Vector is committed to:

- Ensuring environmental aspects and impacts are considered as part of all business decisions;
- Meeting and where possible, exceeding the requirements of all relevant environmental compliance obligations;
- Providing environmental leadership through participation in business networks and working with government to create pragmatic laws, regulations, standards and codes of practice to protect the environment;
- Operating in a manner that prevents pollution, minimises environmental impacts and promotes beneficial environmental performance;
- Monitoring and continually improving our environmental footprint;
- Consulting with Vector People, customers and other relevant stakeholders on our environmental performance; and
- Using our knowledge, resources and technology to influence positive environmental outcomes throughout the industries and geographic areas we interact with.

To deliver this strategy Vector will:

- Increase environmental awareness across the business
- Focus on responsible energy management within our assets;
- Establish environmental goals through our business health, safety and environmental plans and continually monitor, review and improve the effectiveness of our Health, Safety and Environmental Management System;
- Improve environmental capability of all Vector People;
- Set environmental criteria through our purchasing processes; and
- Deliver services and technology to our customers that displace carbon emissions and other forms of pollution.

Vector is developing more sustainable supply chains and we intend to put plans in place with its suppliers of batteries to recover and recycle the product at end of life. A further example is the retirement of power transformers where Vector has an arrangement with smelters for the steel from cores to be melted and reused.

4.2.11 SAFETY IN DESIGN STRATEGY

The transmission and distribution of HV and LV electricity involves managing significant electrical hazards, and HSWA places greater accountability on designers to achieve safe outcomes for works. Safety in Design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise the risks to health and safety throughout the life of the structure being designed. Safety in design applies to any plant, substance or structure that is constructed whether fixed or movable.

It is the fundamental of getting Asset Management practices right and forces us to take a collaborative, well considered, risk based multidisciplinary approach across the lifecycle of the asset.

This strategy is covered by Vector's Corporate HSEMS Key Requirement 12.1, Safety in Design.

4.2.12 DIGITAL STRATEGY

Vector has recognised the convergence of digital technologies including Cloud computing, IoT, machine learning and Big Data and has revised our technology strategy to better reflect the opportunities digital convergence presents for our organisation with the objective of creating a new energy future for our customers and partners (see our vision in Section 1.4 and business case in Section 5.3.1).

Customer Engagement Platform - Using digital platforms and technology to improve the customer's experience by providing a frictionless multi-channel, bi-directional and secure method of engagement with Vector across all of their interactions. For electricity, this will include new connections, faults, outage management and safety.

Business Enablement Platform - The development of microservices and fit for purpose core business enablement platforms will reduce complexity and risk on legacy platforms. The existing legacy, monolithic enterprise platforms will result in significant cost and risk to migrate when they start to reach end of life and the BEP will provide Vector the ability to complete lifecycle migration activity and improve our capability to meet changing customer and technology demands.

Operational Technology Platform - Using digital platforms and technology to improve how Vector operates the network. The increasing instance of customer distributed generation demands improved ability to connect, collect and control network assets to enable management and insight. So, this is especially focussed around the areas of IoT and Big Data where increasing information from the network delivered in a secure way improves our ability to effectively and safely deliver our services.

4.3 ASSET SPECIFIC STRATEGIES

Vector's Asset Strategies for each of its asset classes describe in detail Vector's long-term actions and plans required to deliver specific objectives and network outcomes based on stakeholder requirements and long term service level performance criteria. A list of all of Vector's Asset Strategies is provided in Appendix 2.

Each asset strategy provides an overview of the class of asset, its purpose and information about its population, asset class replacement considerations, its maintenance requirements, failure modes, specific known issues, risks and asset health indicators and refurbishment requirements. A high-level summary of these strategies is given below.

EQUIPMENT CAPACITY ASSESSMENT

Vector has a policy of using standard equipment on its network to minimise long-term cost. The key factor in deciding the standard capacities (20 MVA and 10 MVA) of power transformers is the load density of the area being supplied. While economy of scale suggests the use of large capacity transformers, higher capacity zone substations will result in a larger supply catchment area (for the same load density) and longer distribution feeders. Larger supply catchment areas will also result in zone substations further away from GXPs, thus requiring longer sub-transmission feeders. Deciding the optimal economic capacity of standard urban transformers requires optimisation between cable and transformer costs to achieve the lowest overall cost per MVA of network capacity. Scenario analysis (of different transformer capacities and feeder lengths), considering a range of equipment costs and load densities, supported a decision on standardising urban transformer capacity at 20 MVA. Other factors considered include the impact of transformer capacity on fault level, transformer impedance, reactive power and tap changer/voltage control.

For power transformers used in rural zone substations, voltage performance of the distribution network is another important factor in addition to those stated above. The result of the analysis for these areas indicates that here 10 MVA is the optimal transformer capacity.

Apart from the capacity of power transformers, most of the equipment installed on the Vector network is standardised. This includes:

- Protection and control equipment;
- Zone substation buildings;
- Sub-transmission switchgear;
- Distribution transformers;
- Distribution switching equipment;
- Distribution cables; and
- Poles.

Asset capacities are specified at the equipment specification stage prior to the procurement of network equipment, and verified through type-testing (e.g. switchgear) or individual test results (e.g. transformers). Existing equipment relies on equipment procurement records or name-plate parameters. Standard distribution cable sizes are nominated to ensure a relatively small range of cables are held in stock and to minimise spares. We apply the same principle for overhead conductors for which standard conductor sizes are nominated to ensure a small range of stock. Cable ratings are calculated using CymCap cable-rating software based on field-tested ground thermal conductivity results and standardised cable installation practices. All new sub-transmission cables are modelled including the provision of trench profiles to ensure the required network rating can be achieved prior to procurement of the assets. Circuit ratings are the lowest of the individual asset ratings in the circuit. As the forecast demand is compared against circuit ratings to identify potential security breaches, solutions clearly include the replacement or uprating of inadequately rated equipment to increase the overall circuit capacity.

4.3.1 SUBTRANSMISSION FEEDERS

Vector's strategy for subtransmission cables is described in EAA301 Underground Cables. Vector maintains its fleet of subtransmission feeders, some of which are approaching forecast end of life, to provide service for as long as possible into the future without increasing the risk profile of this asset to an unacceptable level.

Our experience and monitoring of the condition of 33 kV and 22 kV oil filled cable have shown that with proper and regular maintenance and continuous condition monitoring, as per Vector's maintenance standard ESM301, the life of this asset can be extended well into the future and in some instances beyond its forecast end of life. The cyclic inspections of oil-filled cables are supplemented by real time monitoring of oil-pressure using SCADA, complete with operational alarms, to alert the EOC of low oil-pressure. Hence replacement of oil-filled cables forms part of the replacement programme described in SECTION 5.

Our experience and monitoring of condition show that in terms of underground subtransmission networks, that ageing 33 kV and 22 kV PILC cables are currently the worst performing in Vector's subtransmission network. Failures on this type of cable is such that continuous repair and piecemeal replacement are not economical anymore and therefore this type of cable makes up most of the programme for replacement in the programme as described in SECTION 5 for subtransmission cables.

Our solid insulated XLPE subtransmission cables are performing well, and although some circuits have been in service since the 1970s, there is no need to replace any of this type of cable.

Vector still operates a gas-filled subtransmission cable between Kingsland zone substation and Ponsonby zone substation and its condition is such that it will be replaced in FY19.

4.3.2 ZONE SUBSTATIONS

Management of our zone substation fleet is undertaken in accordance with Vector's asset strategy EAA701 Network Infrastructure and Facilities.

Zone substation assets are developed and maintained to comply with Vector's SoSS. Wherever practical, standardised design and modular design and construction are used to reduce capital costs and reduce asset stranding risks posed by new energy technologies. Vector's ESE700 suite of design standards describe the standardised design requirements for zone substations.

Management of all zone substations includes the use of inspections as defined in Vector's maintenance standard ESM701, Maintenance of Buildings, Structures and Facilities. Security, Air and Fire Management Systems are maintained in accordance with ESM603, Maintenance of Building Security, Air and Fire Management systems.

These inspections are used to identify any non-compliance with the afore-mentioned standards and perform minor maintenance tasks. The cyclic inspections are supplemented by real time monitoring of zone substations using SCADA to monitor and record each substation's key parameters (e.g. switch status, temperatures, voltages, etc.) as well as provide operational alarms. In the medium term, CBARM practices will be used more extensively to supplement cyclic maintenance and replace the cyclic inspection practice in the longer term. Data captured through inspection and monitoring of zone substations supports the asset management practice as described in more detail in SECTION 3.

Where non-compliance and performance issues are identified, a broad range of testing methods are used to investigate in accordance with Vector's maintenance standards, as well as specific testing standards. Test data supports asset management practice and assists in the development of asset interventions (responses). Corrective maintenance is then used to respond to any asset non-compliance.

4.3.3 DISTRIBUTION FEEDERS (HV AND LV)

ALL FEEDERS

Vegetation management is a key focus area for overhead parts of feeder at all voltages, although criticality generally increases as voltage increases. Our approach is documented in our Vegetation Management Strategy (see 4.2.8) and programme detailed in Section 5.2.

HV UNDERGROUND FEEDERS

The Auckland Council Unitary Plan requires urban reticulation for new developments to be placed underground. Vector works with developers and property owners to deliver this outcome.

With the exception of the Highbrook Development, whose reticulation voltage is 22 kV, the HV reticulation is at 11 kV. The Auckland CBD is progressively being upgraded from the existing 11 kV network to 22 kV. Subject to the availability of the 22 kV network, all customer capacity upgrades and new connections within the CBD will be at 22 kV.

Vector plans to increase the penetration of monitoring and remote control capability of the HV network to create a more dynamic network. This is driven by the Future Networks Strategy (see Section 4.2.3).

HV OVERHEAD FEEDERS

HV overhead feeders are maintained in accordance with Vector's maintenance standard ESM401 Maintenance of Overhead Lines. The strategy for renewal is also described in Vector's asset strategy EAA401 Overhead Lines.

Ongoing issues for conductor life is that Vector's network is all relatively close to the sea and therefore subjected to a more corrosive environment. All of Vector's network less than 15 km from the nearest shoreline, and approximately 50% within 3 km of the shoreline. Overhead conductors also harden over time (anneal), becoming brittle due to wind induced vibration, movement and thermal cycling and loses some of its tensile strength.

Vector has commenced a programme to replace degraded conductors with an initial focus on copper conductors, based on concerns about the condition of mostly small sized copper conductors (16mm² or smaller) that hails from the 1950s and onwards. The number of joints and failure history show that this type of conductor requires a focused programme of renewal. Further details of the quantity of copper conductors in Vector's network is stated in Section 4.1.4 and details of the program of work can be found in SECTION 5.

As part of the programme to renew HV overhead feeders, Vector uses acoustic technology to find failed or failing insulators that are then replaced. Conductor sampling is also used to assess condition and to build up a profile and database of the network that contains conductor with poor asset health. As part of conductor condition driven rebuilds, poles, crossarms and stays will be replaced as required.

LV DISTRIBUTION FEEDERS

As set out in the Future Network Strategy (see Section 4.2.3), Vector intends to undertake a programme of inspections to improve its visibility of the status and condition of the LV network. This will involve leveraging existing inspection programmes by expanding them and implementing new inspection practices that provide improved network data.

We are enhancing and expand our back-end data systems and improving our analytics and mapping capabilities (linked to Vector's asset information systems, enhanced tariffs, and peer to peer trading). This includes enhancing our capability to model and analyse the behaviour of our LV network, and the customer energy demands placed on it particularly where DER and transport electrification is becoming pronounced.

Any new LV distribution feeders in Vector's network will be underground. Replacement of LV overhead conductors will be undertaken with either aerial bundled conductor (ABC) or covered conductor.

4.3.4 DISTRIBUTION SUBSTATIONS AND VOLTAGE REGULATORS

Our asset strategy for distribution substations is described in EAA501 Distribution Network. The strategies cover distribution switchgear and distribution transformers.

Distribution substations are maintained in accordance with ESM503 Maintenance of Ground Mounted Distribution Equipment and Voltage Regulators. To deliver to this, Vector implements extensive routine and operational preventive activities that include cyclical inspections, planned maintenance, asset inspections, maintenance servicing and condition testing. These preventive tasks uncover non-compliant or serviceability asset observations which are then treated as a corrective maintenance action or an asset renewal action depending on the extent and risk with regard to performance and safety.

The identification of serviceability or non-compliant asset observations, consider generic performance and safety consequences. These consequences are used to determine the treatment criteria. The timeframes for treatment are strongly driven by the likelihood of the hazard. The applied maintenance approach has developed from a pure condition-based maintenance strategy to incorporate risk elements but the adoption of a more formal CBARM framework is being implemented.

RING MAIN UNITS

One of the big challenges facing Vector is an ageing 11 kV RMU population, see Section 4.1 for details of the population. Certain types of the ageing oil-filled ring main population are more prone to failure and have been identified as one of the high risks in Vector's network to operational staff.

The present replacement strategy relies on a deterioration in condition being identified by routine maintenance inspections and replacement undertaken as required by the risk under the corrective maintenance programme. The concern is that the population has a similar age profile as all are approaching the end of expected service life together, a sudden increase in deterioration / asset failures is likely and may encompass a greater number of assets that can be attended to under the budgeted corrective maintenance programme. Vector will therefore move away from the current replacement strategy to undertake a scheduled programme over a number of years, replacing oil-filled ring main units, with priority based on condition and criticality. Details of the programme to replace oil-filled distribution switchgear can be found in Section 5.2.4.

While remote large scale generation has historically dominated the supply chain, the availability of economic renewable generation at the district and installation levels of the power system, will progressively localise electrical energy supply and our distribution substations need to take this into consideration (see Section 1.6).

Going forward we will enhance our HV feeder automation by adding more remote controlled switches at cross feeder ties, mid-feeder segregation (possibly with some auto-changeover capability), and cross zone ties (possibly with some auto-changeover capability). Vector will target critical feeders first and areas where reliability will be enhanced the most (high

SAIDI feeders – high criticality feeders) and add telemetry devices to the HV network at critical points to provide network visibility and links for Vector's Energy IoT.

Vector has implemented a suite of new design standards for distribution substations with a focus on providing guidance to customers, e.g. developers, architects, engineers etc. who provide or design substations in customer owned buildings. This is to ensure that there is a level playing field and that the same engineering requirements as well as safety requirements are available to and adhered to by all. Full details can be found in Vector's ESE500 suite of engineering design standards.

DISTRIBUTION TRANSFORMERS

Distribution transformers are maintained in accordance with the maintenance standards listed in Appendix 2. Asset condition data show that there is no requirement for an intervention programme, i.e. planned replacement. Distribution transformers are replaced on failure for example and in the event of severe rust and oil leaks.

Vector is investigating the use of dry-type transformers in locations where oil-filled distribution transformers present a risk to facilities in the event of a catastrophic fire and explosion.

To provide visibility of the loading and status of distribution transformers in the network Vector plans to install transformer monitors. A trial will be undertaken in FY18 in which lightweight 3-phase monitoring units with SCADA capability will be installed and tested. The ability to monitor power flows from distribution transformers will become more and more important for the energy network of the future.

LOW VOLTAGE DISTRIBUTION FRAMES

Vector has a sizeable population of old style DIN-type vertical fuse disconnect LV frames. This style of LV frame holds a higher risk of arc-flash to operators when a fuse is pulled under energised conditions.

Vector will undertake a risk-based assessment for a programme to upgrade to modern LV frames that for larger transformers (larger than 500 kVA) will include a CB to further reduce the risk and consequences of arc-flash.

At the time of writing, this specific topic is not fully covered in an asset strategy as the strategy is being developed.

VOLTAGE REGULATORS

Voltage regulators will be installed in lengthy rural feeders as required to improve the supply.

4.3.5 SYSTEMS AND OTHER NETWORK ASSETS

PROTECTION SYSTEMS

Although electro-mechanical protection relays in Vector's subtransmission network are reliable, they have no reporting and analysing capability to Vector SCADA. They are only able to provide trip alarms to the EOC. Vector has a wide range of electro-mechanical line differential protection schemes that date from the 1960s and in terms of skill sets to maintain these it is becoming a challenge to employ personnel that are able to maintain and repair these schemes.

Modern numerical (microprocessor) relays, also referred to as IEDs, offer many advantages over electromechanical, static and first generation numerical relays, namely providing significant SCADA improvements, device health monitoring improvements, improved safety (by additional protection functions and improved device sensitivity for network faults), savings on maintenance costs, and provide advanced device configuration functionality (logic programmability).

Vector's asset strategy for protection systems is described in EAA801 Protection Systems. In light of the continuing and increasing failure of the 50 year plus copper pilot communications cables (see below), Vector will systematically replace subtransmission protection schemes with modern numerical protection schemes that use fibre optic communications channels.

Our numerical IED protection schemes are based on standardised and modular designs that are laid out in the ESE800 suite of design standards and EDE8000 suite of standard design drawings. Vector has standardised on the IEC 61850 internet based communications system that allows for easy integration of new IEDs into its network. This standard also allows easy communications from SCADA to IEDs and between IEDs.

TRANSFORMER MANAGEMENT SYSTEMS

Around 50% of TMS systems on power transformers have been replaced with modern numerical systems with advanced control, reporting and analysing functions. A programme is in place to replace all electro-mechanical and PLC based TMS systems in the next five to six years.

The strategy for this asset is described in EAA802 Transformer Management Systems. Refer to SECTION 5 for the programme of replacement.

POWER QUALITY METERS

The age of the PQM population is approaching 17 years and cannot be upgraded to the latest PQM reporting software. To ensure continued visibility of the quality of power supply at the zone substation busbars, Vector is undertaking a staged and scheduled programme to replace PQM meters. This is in accordance with Vector's strategy for power quality as described in EAA803 Power Quality Metering.

Vector uses a standardised and modularised design for PQM panels, allowing easy interchange or replacements.

ZONE SUBSTATION AUTOMATION SYSTEMS

New LANs and RTUs are of a modular design in accordance with Vector engineering standard ESE802, Automation and Control in Zone Substations. The Asset Strategy for zone substation automation systems is detailed in Vector's asset strategy EAA805 Automation Systems.

The RTU located at Vector's zone substations provide an essential part of the SCADA system to collect status information from site and allow remote control of plant at site. Vector has an ongoing programme to proactively replace RTUs approaching end of life to ensure adequate reliability is maintained hence remote control of substations is not impaired.

Vector has a standardised and modular design for substation LAN systems. This is described in design standard ESE802 Automation and Control in Zone Substations and the EDE8004 suite of design drawings. These modular designs are used for zone substation refurbishments and new zone substations.

DC SUPPLIES

Vector has standardised and modularised its design for DC systems. The modular designs are in accordance with Vector's design standard ESE601 DC Systems. Vector's asset strategy for DC systems is described in strategy report EAA601 Auxiliary Systems.

Vector's zone substation battery chargers are progressively reaching end-of-life and are now showing an increasing failure rate compounded by limited replacement stock availability. A replacement programme to phase out the Benning chargers will start in FY18. Sites will be prioritised by the criticality of connected customers and the age, condition and failure history of the charger.

The risk for Vector customers is that without a reliable charger supply the zone substation will fail within the 24-hour capacity of the 110V battery string. There is an associated asset risk from a substation fire should a downstream network fault occur.

COMMUNICATIONS CIRCUITS

The network is continually adapted to meet Vector's specific needs and this has resulted in the adoption and deployment of Ethernet and IP based communication technology.

Vector is undertaking a programme to replace ageing copper pilot cables with fibre-optic communications networks. Vector is working closely with Vector Communications to establish a modernised fibre optic based communications networks and a number of initiatives are underway as described in SECTION 5. Not only will this improve the reliability of line differential protection schemes and SCADA but make provision for the expected increase in communications bandwidth as part of the Distributed Energy Resource Management System (DERMS) as described in Section 1.6.

There are no systemic issues with the wireless 2G/3G routers but a hardware refresh will be required in the next three years. 2G and 3G will become redundant in the 2020s and Vector will migrate to 4G and 5G.

RIPPLE CONTROL SYSTEMS

Refer to Network Demand Strategy (Section 4.2.4) for our strategy around ripple control systems.

EARTHING SYSTEMS

Earthing systems for zone substations are installed in accordance with Vector engineering standard ESE704 Zone Substation Earthing. Earthing systems for the distribution network are installed in accordance with Vector engineering standard ESE506 Distribution Earthing. Vector's asset strategy for earthing systems is described in strategy report EAA601 Auxiliary Systems.

Earthing systems are maintained and tested in accordance ESM607 Maintenance of Earthing Systems to ensure the integrity of earthing systems and its capability to carry fault currents and limit step and touch potentials.

Earth studies and measurements are undertaken for every new zone substation or BESS project to provide the necessary baseline information to design the new earthing system.

FIRE AND SECURITY SYSTEMS

In FY18 Vector's zone substation replacement programme to install CardaxTM security monitoring was completed. This replaced the end of life 1970's control units fabricated by Guardall New Zealand. The intention is also for the zone substation fire detection system to communicate to the local Cardax security system for fire annunciation at Vector EOC, for EOC to then contact the Fire and Emergency New Zealand responder service. Category 1 substations, typically in the Auckland CBD, are also directly annunciated to Fire and Emergency New Zealand.

Recently a sample assessment of the completed Cardax installations has found some sites non-compliant in this regard. A risk assessment has identified that a programme for the balance of zone substation buildings is required. The desktop study has identified 27 Auckland sites and 17 Northern sites, 44 in total. Our strategy includes replacing the old fire monitoring equipment by adding a Cardax fire detection isolation and annunciation panel connected to the existing Cardax security installation, and fire monitoring integration where multiple buildings exist. Connection to the automated fire annunciation service will also be added to the Category 1 Liverpool 110 kV and 22 kV switch rooms, and the three transformer buildings at Auckland Airport. The project will ensure zone substation buildings still have a properly integrated fire safety system. This gives assurance of the correct Fire and Emergency New Zealand response for fire and mitigates a recently identified HILP risk to the zone substation buildings, plant, personnel, customer power supply (potential SAIDI impact), and ultimately the public and our customers.

SECTION

05.

MANAGING OUR ASSET'S LIFECYCLE

SECTION 5. MANAGING OUR ASSET'S LIFECYCLE

This section sets out Vector's project proposals for the next 10-year period. Project proposals are created through the 'Needs Management' process described in Section 3.5.2 and are categorised as either 'Network Development' or 'Operate, Maintain, Renew, Replace' projects. They comprise both standalone projects, where investment is focused on a specific asset and need, and programmes of work, which may comprise a series of projects to address the same need.

These proposals will assist Vector in achieving service level targets through addressing the current or forecast performance issues (see Section 2.2 and Section 2.3), and delivering our network vision (see Section 1.4). The proposals are aligned with our asset management strategies (see Section 4.2).

According to a National Institute of Water and Atmospheric Research study in 2017 extreme rainfall, severe droughts, wildfires and wind with increased speeds could hit Auckland in years to come. Those parts of the network that are in a condition such that its resilience is doubtful will require investment to improve its resilience to ride through storms. This particularly applies to ageing overhead networks in areas that are known to be exposed to high winds. We also have an issue with small diameter conductors that is showing an increasing rate of failure. Large tracts of the small diameter conductor networks exist in urban areas and this presents an unacceptable safety risk to our customers. Investments are included below that will focus on improving the reliability and resilience to our customers. Our Needs statements and expenditure profiles make provision to harden the network in the AMP period. However, at this point in time there is uncertainty on the impact that future climatic events and changes will have on our network but recent events have shown that certain parts of our network is vulnerable to extreme weather (see Section 1.8). Vector will also improve its data analytics for this uncertainty (see Section 3.7.3).

Project proposals for Asset Development are grouped under network themes while Operate, Maintain, Renew, Replace projects are described as per the following details.

Need: The need sets out how the project is aligned with Vector's service level targets (see Section 2.2), particular shortfalls in performance (see Section 2.3) and particular strategies (see Section 4.2). Any risks relating to the ongoing performance of the network are highlighted. By having close alignment with the service levels, this ensures projects are in accordance with the asset management objectives.

Options considered: Viable options to address the need are set out in an options table. Where applicable, options consider non-network solutions and innovations and deferral of investment. The options table includes the expected cost of the option, the reason for choosing or rejecting and the post investment risk.

Preferred option: A brief description of the option selected to address the need is described, which forms the basis of the project. Any inter-dependencies with other investment projects are noted.

Investment summary: An investment summary table gives forecast expenditure on the project for the 10-year period in New Zealand dollars. The forecast annual expenditure is given in FYs and all amounts are shown in millions of dollars nominal to two decimal figures.

5.1 NETWORK DEVELOPMENT

Auckland is the largest urban area in New Zealand and accounts for 37 percent of New Zealand's economy. It is also one of the fastest growing cities in the world. A safe, reliable, economically competitive and environmentally sustainable electricity distribution network is the cornerstone of a strong and prosperous Auckland economy.

Our customers' preferences and expectations are shifting towards fewer carbon emissions, greater choice, real-time interaction and sharing, always-on connection, greater transparency, personalised experiences and learning opportunities - through services more than products – and better reliability and security.

To meet our existing and future customers needs we are transforming our network planning approach to be more diverse and customer-centric. Our approach promotes a lower-cost, smarter, more decentralised, yet more connected electricity network, which enables customers' DERs to actively participate in the provision of resilience and improved network asset utilisation.

This section sets out Vector's network development project proposals for the next 10-year period, which are related to the expansion and interconnection of the electricity network to account for Auckland's growth, the densification of suburban areas, the urbanisation of rural areas, and the improved resilience for more isolated rural communities. The projects comprise both standalone projects, where investment is focused on a specific asset, and programmes of work, which may comprise a series of projects to address the same need. A business case has been developed for all projects that are put forward.

Network development costs require long investment horizons, with much of the costs being carried by future generations. On this basis, Vector applies scrutiny to investments to ensure our assets can serve our community throughout their lifetime, whilst avoiding intergenerational inequity. This means increasingly designing and valuing distribution networks that are agile, flexible and modular to respond to change, while navigating through an era of uncertainty. Our investment strategy values optionality, flexibility, latest technology, data and advanced operational practices to meet Auckland growth and optimise the outcome for our customers.

Auckland's growth is based on the Future Urban Land Strategy laid out in the Auckland Unitary Plan. Under this plan, the network will need to expand into new greenfield areas (e.g. Takanini and Wainui) and densify in sparsely developed regions (e.g. Whenuapai). These areas are currently supplied by a low capacity rural feeders and intensification to urban residential levels requires both investment in new zone substations and distribution reticulation.

To account for the potential high uptake of DERs, all new zone substation investments are designed flexibly by deploying a single transformer complemented by a BESS and the option for a second (mobile spare) transformer to be rapidly deployed if required. This provides the flexibility to adapt to future demand profiles. Even in a scenario where a second transformer would be needed permanently, customers would have benefited from a network investment deferral as well as from the optionality that BESS create as they are relocatable. The first such design on our network is the Hobsonville Point zone substation. This new zone substation design also means that the subtransmission network can be designed skinnier, as peaks are reduced due to either increasingly local DER availability or the possibility to reduce peaks with the BESS.

The following sections group the network development projects by geographical regions. The purpose is to provide visibility on those areas where growth will overtake existing capacity and investment is required. For all projects identified below we always look for the optimal solutions prior to investment whether it is through the use of network, non-network solutions or customers DERs. In all cases, we have identified a solution that will deliver the best outcomes for our customers.

5.1.1 WELLSFORD TO WARKWORTH

The Wellsford/Warkworth area covers the northern most part of the reticulation area managed by Vector. This area includes Wellsford and Warkworth townships, and the smaller townships of Matakana, Sandspit, Omaha, and Snells Beach.

Growth in the Warkworth area is increasing local network demand leading to forecast capacity constraints on the upstream subtransmission network, currently supplied from Wellsford GXP some 19km to the north. Zone substations at Snells Beach and Warkworth are approaching capacity. Current projects already under construction include the installation of a BESS at the Warkworth South site and at Snells Beach zone substation to reduce peak demand to allow the ongoing connection of new load while deferring major reinforcement.

Acknowledging that in due course, demand is forecast to overtake the extra capacity gained from the two BESS units, a number of staged reinforcement projects have been included to increase the capacity to the Wellsford – Warkworth subtransmission circuits (State Highway (SH) 1 Dome Valley future-proofing ducts, Wellsford-Warkworth 33 kV upgrade stage 1 and Wellsford-Warkworth 33 kV upgrade stage 2). This work will be carried out in association with New Zealand Transport Authority SH1 road alterations and the proposed new Puhoi – Wellsford motorway extension. As these projects are not scheduled until the middle of the next decade we will continue to explore options that will manage the local load, (through the use of both network and customer DER) to avoid unnecessary network investment.

To increase local zone substation capacity beyond that available from BESS installations, a transformer upgrade at Snells Beach zone substation is proposed. Similarly, to reduce the demand on Warkworth zone substation a new zone substation at Warkworth South is proposed to be constructed alongside the existing network BESS. A subtransmission cable is proposed to be installed between Warkworth zone substation and the Warkworth South site to provide the subtransmission supply.

Two long 11 kV feeders, one from Warkworth zone substation (between Warkworth and Matakana) and the second from Wellsford zone substation (close to Whangateau) are joined west of Omaha. Load growth in Matakana coupled with the long 11 kV feeders results in significant voltage regulation issues when one feeder is used to support load from the other. Because of their wide coverage, outages due to faults have significant SAIDI implications for Vector. A small capacity 33 kV/11 kV zone substation near Omaha is to be installed to augment these two 11 kV feeders. The benefits are improved voltage support, and reduced SAIDI as each of the 11 kV feeders are split into two.

The demand forecast has signalled the need for 11 kV feeder reinforcements projects at Tawharanui, Matakana and Sandspit enabling improved meshing of the network to maintain security. All projects are growth related.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Snells Beach - BESS	Demand on the Wellsford-Warkworth 33 kV lines exceeds the firm capacity	BESS projects at Snells beach and Warkworth South will enable peak shifting	Project underway. Completion in FY19
Tapora micro grid	Horticultural and residential developments require reliability improvement in the remote Tapora district	A micro grid will allow supply to be maintained during network outages	Project underway. Completion in FY19
Wellsford-Warkworth 33 kV upgrade stage 1	One of the Wellsford-Warkworth 33 kV lines is constrained due to a short section of small conductor.	The under-sized section of line will be upgraded to match the remainder of the circuit	Replacing a short section gives a large capacity increase at a low cost
Omaha zone substation	The Matakana (Warkworth feeder) and Whangateau (Wellsford feeder) are long feeders. Using one feeder to back up the other results in voltage issues. The long feeders result in extended outages when fault finding	A small rural 33 kV/11 kV zone substation will be installed on an existing site, with a transformer secured from another zone substation undergoing an upgrade.	Omaha zone substation will offload Warkworth, improve the security to Snells Beach zone substation, and improve reliability for Matakana, Omaha and Leigh townships.
Sandspit Road – 11 kV feeder reinforcement	Warkworth and Snells Beach feeders are forecasted to experience backstop shortfall.	11 kV cable and future-proof ducts will be laid along Sandspit Road to increase backstop capacity between the two zone substations	This project will be coordinated with a Watercare pipeline project to reduce costs and minimise disruption
SH1 Dome Valley - future proof ducts	Widening of SH1 in Dome Valley requires the relocation of Vector assets.	Future-proofing ducts will be laid as part of this project.	Significant savings accrue from sharing civil costs, and disruption to SH1 traffic is reduced when projects are combined

Snells Beach - transformer upgrade	Residential development means the capacity of the single-transformer Coatesville zone substation will shortly be exceeded at peak demand. This also means that backstop to Warkworth zone substation is restricted, compromising security of supply	The transformer will be replaced by a larger unit from another zone substation undergoing an upgrade	The Snells Beach BESS has deferred this project
Matakana – 11 kV feeder reinforcement	Security of supply to the Matakana town will be compromised	A new express circuit from Warkworth zone substation will be installed	Omaha zone substation will defer this project.
Warkworth South zone substation	Growth in the north will accelerate as the Puhoi-Warkworth motorway nears completion. Warkworth zone substation is already at capacity	A new zone substation will be constructed on an existing site. 33 kV cable is already laid	This project is deferred by the Warkworth South and Snells Beach BESS, Omaha zone substation, and the Snells Beach upgrade
Warkworth - Wellsford motorway ducts	The Warkworth-Wellsford subtransmission circuits will reach firm capacity and will require reinforcement. The proposed Warkworth-Te Hana motorway will provide an opportunity to lay ducts at a reduced cost	Ducts will be laid alongside part of the motorway corridor with the roading project	Access to new corridors will be effectively impossible once the works are complete
Wellsford-Warkworth - 33 kV upgrade stage 2	The Warkworth-Wellsford subtransmission circuits will reach firm capacity and will require reinforcement	Upgrade the conductor size on the existing poles to increase the capacity of the circuits	Upgrading the conductor will increase the circuit capacity and defer the need for cables in the Warkworth - Te Hana motorway
Wellsford GXP - Wellsford 33 kV upgrade	The circuits supplying Vector's network from Transpower's Wellsford GXP will reach firm capacity at peak demand in 2027.	New subtransmission circuits will be installed	This project is deferred by the Warkworth South and Snells Beach BESS
Tawharanui - 11 kV feeder reinforcement	Omaha and Snells Beach feeders will experience backstop shortfall	An 11 kV cable will improve security of supply for both zone substations	

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Snells Beach - BESS	0.30										0.30
Tapora micro grid	1.40										1.40
Wellsford-Warkworth 33 kV upgrade stage 1	0.10										0.10
Omaha zone substation	0.20	2.50									2.70

Sandspit Road – 11 kV feeder reinforcement	0.85	0.85									1.70
Snells Beach - transformer upgrade			0.10	1.00							1.10
SH1 Dome Valley future proof ducts				0.20	2.20						2.40
Matakana express 11 kV feeder						2.00					2.00
Warkworth South zone substation							0.10	4.40	4.40		8.90
Warkworth-Wellsford motorway ducts								3.50	3.50	3.50	10.50
Wellsford-Warkworth 33 kV upgrade stage 2								3.50			3.50
Wellsford GXP - Wellsford 33 kV upgrade								2.50	2.50		5.00
Tawharanui 11 kV reinforcement									2.50		2.50
Total	**2.85**	**3.35**	**0.10**	**1.20**	**2.20**	**2.00**	**0.10**	**13.90**	**12.90**	**3.50**	**42.10**

5.1.2 SILVERDALE – OREWA

This area covers the area surrounding Silverdale including Orewa, Whangaparoa and west towards Kaukapakapa and Helensville.

Significant greenfields residential growth is occurring west of Orewa towards Millwater and Wainui. To accommodate the additional demand two projects are proposed. The first is an 11 kV switchboard upgrade at Orewa zone substation to remove an existing local capacity constraint, limiting the overall capacity of this zone substation. This project is under construction.

The second project is the construction of Millwater zone substation, initially comprising a single transformer/BESS configuration in its early stages. The zone substation site is adjacent to SH1 and will supply the residential load on both sides of the motorway once constructed.

Spur Road zone substation south of Silverdale, supplies a mix of rural and commercial areas. This is a single transformer zone substation and forecast demand has increased sufficiently to initiate a capacity reinforcement. A second transformer is proposed.

Helensville zone substation to the west of Spur Road supplies a large distribution area. Growth on this zone substation is forecast to exceed the security levels currently constrained by the capacity of the existing transformers. The proposed solution is to upgrade the existing transformers to larger capacity units. Towards the end of the planning period a new zone substation at Kaukapakapa is forecast. This zone substation will supplement the security of supply to Helensville, and east towards Wainui and Millwater.

Glenvar Road runs down the ridgeline from East Coast Road (SH25) to the coast at Torbay. Long Bay is a relatively new residential development to the north of Torbay. This development is expected to extend north to the Okura River and inland towards East Coast Road. The added growth will impose security constraints on the adjacent Torbay zone substation. Torbay is a single transformer zone substations situated on the coast, as is the neighbouring zone substation of Waiake to the south. Because of their location near the coast, their distribution area is limited preventing delivery of the benefits that may result by increasing their capacity. The proposed solution is to situate a new zone substation (Glenvar zone substation) close to East Coast Road in the centre of the future residential development. This zone substation will support Torbay, Waiake and East Coast Road zone substations. In the interim, capacity in this area will be increased by reinforcing the existing 11 kV feeder from East Coast Road zone substation.

We have been implementing a micro grid solution at Tapora near Wellsford. Its purpose is to reduce the outage time seen by customers who live near the end of long 11 kV feeders. The project is still to commence construction but based on the success of this project, the solution may be replicated at other similar locations throughout the network. South Head and Kaukapakapa suffer regular outages due to the length of the 11 kV feeders and the length of time taken to patrol them when a fault occurs. We have included a project to explore an off-grid solution for both the South Head and Kaukapakapa feeders.

Three 11 kV feeder reinforcement projects are planned to maintain network security. These are reinforcements at Gulf Harbour on the Whangaparoa Peninsula, improved 11 kV connection between Manly zone substation and Orewa and a new feeder from Orewa zone substation towards Spur Road zone substation to improve the connectivity and security of both zone substations.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Orewa - 11 kV switchboard upgrade	The capacity of Orewa zone substation is constrained by the switchgear rating	11 kV switchboard upgrade	Project in progress
Spur Road - second 33 kV/11 kV transformer	The capacity of the single-transformer Spur Road zone substation will shortly be exceeded at peak demand, and growth of 13 MVA is expected over the next ten years	Replace the existing transformer and install a second transformer. Both transformers will be rated for 20 MVA. The displaced 12.5 MVA transformer will be used elsewhere on the network.	There is no feasible alternative to increased transformer capacity for load increases of this size at this point. However, options are being actively investigated and if adopted could change or defer the proposed project
Helensville - upgrade 33 kV/11 kV transformer	The transformers at Helensville zone substation are heavily loaded, with residential growth of 8 MVA in the next decade forecast	The existing 2 x 15 MVA transformers will be replaced with 2 x 20 MVA units. One is being replaced for life-cycle reasons and funded from the asset replacement budget. This project provides budget to replace the second transformer.	This project will defer Kaukapakapa zone substation
Gulf Harbour - 11 kV feeder reinforcement	The Gulf Harbour zone substation will have a backstop capacity shortfall	An 11 kV cable from Manly zone substation will allow load transfer and improve security of supply for both zone substations	
Glenvar zone substation	Developments in Long Bay and Brown Bay will compromise security of supply	A new zone substation will be constructed on an existing site	Upgrading Torbay zone substation is an option but its location results is a constrained distribution area. This will initiate the early construction of Glenvar zone substation, stranding the investment made in Torbay. This solution is not an efficient use of

			capital. A better solution is the one proposed
Millwater zone substation	Over 7000 new dwellings are in planning or already built in Silverdale (Millwater and Wainui). The capacity of the existing network needs to be increased.	A new zone substation will be constructed on an existing site	There is no feasible alternative to increased transformer capacity for load increases of this size at this point. However, options are being actively investigated and if adopted could change, or defer the proposed project
Hibiscus Coast - 11 kV feeder reinforcement	Red Beach and Orewa zone substations have backstop limitations on the seaward side of their network areas	A new cable between the zone substations will improve security of supply for both zone substations	
South Head micro grid	To reduce the outage time experienced by customers at the end of these long 11 kV feeders. All faults on this feeder are experienced by these customers	Establish a limited capacity micro grid to allow continuity of micro grid supply following a network outage	Replicate the 11 kV feeder which is prohibitively costly.
Kaukapakapa zone substation	Residential growth in Helensville and Kaukapakapa will result in the Helensville zone substation being overloaded and security of supply eroded. There are reliability problems in the large rural area supplied by Helensville	A new zone substation will be constructed on an existing site. This will address reliability as well as capacity and security breaches	The Helensville transformer upgrade will defer this project
Orewa - 11 kV feeder reinforcement	Orewa and Spur Road feeders will experience backstop shortfall	An 11 kV cable will improve security of supply for both zone substations	
Dairy Flat - land purchase	The Dairy Flat district will be developed in the future, and increased capacity in the area will be needed	Secure land for a zone substation to enable designation/consenting to be obtained ahead of zone substation construction	

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Orewa – 11 kV switchboard upgrade	2.63	1.75									4.38
Spur Road - Second 33 kV/11 kV transformer	3.00	3.33									6.33
Helensville - upgrade 33 kV/11 kV transformer		1.50									1.50
Kaukapakapa Micro grid		2.00	2.00								4.00
Gulf Harbour - 11 kV reinforcement				3.20							3.20

Glenvar zone substation				1.00	3.10	4.00					8.10
Millwater zone substation				1.00	3.39	3.39					7.78
Hibiscus Coast - 11 kV reinforcement							2.00				2.00
South Head Micro grid							2.00	2.00			4.00
Kaukapakapa zone substation								1.00	2.50	2.50	6.00
Orewa - 11 kV reinforcement									1.50		1.50
Dairy Flat - Land Purchase										1.50	1.50
Total	**5.63**	**8.58**	**2.00**	**5.20**	**6.49**	**7.39**	**4.00**	**3.00**	**4.00**	**4.00**	**50.29**

5.1.3 ALBANY

The Albany area has been classified as the area from Browns Bay, south to Forrest Hill.

This area is predominantly well established but pockets of greenfields and infill development are creating demand growth and compromising the security of existing zone substations nearing capacity. No new zone substations are planned in this area within the next ten years although capacity increases are proposed at Coatesville and Rosedale with second transformers, and zone substation transformer upgrades at Forrest Hill, Sunset Road and James Street zone substations

Cable ducts will be installed at the new interchange at the intersection of Constellation Dr and SH1 in conjunction with New Zealand Transport Agency works. This is to ensure continued access to our transmission corridor after the interchange is completed. This project is at an advanced design stage.

Feeder reinforcement projects are planned for East Coast Road zone substation to both relieve existing capacity constraints, and improve the 11 kV security to Rosedale zone substation, the Kewa Road 11 kV feeder, and the Paremoremo 11 kV feeder.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Rosedale – second 33 kV/11 kV transformer	Commercial load increases in the Rosedale Road area are leading to network security constraints at Rosedale s zone substation	Install a second transformer at Rosedale zone substation	This project is currently under construction
East Coast Road - 11 kV feeder reinforcement	Two East Coast Road feeders are at capacity, limited by the conductor size	The limiting sections will be reconductored	
Northern Corridor Improvements - 33 kV futureproof ducts	Major roading works are underway where SH18 meets SH1 at Unsworth Heights. Vector's assets require relocation.	Future-proofing ducts will be laid as part of this project.	Access to new corridors will be effectively impossible once the New Zealand Transport Agency works are completed.

Coatesville - second 33 kV/11 kV transformer	Residential development means the capacity of the single-transformer Coatesville zone substation will shortly be exceeded	A second transformer will be installed, from another zone substation undergoing an upgrade	Coatesville already has multiple subtransmission circuits and a 33 kV switchroom with spare breaker, so a second transformer is the most efficient option
Kaukapakapa Micro grid	To reduce the outage time experienced by customers at the end of these long 11 kV feeders. All faults on this feeder are experienced by these customers	Establish a limited capacity micro grid to allow continuity of micro grid supply following a network outage	Replicate the 11 kV feeder which is prohibitively costly.
Kewa Road – 11 kV feeder reinforcement	Residential developments in Albany Heights will exceed the load which is acceptable on a spur circuit	A second circuit will be extended to Kewa Road across the motorway bridge from Fairview Heights	This will also improve network connectivity in north Albany
Sunset Road - upgrade 33 kV/11 kV transformers	The transformers at Sunset Road zone substation are heavily loaded, with an extra 8 MVA forecast over the next decade	The 12.5 MVA transformers will be replaced by 20 MVA units	The adjacent zone substations are also capacity constrained
Rosedale - East Coast Road - 11 kV feeder reinforcement	East Coast Road zone substation will experience backstop shortfall	An 11 kV cable connection between these zone substations will improve security of supply for both.	
Piha Micro grid	To reduce the outage time experienced by customers at the end of these long 11 kV feeders. Because of the radial nature of these feeders all faults on the feeder are experienced by these customers	Establish a limited capacity micro grid to allow continuity of micro grid supply following a network outage	Replicate the 11 kV feeder would be prohibitively costly.
Forrest Hill - upgrade 33 kV/11 kV transformers	Demand on Forrest Hill zone substation will exceed firm capacity in 2027 and is forecasted to grow by 6 MVA in the next ten years	The 12.5 MVA T1 transformer will be replaced by a 20 MVA unit.	To defer an upgrade to the adjacent Milford zone substation, this project will take place by 2025
James Street - upgrade 33 kV/11 kV transformers	The transformers at James Street zone substation are heavily loaded, with 10 MVA growth forecast over the next ten years	The 12.5 MVA transformers will be replaced by a 20 MVA unit	This project defers upgrades to Birkdale and Wairau Road zone substation
Paremoremo – 11 kV feeder reinforcement	There will be insufficient backstop capacity in both the Paremoremo and west Greenhithe areas	A submarine cable will be installed between the two networks	

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Rosedale – second 33 kV/11 kV transformer	1.20										1.20
East Coast Road - 11 kV feeder reinforcement	0.95										0.95
Northern Corridor Improvements 33 kV futureproof ducts	0.15	0.15									0.30
Coatesville - Second 33 kV/11 kV transformer		1.25									1.25
Kewa Road – 11 kV feeder reinforcement			0.50								0.50
Sunset Road – transformer upgrade			0.20	2.20							2.40
Rosedale-East Coast Road - 11 kV feeder reinforcement				0.50	1.00						1.50
Forrest Hill - transformer upgrade						0.20	2.20				2.40
James Street - upgrade 33 kV/11 kV transformers							0.20	2.20			2.40
Paremoremo – 11 kV feeder reinforcement										1.50	1.50
Total	2.30	1.40	0.70	2.70	1.00	0.20	2.40	2.20	0.00	1.50	14.40

5.1.4 NORTH SHORE

From a distribution planning perspective, North Shore is the area south of Bayview and Forrest Hill, including Greenhithe, Milford, and Takapuna to Devonport.

Takapuna City is supplied from a single transformer zone substation. Growth comprising mainly infills and apartments in Takapuna, and a mix of infills and greenfield developments in the surrounding areas of Milford, Greenhithe and Highbury, have initiated reinforcement projects at these zone substations. Like Takapuna, Highbury, Hauraki, Greenhithe and Milford are single transformer zone substations and, to meet both growth forecasts and maintain network security, a second transformer is proposed for each. Wairau Road and Belmont are both dual transformer zone substations and the proposed solution is to upgrade these zone substations with larger capacity transformers.

Currently the two Belmont 33 kV subtransmission lines from Takapuna zone substation supplying Belmont, Hauraki and Ngataringa Bay zone substations, share the common poles and towers. Due to the close separation of the two circuits, repairs on one circuit will require an outage on the other circuit for safety. The limited capacity of the backup circuits and the load on these three zone substations results in a small window of time when both subtransmission circuits can be out-of-service together without loss of supply to customers. The installation of the second transformer at Takapuna also include a second 33 kV supply (from Wairau) to this zone substation to increase the backup capacity to Belmont, Ngataringa Bay and Hauraki zone substations.

11 kV feeder reinforcements are proposed at Greenhithe, Ngataringa Bay, Milford and Wairau zone substations.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Takapuna - second 33 kV/11 kV transformer	Backstop capacity for the single-transformer Takapuna zone substation is already exceeded at peak demand, compromising security of supply for the North Shore CBD	A second transformer will be installed, with extensions to 33 kV and 11 kV switchboards	Significant infill development is expected in Takapuna
Highbury - second 33 kV/11 kV transformer	Backstop capacity for the single-transformer Highbury zone substation is decreasing, compromising security of supply. The transformer capacity will also be exceeded in the near future as 7 MVA of new load is forecast in the next decade	A second transformer will be installed, along with a subtransmission cable and 33 kV switchroom	This project defers an upgrade to Birkdale zone substation, and enables continued backstop support to the single-transformer Northcote and Balmain zone substations 2025-2026
Greenhithe Bridge – 11 kV cable	Lack of backfeed capability between Hobsonville Point and Greenhithe zone substations	Install an 11 kV cable across the Greenhithe Bridge	An under-harbour cable is a more expensive option Separating reinforcement projects for Greenhithe and Hobsonville Point will result in higher costs over the proposed project
Ngataringa Bay - 11 kV feeder reinforcement	Backstop capacity for Ngataringa Bay zone substation will shortly be exceeded	An 11 kV cable will allow load transfer and improve security of supply between Belmont and Ngataringa Bay	
Greenhithe – Bush Road 11 kV feeder reinforcement	Bush Road zone substation and a Greenhithe feeder will experience backstop shortfall	An 11 kV cable will improve security of supply for both zone substations	This project will be coordinated with a Watercare pipeline project to reduce costs and minimise disruption

Wairau - upgrade 33 kV/11 kV transformers	The electrical demand of the Wairau Valley industrial zone is expected to grow by 6 MVA by 2028. The Wairau zone substation firm capacity is already exceeded and backstop capacity will be exceeded	The 16 MVA transformers will be replaced by 20 MVA units	The adjacent zone substations are also capacity constrained, and significant 11 kV investment would be required to transfer load
Milford - 11 kV feeder reinforcement	The capacity of the single-transformer Milford zone substation will be exceeded at peak demand, and backstop capacity will also be insufficient	An 11 kV express cable from Forrest Hill will allow load transfer and will improve security of supply for both zone substations	The Forrest Hill upgrade and this project defer the need for a second transformer and 33 kV cable for Milford
Hauraki – second 33 kV/11 kV transformer	Backstop capacity for the single-transformer Highbury zone substation is decreasing, compromising security of supply. The transformer capacity will also be exceeded by 2025 as 5 MVA of new load is forecast in the next decade	A second transformer (20 MVA) will be installed, along with a 33 kV switchroom	Alternatives to increased transformer capacity are being actively investigated and if adopted could change, defer or cancel forecast projects
Belmont - upgrade 33 kV/11 kV transformers	Demand on Belmont zone substation will exceed firm capacity in 2019 and is forecasted to grow by 6 MVA in the next decade. While there is sufficient backstop capacity from adjacent zone substations, the transformers will become overloaded	The 12.5 MVA transformers will be replaced by 20 MVA units	11 kV reinforcement to allow load transfer to adjacent zone substations is possible, but these are also capacity constrained
Hillcrest - 11 kV feeder reinforcement	The Hillcrest zone substation transformers are forecast to be overloaded by 2027	A new 11 kV cable from Northcote zone substation will allow load transfer	
Greenhithe - second 33 kV/11 kV transformer	Backstop capacity for the single-transformer Greenhithe zone substation is decreasing, compromising security of supply	A second 20 MVA transformer will be installed	The Greenhithe Bridge cable will defer this project
Wairau - 11 kV feeder reinforcement	The electrical demand of the Wairau Valley industrial zone is expected to grow by 6 MVA by 2028. A zone substation upgrade will provide transformer capacity, but the 11 kV network will also require reinforcement to maintain capacity and security of supply	11 kV cables load transfer and improve backstop connections to James Street, Sunset Road and Forrest Hill zone substations	

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Takapuna - second 33 kV/11 kV transformer	2.70	5.10									7.80
Highbury - second 33 kV/11 kV transformer	0.20	4.17									4.37
Greenhithe Bridge - 11 kV feeder reinforcement	1.00	1.00									2.00
Ngataringa Bay – 11 kV feeder reinforcement			1.20								1.20
Greenhithe-Bush Road - 11 kV feeder reinforcement			1.00	1.00							2.00
Wairau Road – transformer upgrade						0.20	2.20				2.40
Milford - 11 kV feeder reinforcement							1.20				1.20
Hauraki – second 33 kV/11 kV transformer							1.80				1.80
Belmont – transformer upgrade								0.20	2.20		2.40
Hillcrest - 11 kV feeder reinforcement								1.00	1.00		2.00
Greenhithe - second 33 kV/11 kV transformer									0.20	2.20	2.40
Wairau - 11 kV feeder reinforcement										1.50	1.50
Total	3.90	10.27	2.20	1.00	0.00	0.20	5.20	1.20	3.40	3.70	31.07

5.1.5 WESTGATE TO WAIMAUKU

This area extends from Greenhithe in the east to Waimauku in the west and includes the growth areas of Hobsonville, Whenuapai, Red Hills and Riverhead.

The wider Hobsonville, Westgate, and Red Hills areas at the western end of the North-Western motorway comprises rural land zoned for residential development. Projects recently completed are the Westgate zone substation installed to supply the commercial growth associated with the Westgate Shopping Centre and provide capacity for the early stages of the Red Hills residential development to the west, and the Hobsonville Point zone substation which is currently under construction. Once completed this zone substation will comprise a combination of a single transformer, a BESS and the option for a second (mobile spare) transformer to be rapidly redeployed if required, to deliver capacity for the next stage of the Hobsonville Point development.

Waimauku zone substation, on the western side of Kumeu, has transformer capacity but lacks subtransmission security, as it is supplied by a single, long subtransmission line through rural land. A second subtransmission line is proposed with a 33 kV switchboard at Waimauku zone substation to allow this zone substation to be meshed with Helensville and ultimately Kumeu zone substations.

Land purchases are proposed to enable sites to be secured for future zone substations in the greenfields growth areas. Those areas identified in this AMP are Whenuapai, Brighams Creek, Red Hills and Kumeu.

To support future growth, new zone substations have been identified for the Red Hills and Hobsonville developments. The Red Hills development extends west from Westgate, whereas the Hobsonville development comprises the greenfields area between Westgate and Hobsonville Point, northwards towards and including Whenuapai. Both sites will be established as new zone substations comprising a single transformer/BESS combination like that proposed for the Hobsonville Point zone substation.

To support the additional growth forecast for the Red Hills/Westgate areas, a new subtransmission cable from Henderson GXP is proposed. This will utilise the existing ducts installed along SH16 as part of the New Zealand Transport Authority motorway widening project.

Riverhead zone substation is forecast to exceed security levels. A project has been included to upgrade the existing transformers to 20 MVA units.

As part of the Hobsonville development additional 11 kV capacity will be needed in Northside Drive to support the commercial development at Westgate. In due course these new cables will extend beyond Westgate and into the Red Hills area to provide early capacity to this development

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Hobsonville Point zone substation	This project was initiated to address greenfields growth at Hobsonville, Hobsonville Point and Scotts Point	A zone substation comprising a zone transformer and BESS	Completion of project in progress (FY19)
Red Hills - land purchase	See Red Hills zone substation below	Secure land for a zone substation to enable designation/consenting to be obtained ahead of zone substation construction	
Waimauku - second 33 kV circuit	The Waimauku zone substation has two transformers and a single subtransmission cable, leaving the site on N security. The backstop capacity is already exceeded	The transformers will be replaced by larger units, and a 33 kV cable and switchroom installed to provide N-1 security for the growing Huapai/Kumeu district. A new 11 kV cable into Kumeu will also be installed	The cable ducts will be installed as part of New Zealand Transport Agency road widening on SH16. Staged reinforcement will see upgrades at Waimauku, Riverhead, and finally a new zone substation at Kumeu
SH18 future-proofing ducts - Hobsonville Point	New Zealand Transport Agency works on SH18 provide an opportunity to install ducts at reduced cost	Future-proof ducts will be laid	Access to new corridors will be effectively impossible once the New Zealand Transport Agency works are completed
Northside Drive - 11 kV cable upgrade - stage 1	Growth in the Westgate-Red Hills-Whenuapai-Hobsonville area	An 11 kV cable will be laid in the western end of Northside Drive	This project will be coordinated with a motorway crossing bridge

	requires extension of the 11 kV network for capacity and security of supply		project to reduce costs and minimise disruption
Northside Drive – 11 kV cable upgrade - stage 2	Growth in the Westgate-Red Hills-Whenuapai-Hobsonville area requires extension of the 11 kV network for capacity and security of supply	An 11 kV cable will be laid in the eastern end of Northside Drive	This project will be coordinated with road works to reduce costs and minimise disruption
Kumeu - land purchase	Kumeu/Huapai area is supplied from Riverhead and Waimauku zone substations. Forecast growth will necessitate a new zone substation in this area in the future	Secure land for a zone substation to enable designation/consenting to be obtained ahead of zone substation construction	Riverhead and Waimauku zone substations will be upgraded, but the capacity required will eventually necessitate a new zone substation
Whenuapai - land purchase	The Westgate-Red Hills-Whenuapai-Hobsonville area is one of the largest development zones in the Auckland Unitary Plan. New zone substations at Red Hills and Whenuapai will provide for demand growth in the next decade	A suitable site will be acquired in Whenuapai	
Red Hills zone substation	The Westgate-Red Hills-Whenuapai-Hobsonville area is one of the largest development zones in the Auckland Unitary Plan. Red Hills is the next district to be developed, and the existing network capacity is insufficient	A new zone substation and subtransmission cables will be installed	There is no feasible alternative to a new zone substation for load increases of this size at this point. However, options are being actively investigated and if adopted could change, defer or cancel this proposed project
Westgate To Henderson - 33 kV cable	The Westgate-Red Hills-Whenuapai-Hobsonville area is one of the largest development zones in the Auckland Unitary Plan. The 33 kV supply into this area is via two Hobsonville and one Westgate circuit. The capacity of these circuits will be exceeded by 2026	A new cable will be installed in the ducts currently being installed as part of New Zealand Transport Agency's Lincoln-Westgate motorway widening	This project is deferred by the Hobsonville Point BESS. A second cable will be required in the future
Riverhead - 33 kV/11 kV transformer upgrade	Kumeu/Huapai area is supplied from Riverhead and Waimauku zone substations. Forecast growth will exceed the network capacity in this area	The transformers will be replaced by 20 MVA units and a 33 kV switchroom installed	Staged reinforcement will see upgrades at Waimauku, Riverhead, and finally a new zone substation at Kumeu
Brighams Creek – land purchase	The Westgate-Red Hills-Whenuapai-Hobsonville area is one of the largest development zones in the Auckland Unitary Plan. New zone substations at Red Hills and Whenuapai will provide for demand growth in the next decade, but a third zone substation may be needed in the longer term	Secure land for a zone substation to enable designation/consenting to be obtained ahead of zone substation construction	
Whenuapai zone substation	The Westgate-Red Hills-Whenuapai-Hobsonville area is	A new zone substation and subtransmission cables will be	There is no feasible alternative to a new zone substation for load

	one of the largest development zones in the Auckland Unitary Plan. Whenuapai will be developed in the second half of the next decade, and the existing network capacity is insufficient	installed (some expenditure is outside the AMP period)	increases of this size at this point. However, options are being actively investigated and if adopted could change or defer this proposed project

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Hobsonville Point zone substation	7.00	2.00									9.00
Red Hills land purchase	1.50										1.50
Waimauku second 33 kV circuit	0.60	0.01	3.00	3.40							7.01
SH18 future-proofing ducts - Hobsonville Point	0.03	0.25									0.28
Northside Drive – 11 kV cable upgrade - stage 1		0.19									0.19
Northside Drive – 11 kV cable upgrade - stage 2			0.19								0.19
Kumeu - land purchase			1.50								1.50
Whenuapai - land purchase				1.50							1.50
Red Hills zone substation				3.79	11.93						15.72
Westgate To Henderson – 33 kV cable								1.23			1.23
Riverhead – 33 kV/11 kV transformer upgrade								1.07	2.36		3.43
Brighams Creek – land purchase									1.50		1.50
Whenuapai zone substation										4.54	4.54
Total	9.13	2.45	4.69	8.69	11.93	0.00	0.00	2.30	3.86	4.54	47.59

5.1.6 WEST AUCKLAND

West Auckland comprises the area to the south of Westgate to New Lynn and includes Te Atatu, Glendene and the Henderson Valley.

New Lynn has been included in the Auckland Council's transformation programme as an area for revitalisation and growth. Upgrading the existing transformers at New Lynn zone substation and installing a second transformer at Brickworks zone substation will accommodate this growth.

The demand forecast has indicated that Sabulite, Triangle Road, Te Atatu and Henderson zone substations will exceed their security limits, currently constrained by transformer capacity, within the next ten years. Larger capacity transformers are proposed for these sites as the solution. Waikaukau and Woodford Road zone substations will be upgraded with the addition of a second transformer.

Keeling Road zone substation has two 20 MVA transfomers installed but is supplied from a single subtransmission circuit. A second subtransmission circuit will be installed to improve the security of the zone substation.

An off-grid micro grid projects is planned for Piha to reduce the outage times for customers at Piha following a feeder fault.

11 kV feeder projects are proposed for Brickworks zone substation with reinforcement of the Clark Street feeder, McLeod Road to reinforce the Carhaven feeder, and the Lincoln Road feeder from Woodford Road feeder to ensure ongoing network security is maintained. An 11 kV feeder reinforcement is proposed from Simpson Road zone substation to ensure ongoing network security.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Clark Street - 11 kV feeder reinforcement	A Brickworks feeder is at capacity	An 11 kV cable will enable load transfer to another feeder	
McLeod Road – 11 kV feeder reinforcement	The Carhaven feeder has insufficient backstop capacity, so that load on the single-transformer McLeod Road zone substation cannot be fully restored after an outage	An 11 kV express cable between Keeling Road and McLeod Road zone substations will improve security of supply for both zone substations, as well as the Carhaven feeder	This project defers the need for a second transformer and 33 kV switchroom at McLeod Road zone substation, and defers the Keeling Road second 33 kV supply project
Sabulite Road - upgrade 33 kV/11 kV transformers	The transformers at Sabulite Road zone substation are heavily loaded, with significant growth forecast	The transformers will be replaced by larger units	Five neighbouring zone substations are forecasted to reach capacity over the next ten years. This project will add transformer capacity and defer upgrades to Henderson Valley, Keeling Road, Simpson Road and Waikaukau zone substations
Lincoln Road - 11 kV feeder reinforcement	Peak demand on a Woodford feeder will exceed capacity	11 kV cables in Lincoln Road will allow load transfer, and improve security of supply for Woodford, Te Atatu and Triangle Road zone substations	This project will be coordinated with road widening works to reduce costs and minimise disruption
Simpson Road - 11 kV feeder reinforcement	A Simpson Road feeder will experience backstop shortfall	11 kV cables will allow load transfer and improve backstop connections	This project defers a second transformer at Simpson Road
Te Atatu - upgrade 33 kV/11 kV transformers	The transformers at Te Atatu zone substation are heavily loaded, with 9 MVA growth forecast over the next ten years. Backstop capacity will also be exceeded later in the decade	The transformers will be replaced by larger units	The adjacent zone substations are also capacity constrained
Henderson - upgrade 33 kV/11 kV transformers	The transformers at Henderson Valley zone substation are heavily loaded, with significant industrial	The transformers will be replaced by larger units	Five neighbouring zone substations are forecasted to reach capacity over the next ten years. This project will add

	growth forecast (10 MVA in ten years)		transformer capacity and defer upgrades to Keeling Road, Simpson Road and Waikaukau zone substations. The Sabulite Road upgrade will defer this project
Brickworks - second 33 kV/11 kV transformer	A major commercial development will exceed the capacity of the single-transformer Brickworks zone substation	A second transformer will be installed, along with a second subtransmission cable from New Lynn	New Lynn zone substation on one side does not have spare capacity, and on the other side is the Roskill 22 kV subtransmission area, limiting backstop opportunities
Triangle Road - upgrade 33 kV/11 kV transformers	The transformers at Henderson Valley zone substation are heavily loaded, with significant industrial growth forecast (10 MVA in ten years)	The 10 MVA transformers will be replaced by 20 MVA units	There is no feasible alternative to increased transformer capacity for load increases of this size at this point. However, options are being actively investigated and if adopted could change or defer the proposed project
Waikaukau - second 33 kV/11 kV transformer	The capacity of the single-transformer Waikaukau zone substation will be exceeded at peak demand	A second transformer will be installed (15 MVA)	
Woodford Road - second 33 kV/11 kV transformer	Backstop capacity for the single-transformer Woodford zone substation is already exceeded at peak demand, compromising security of supply to the district including Waitakere Hospital	A second transformer (20 MVA) will be installed	The Keeling Road project will have provided a 33 kV switchroom and second cable for Woodford
Keeling Road - second 33 kV subtransmission circuit	The Keeling Road zone substation has two transformers and a single subtransmission cable, leaving the site on N security. The backstop capacity is forecast to be exceeded in 2027.	A 33 kV cable will be installed from Woodford zone substation, enabling N-1 security. A new 33 kV switchroom will be built at Woodford to connect the cable.	

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Clark Street - 11 kV reinforcement	0.30										0.30
McLeod Road – 11 kV reinforcement	1.20										1.20
Sabulite Road - upgrade 33 kV/11 kV transformers		0.20	2.20								2.40
Lincoln Road - 11 kV feeder reinforcement			0.80								0.80
Piha Micro grid				2.00	2.00						4.00

Simpson Road - 11 kV feeder reinforcement					1.00						1.00
Te Atatu - upgrade 33 kV/11 kV transformers					0.20	2.20					2.40
Henderson - upgrade 33 kV/11 kV transformers						0.20	2.20				2.40
Brickworks - second 33 kV/11 kV transformer						1.46	1.96				3.42
Triangle Road - upgrade 33 kV/11 kV transformers							0.20	2.20			2.40
Waikaukau - second 33 kV/11 kV transformer							0.10	1.00			1.10
Woodford - second 33 kV/11 kV TX New									1.00	6.20	7.20
Keeling Road - second 33 kV subtransmission circuit									2.00	3.43	5.43
Total	1.50	0.20	3.00	2.00	3.20	3.86	4.46	3.20	3.00	9.63	34.05

5.1.7 ROSEBANK TO CBD

This area covers Rosebank to the CBD and includes Avondale, Chevalier, Kingsland, and Ponsonby through to Freemans Bay. The area is largely reticulated with growth expected from re-development and infill.

Housing New Zealand have proposed housing intensification programmes for Avondale, Mount Roskill, Mount Albert and Onehunga. Except for Avondale where an 11 kV feeder reinforcement is required none of the other identified areas require distribution or subtransmission reinforcement at this time.

In addition to the Avondale feeder, 11 kV distribution reinforcements have been identified at Freemans Bay, Kingsland and Rosebank.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Freemans Bay - 11 kV feeder reinforcement	Security constraints have been forecast on Freemans Bay feeders K13, K15 and K19 from 2027	Install a new 11 kV feeder and rearrange the 11 kV network	This project is scheduled for implementation towards the end of the planning period. We will explore other network and customer options closer to project execution

Avondale - 11 kV feeder reinforcement	Capacity and security constraints in are forecast on Avondale feeders K01, K02 and K05 from 2028	Install two new 11 kV feeders and rearrange the 11 kV network	This project is scheduled for implementation towards the end of the planning period. We will explore other network and customer options closer to project execution
Kingsland - 11 kV feeder reinforcement	Security constraints have been forecast on Kingsland feeders K05 and K20 from 2028	Install a new 11 kV feeder and rearrange the 11 kV network	This project is scheduled for implementation towards the end of the planning period. We will explore other network and customer options closer to project execution
Rosebank - 11 kV feeder reinforcement	Security constraints have been forecast on Rosebank feeder K02 from 2028	Install a new 11 kV feeder and rearrange the 11 kV network	This project is scheduled for implementation towards the end of the planning period. We will explore other network and customer options closer to project execution

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Avondale - 11 kV feeder reinforcement									2.00		2.00
Kingsland - 11 kV feeder reinforcement										2.00	2.00
Freemans Bay - 11 kV feeder reinforcement										2.00	2.00
Rosebank - 11 kV feeder reinforcement										2.00	2.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	6.00	8.00

5.1.8 CBD

The Auckland CBD covers the area bounded by the Northern Motorway SH1 towards the Harbour Bridge, the extension of SH16 down Grafton Gully and the Waterfront. The area is served by three primary zone substations, namely Liverpool, Hobson and Quay.

Since 2004 new distribution feeders installed in the CBD have been 22 kV rated. With restricted space to install cables, increasing the voltage from 11 kV to 22 kV doubles the network distribution capacity for a similar installed cost. An ongoing programme included in this AMP allows expanded 22 kV cable coverage within the CBD to enable new customer connections and distribution zone substation upgrades connection to the 22 kV network. Over time the 11 kV network will be retired and replaced with the 22 kV network.

Quay zone substation is supplied by a single 110 kV cable but supported by a 22 kV connection to Hobson zone substation. The N-2 security limit of Quay zone substation is 40 MVA. However, the peak load on Quay zone substation in 2018 was 42 MVA, exceeding the 40 MVA threshold for 8 hours during the year. The proposed solution is to install a 110 kV cable between Hobson 110 kV switchboard, in pre-existing ducts along Quay Street to Quay zone substation. The cable will be terminated on an existing 110 kV/22 kV transformer already located at Quay zone substation. This project has been planned for some time but delivery has been dependent on growth reaching security thresholds.

The focus of the major CBD projects is to maintain security of supply and manage risk. Two projects at Liverpool zone substation are proposed. The first is to replace one of the 110 kV/22 kV transformers (transformer T3) to increase the capacity from this zone substation. Currently T3 transformer is electrically mismatched with the other two transformers and restricts available 22 kV capacity. The replaced T3 transformer will be moved to Quay zone substation. The second project is to extend the 110 kV switchboard at Liverpool zone substation to allow a redistribution of the existing 110 kV circuits and operationally improve the supply of load under HILP risk scenarios.

The load forecast for Quay zone substation has confirmed the need for both additional 11 kV and 22 kV capacity, requiring a 3rd 22 kV/11 kV transformer and additional 22 kV distribution feeders. The existing 22 kV switchboard cannot be extended initiating a project to install a second 22 kV switchboard to provide the extra capacity

22 kV network modelling shows the 22 kV capacity of the two 110 kV three-winding 110 kV/22 kV/11 kV transformers at Hobson zone substation will be a constraint in the future. The 40 MVA capacity of the 22 kV winding will ultimately limit the capacity from Hobson zone substation. This constraint has been acknowledged with a project to replace one of the three-winding transformers with a larger capacity unit. Space constraints at Hobson and our ability to off-load the 11 kV load ensures that this project is not straightforward. Further analysis will be required before committing to any solution.

Two major projects have been initiated that have a significant impact on the CBD distribution network. The open-cut construction approach applied to the City Rail Link between Lower Albert and Wellesley Street's has caused major disruption to the electricity reticulation in this area. Beyond Wellesley Street, the City Rail Loop will be tunnelled to Mount Eden station, leaving surface reticulation unaffected. The second project is the proposed Light Rail Transit system. It is envisaged that this project will be similarly disruptive to existing network infrastructure.

Three 22 kV feeder projects have been included. The reticulation of the Wynyard Quarter at 22 kV is nearing completion which places this area in a sound position for the ongoing re-development. To supplement the 22 kV capacity into the Wynyard Quarter a new 22 kV feeder from Hobson zone substation is proposed. The third project is to install 22 kV reticulation on the southern side of Fanshawe Street to allow the new buildings near Victoria Park to connect to the 22 kV network.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
CBD - 22 kV network rollout	To accommodate future growth within the CBD the distribution voltage for new investment is 22 kV	This budget allows for the installation of 22 kV cables within the CBD to allow the connection of new customers, and upgrading the supply to those customers requiring increased capacity. The budget also allows the conversion of selected zone substations from 11 kV to 22 kV to facilitate the retirement of end-of-life 11 kV cables.	This is a long-term project tailored to delivering maximum utilisation of the existing 11 kV network while facilitating the connection of customers to the new 22 kV network
Hobson - Quay Street - 110 kV subtransmission cable	Based on forecast load growth in CBD, the existing sub-transmission network configuration at Hobson and Quay zone substations will result in capacity and security constraints in 2019	Install a 110 kV circuit from Hobson to Quay, in combination with the existing 110 kV circuit from Liverpool, to supply the two transformers at Quay	Upgrade the two 110 kV/22 kV/11 kV transformers and the two 22 kV/11 kV transformers. This is a higher cost option
Liverpool - 110 kV/22 kV transformer upgrade	The existing 110 kV/22 kV 60 MVA T3 transformer at	Replace T3 with a transformer matching T1 and T2	Stay as is. This option will result in capacity constraints at the

	Liverpool zone substation is a low impedance transformer. Operated in parallel with the two 75 MVA transformers results in uneven load-sharing, limiting the combined zone substation capacity. It also results in high fault level at 22 kV bus		Liverpool zone substation from 2019. Alternatively install reactors on T3 to match the impedance of T1 and T2. This is a higher cost option
Hobson - 22 kV feeder extension from Victoria Street to Fanshawe Street, CBD	New developments in Fanshawe Street. will increase the load on existing feeders beyond current capacity in 2019.	Install a new 22 kV circuit from the existing 22 kV distribution network in Victoria Street to Fanshawe Street	The alternative is to connect the new load to the existing 11 kV network resulting in a later 22 kV upgrade, at significantly higher cost
Light Rail Transit - supply reinforcement	Auckland Transport is investigating a Light Rail Transit network as a solution to traffic congestion on arterial roads out of the CBD. Light Rail Transit will take supply from Vector's 11 kV network at various locations along the route. With the additional load, there is the risk of Security of Supply breaches. Auckland Transport will determine the timeframe	Reinforce the network and install future-proofing ducts along Light Rail Transit route where appropriate	
Wynyard South - 22 kV feeder reinforcement	Auckland Council is in the process of redeveloping the Wynyard Quarter. The 22 kV network has been extended to accommodate the extra load the redevelopment will bring	Extend the 22 kV distribution network as roading alterations are commenced	This is the final stage of a multi-year project
Hobson - 22 kV feeder reinforcement – Wynyard Quarter	The redevelopment of the Wynyard Quarter is leading to extra load and the need for additional capacity in 2025.	Install a third 22 kV feeder from Hobson zone substation to the Wynyard Quarter	
Quay – second 22 kV switchboard	Forecast load growth in CBD has identified the need for additional 22 kV distribution feeders from Quay zone substation from 2021. It is impractical to extend the existing 22 kV switchboard.	Install second 22 kV switchboard at Quay zone substation	There is insufficient space to extend the existing switchboard. Further installing a second 22 kV switchboard allows outage risk to be minimised
Liverpool - 110 kV switchboard extension	The Liverpool 110 kV bus is a critical asset for the security of supply within the CBD. A review of the existing supply from this switchboard has identified shortcomings.	Extend the switchboard and rearrange the 110 kV feeders	The existing configuration of the switchboard can result in multiple transformer outages under certain HILP events. The 110 kV supply to Quay zone substation is supplied via a double-cable box arrangement due to insufficient circuit-breakers on the switchboard. Extending the existing switchboard will minimise the risk presented by these issues.
Hobson - 22 kV transformer capacity upgrade	Forecast load growth in the CBD will result in constraints on the 22 kV supply at Hobson zone	Replace one of the existing 110 kV/22 kV three-winding transformers with a two-winding	An alternative solution is to upgrade the 22 kV capacity at Quay zone substation, install

	substation from 2025. Currently the 22 kV supply comprises 2 x 40 MVA from the two 110 kV/22 kV three-winding transformers and 75 MVA from the third 110 kV/22 kV transformer (T5)	transformer matching the capacity and electrical characteristics of the existing T5 110 kV/22 kV transformer	additional 22 kV feeders between Hobson and Quay zone substations and transfer load. This is a higher cost option
Quay - third 22 kV/11 kV transformer	CBD demand forecasts have security constraints on the 11 kV supply from Quay zone substation from 2026.	Install a third 22 kV/11 kV transformer at Quay zone substation	Alternative solutions are to accelerate the 11 kV to 22 kV load transfer project within the CBD. Current 11 kV load on Quay zone substation preclude this as a solution at this time.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
CBD - 22 kV cables rollout	3.00	3.00	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	31.60
Light Rail Transit - supply reinforcement	0.10	0.10	0.50	0.50							1.20
Hobson - Quay Street- 110 kV subtransmission cable	1.50										1.50
Liverpool - 110 kV/22 kV transformer upgrade	2.00										2.00
CBD - 22 kV feeder extension - Victoria Street to Fanshawe Street	0.80										0.80
Wynyard South – 22 kV reinforcement	0.10										0.10
Liverpool - 110 kV switchboard extension			0.70	6.00							6.70
Quay – second 22 kV switchboard			2.00								2.00
Hobson – 22 kV feeder reinforcement – Waterfront						0.98	0.08				1.06
Hobson - 22 kV transformer upgrade							2.00				2.00

Quay – third 22 kV/11 kV transformer								1.50			1.50
Total	7.50	3.10	6.40	9.70	3.20	4.18	5.28	4.70	3.20	3.20	50.46

5.1.9 CBD TO ST JOHNS

This area covers the reticulation to the east of the CBD from Parnell to St Heliers including St Johns.

Two 11 kV reinforcement projects have been identified, one each at Parnell and St Johns zone substations respectively, both addressing forecast security constraints.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Parnell –11 kV feeder reinforcement	Security constraints have been forecast on Parnell 11 kV feeder K13 from 2027	Install a new 11 kV feeder and rearrange the 11 kV network	This project is scheduled for implementation towards the end of the planning period. We will explore other network and customer options closer to project execution
St Johns - 11 kV feeder reinforcement	Security constraints have been forecast on St Johns feeder K03 from 2028	Install a new 11 kV feeder and rearrange the 11 kV network	This project is scheduled for implementation towards the end of the planning period. We will explore other network and customer options closer to project execution

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Parnell –11 kV feeder reinforcement									0.61		0.61
St Johns - 11 kV feeder reinforcement										2.00	2.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	2.00	2.61

5.1.10 NEWMARKET/MOUNT ROSKILL

This area covers Newmarket south to Onehunga and Penrose.

Newmarket zone substation is on the periphery of the CBD. Newmarket's closeness to the CBD is targeted by customers who want to enjoy the benefits of the CBD without actually being in the CBD. This is increasing the load on Newmarket zone substation. A project is currently underway to transfer the Auckland Hospital from Liverpool zone substation, currently supplied from Liverpool zone substation within the CBD, to Newmarket. A second project to supply the redevelopment of the Westfield Shopping Complex at 277/309 Broadway will further increase the load on Newmarket zone substation. Additional capacity is to be added to Newmarket zone substation to accommodate this forecast growth.

The 22 kV switchroom and switchboard at Transpower Penrose needs to be replaced. This GXP supplies two zone substations, Onehunga and Westfield, and these zone substations will be upgraded to 33 kV on replacement of their subtransmission cables scheduled within the term of the current AMP. Rather than replace the switchroom with a long-term asset, the intention is to construct a switchroom with 33 kV rated switchgear that can be relocated and reused elsewhere on the network following the retirement of the 22 kV supply at Penrose. This approach ensures the full technical life of the switchroom and switchboard is gained while delivering the lowest cost solution for our customers.

The demand forecast has identified 11 kV feeder upgrades required at the Drive, Balmoral, Sandringham and White Swan zone substations to maintain security.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Penrose - 22 kV containerised switchboard	The existing building housing 22 kV switchboard at Transpower's Penrose GXP will be demolished due to the presence of asbestos. The existing 22 kV switchboard in the building will be removed. A new switchroom and switchboard needs to be installed to maintain the supply to our Onehunga and Westfield zone substations	Install a containerised 33 kV switchboard (to be owned by Vector) to replace Transpower's existing 22 kV switchboard at Penrose GXP.	The Onehunga and Westfield sub-transmission cables are due to be replaced in 2024/25. Upon their replacement, the supply to these zone substations will upgraded to 33 kV, potentially stranding the replacement switchroom and switchboard. Establishing a containerised switchroom will allow us to relocate and reuse this switchboard either as a temporary 33 kV board to facilitate switchgear replacement on our own network, as an emergency switchboard or as a permanent switchboard at one of our zone substations.
Drive - 11 kV feeder reinforcement to Alexandra Park	There is insufficient spare capacity in the existing 11 kV feeder to supply the commercial development at Alexandra Park from 2020.	Install a new 11 kV feeder from Drive zone substation.	
Newmarket zone substation expansion	The proposed Westfield redevelopment in Broadway, Newmarket and the transfer of the Auckland Hospital load to Newmarket zone substation is forecast to push Newmarket zone substation's load above its security limit	Establish a new zone substation at existing Newmarket zone substation site	Alternatively establishing a second zone substation in Newmarket remote from the existing zone substation. As land is a premium in Newmarket this is a higher cost option
Balmoral - 11 kV feeder reinforcement	Security constraints are forecast on 11 kV feeders K01 and K09 from Balmoral zone substation from 2024	Install a new 11 kV feeder from Balmoral zone substation and rearrange the 11 kV network	
Sandringham - 11 kV feeder reinforcement	Security constraints have been forecast on Sandringham feeder K14 from 2028	Install a new 11 kV feeder and rearrange the 11 kV network	
White Swan - 11 kV feeder reinforcement	Security constraints have been forecast on White Swan feeder K09 and K16 from 2028	Install a new 11 kV feeder and rearrange the 11 kV network	

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Penrose – 22 kV containerised switchboard	2.50										2.50
Drive - 11 kV feeder reinforcement to Alexandra Park		0.86									0.86
Newmarket zone substation expansion				0.16	5.00	2.50					7.66
Balmoral - 11 kV feeder reinforcement						1.50					1.50
Sandringham - 11 kV feeder reinforcement										2.00	2.00
White Swan - 11 kV feeder reinforcement										2.00	2.00
Total	2.50	0.86	0.00	0.16	5.00	4.00	0.00	0.00	0.00	4.00	16.52

5.1.11 MANGERE

Mangere covers the area to the west of SH20, north of Wiri.

Commercial growth is driving the load increase in this area, particularly that associated with the Airport. Additionally, both the Airport and Watercare have advised Vector of prospective load increases over the next decade.

Mangere West zone substation is adjacent to Watercare's Mangere treatment plant. As the treatment plant load increases, the displaced load on Mangere West zone substation will be transferred to Mangere Central zone substation. To accommodate the additional load on Mangere Central zone substation, a 3rd transformer is required. The infrastructure is in place for this upgrade including the subtransmission cable and incoming 11 kV CB. A new zone transformer needs to be installed. Longer term a new zone substation will be required in the Ihumatao area to support the ongoing commercial growth in south Mangere.

A number projects are proposed to supplement the capacity in the Mangere area including 11 kV feeder reinforcement projects at Favona Road, Westney Road, Walmsley Road and Mangere Bridge. These feeders will be supplied from Mangere Central zone substation. New 11 kV feeders are proposed from both Hans and Mangere East zone substation to maintain security of supply.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Mangere Central - 11 kV feeder reinforcement – Favona Road	Mangere Central 11 kV feeder K10 has insufficient backstop and this deficit is forecast to grow steadily over the next few years.	Reinforcement will be achieved by installing two new ring-main-units and a short section of 11 kV cable	A new feeder which is a higher cost option. This project increases the security to Mangere Central K10 feeder.
Mangere Central - 11 kV feeder reinforcement - Westney Road	Mangere Central 11 kV feeder K13 currently supplies a large residential and commercial area. This feeder is loaded to more than 90% of its rated capacity and demand is forecast to grow steadily.	Install a new feeder from Mangere Central zone substation to increase capacity in this area	Mangere Central K13 feeder is forecast to exceed capacity in summer 2019.
Mangere Central - 11 kV feeder reinforcement - Walmsley Road	Mangere Central 11 kV feeder K18 is forecast to grow due to housing intensification in the area. Reinforcement is necessary to provide sufficient backstop and maintain Vector's SoSS.	Reinforcement will be achieved by installing two new ring-main-units and a short section of 11 kV cable	A new 11 kV feeder, which is a higher cost option.
Hans - 11 kV feeder reinforcement	The 11 kV distribution network in this area requires reinforcement to provide sufficient backstop and maintain Vector's SoSS.	Reinforcement will be achieved by installing two new ring-main-units and a short section of 11 kV cable	This project increases the security to Hans K02 feeder.
Mangere Central - third 33 kV/11 kV transformer	The Mangere area is forecast to undergo major industrial, commercial, and residential development over the next 20 years.	Install a third transformer at Mangere Central zone substation to add additional capacity in the area and maintain security of supply	Third transformer at Mangere West. This is a higher cost option as the third 33 kV cable from Mangere GXP to Mangere Central is available for use on site.
Mangere - land purchase	Refer to Mangere South zone substation	Obtain land for construction of Mangere South zone substation	Refer to Mangere South zone substation
Mangere Central – 11 kV feeder reinforcement – Mangere Bridge	Mangere Bridge area is supplied by two 11 kV feeders which also backstop each other. Both these are loaded to 70% and 90% of their rated capacity and demand is forecast to grow steadily.	Cable will be laid to provide additional capacity in the area and allow load transfer from overloaded 11 kV feeders to lightly loaded feeders.	Additional capacity is required in this area due to the proposed housing intensification.
Mangere South zone substation	Large load increases are forecasted for the central and western Mangere area. These include serval major expansions of Watercare treatment plant, Auckland International Airport, and other industrial developments.	Construct a new zone substation at Mangere South. This will utilise the spare capacity in the exiting sub-transmission cables.	Third transformer at Mangere West. This option would require a new 33 kV cable from Mangere GXP and is a higher cost option.
Mangere East - 11 kV feeder reinforcement - Robertson Road	Additional capacity is needed to accommodate the growth in this area.	Install a new 11 kV cable from Mangere East zone substation to Robertson Road	The existing Mangere East K16 feeder is forecast to exceed capacity in 2028.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Mangere West - 11 kV feeder reinforcement	0.01										0.01
Mangere Central - 11 kV feeder reinforcement - Favona Road	0.50										0.50
Mangere Central - 11 kV feeder reinforcement - Westney Road	1.40										1.40
Mangere Central - 11 kV feeder reinforcement Walmsley Road	0.30										0.30
Hans - 11 kV feeder reinforcement	0.40										0.40
Mangere Central - third 33 kV/11 kV transformer		1.40									1.40
Mangere South – land purchase				1.00							1.00
Mangere Central - 11 kV feeder reinforcement - Mangere Bridge					1.60						1.60
Mangere South zone substation								1.20	8.50	2.70	12.40
Mangere East - 11 kV feeder reinforcement - Robertson Road										2.70	2.70
Total	2.61	1.40	0.00	1.00	1.60	0.00	0.00	1.20	8.50	5.40	21.71

5.1.12 FLATBUSH

Flatbush is a greenfields development in South Auckland.

Originally conceived as a development of 40,000 residents, this area has been gradually growing towards this target. A new zone substation was constructed in 2015 to meet the forecast demand. The land blocks are owned by a number of separate developers, each implementing their respective developments to their own timetables and plans. In order to connect these separate developments 11 kV feeders need to be extended in Murphys, Chapel and Ormiston Roads. Ducts are installed as roads are extended followed by the installation of cables once the subdivision reticulation advances. Road widening works in Murphys Road offers the opportunity to install ducts in anticipation of future residential development.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Flatbush - future proofing ducts - Link Road	Demand is forecast to grow steadily in the Flatbush area	Install future proofing duct under a new road project	Installation of ducts later would be at an increased cost.
Flatbush - future proofing ducts - Murphys Road	Refer to Flatbush 11 kV New Feeder – Murphys Road	Install future proofing duct under a road improvement project	Installation of ducts later would be at an increased cost.
Flatbush - future proofing ducts - Chapel Road	Refer to Flatbush 11 kV New Feeder – Chapel Road	Install future proofing ducts under a road widening project	Installation of ducts later would be at an increased cost.
Flatbush - 11 kV feeder reinforcement - Ormiston Road	Flatbush 11 kV feeder K09 is one of the fastest growing feeders. While most of the reticulation is being installed in conjunction with customer projects, a new 11 kV feeder from Flatbush zone substation needs to be extended to increase capacity and maintain security as load grows.	Install a new 11 kV cable and spare duct along Ormiston Road to provide additional capacity in the area.	Flatbush K09 is a lengthy feeder and provides backstop to Maraetai.
Flatbush - 11 kV feeder reinforcement - Chapel Road	Significant growth is expected in the Flatbush area and capacity will be insufficient.	Install new 11 kV cable from Flatbush zone substation and along Chapel Road.	Spare duct installed along Chapel Road under a separate project will be used for this new cable
Flatbush - 11 kV feeder reinforcement - Murphys Road	Developments in Flatbush are progressing rapidly. A new 11 kV feeder is required to increase the capacity in the area and to maintain security of supply as the load grows.	Install a new 11 kV cable from Flatbush zone substation to Flatbush School Road in the existing spare ducts.	Spare ducts will be available for majority of the route, reducing the overall cost of this project.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Flatbush - future proofing ducts - Link Road	0.60										0.60
Flatbush - future proofing ducts - Murphys Road		0.10									0.10
Flatbush - future proofing ducts - Chapel Road		0.20									0.20
Flatbush - 11 kV feeder			2.00								2.00

reinforcement - Ormiston Road											
Flatbush - 11 kV feeder reinforcement - Chapel Road				1.60							1.60
Flatbush - 11 kV feeder reinforcement - Murphys Road				0.70							0.70
Total	0.60	0.30	2.00	2.30	0.00	0.00	0.00	0.00	0.00	0.00	5.20

5.1.13 WIRI

Wiri is a commercial/industrial area south of Manukau City.

The greenfields area to the west of Wiri towards the airport is undergoing extensive commercial growth. Currently this area is supplied from Wiri zone substation which is forecast to reach capacity towards the middle of the next decade. A second zone substation is proposed on land owned by Vector at the intersection of SH20 and Roscommon Road.

A new 11 kV feeder project from Wiri zone substation has also been proposed.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Wiri West zone substation	Significant growth is expected in the area with the land west of McLaughlins Road being rezoned and the Wiri Quarry being developed into a commercial/industrial park. Capacity in this area will be insufficient for these developments.	Construct a new zone substation in Wiri West.	Zone substation land has already been acquired and sub-transmission cables are at the boundary of the property.
Wiri - 11 kV feeder reinforcement	The rural land west of McLaughlins Road has been rezoned and is forecast to undergo rapid and extensive urbanisation. A new 11 kV feeder is required to increase the capacity in this area.	Reconfigure existing network and install a new 11 kV cable to increase the capacity in this area	Network reconfiguration will involve splitting an existing feeder into two and adding capacity for the new greenfield area

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Wiri West zone substation				1.50	4.50	1.10					7.10
Wiri 11 kV - feeder reinforcement					1.00						1.00
Total	0.00	0.00	0.00	1.50	5.50	1.10	0.00	0.00	0.00	0.00	8.10

5.1.14 TAKANINI

The greenfields area between Takanini township and Ardmore airstrip is progressively converting rural farmland to residential urban developments. The area is served by a single zone substation in Airfield Road.

Growth forecasts indicate this zone substation will be inadequate to meet future demands as the urban development expands. A new zone substation in Takanini South has been forecast towards the end of the next decade. Staged zone substation construction is envisaged commencing with a single transformer and BESS combination, progressing to two transformers subject to load growth.

Using DERs has the advantage of slowing down the growth rate and potentially deferring investment in the new zone substation. As the new load growth is predominantly residential we will be exploring this opportunity as new customers are connecting to the network.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Takanini South - land purchase	Refer to Takanini South zone Substation	Acquire land for new zone substation	Refer to Takanini South Zone Substation
Takanini South zone substation	Takanini and Papakura area is undergoing significant development.	Construct a new zone substation at Takanini South.	Upgrade Papakura and Takanini to include a third transformer at each zone substation. This is a higher cost option

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Takanini South - land purchase			1.20								1.20
Takanini South zone substation							2.30	7.50	3.50		13.30
Total	0.00	0.00	1.20	0.00	0.00	0.00	2.30	7.50	3.50	0.00	14.50

5.1.15 MARAETAI, CLEVEDON, BEACHLANDS

Maraetai is a remote settlement on the coast and comprising townships of Beachlands and Maraetai.

Maraetai and Clevedon zone substation are supplied by two 33 kV lines while Waiheke is supplied as a continuation of the 33 kV circuit from Maraetai. Sections of underground cable at the Takanini end of these feeders have a lower rating than the line, constraining capacity. A project has been initiated to upgrade the cable sections to release the full line capacity

A project to install a micro grid at Kawakawa Bay is under construction with the purpose of reducing fault outage duration and improve SAIDI.

Two 11 kV feeder reinforcement projects are proposed, one to support the growth in Beachlands and the second to improve the supply security on Waikheke Island.

PROJECT TITLE	NEED	PREFERRED OPTION	OPTIONS CONSIDERED/COMMENTS
Kawakawa Bay Micro grid	Kawakawa Bay and surrounding area is supplied via a lengthy 11 kV feeder from Clevedon zone substation. The network has experienced numerous and extended outages and has no backup from the Vector network and limited backup from Counties Power network	Carry out network reinforcement and install BESS	Install diesel generation as an alternative solution. This incurs additional annual operating expenditure.
Maraetai - subtransmission reinforcement	The firm capacity of the sub-transmission circuits supplying Maraetai, Clevedon and Waiheke zone substations from Takanini GXP is forecasted to exceed by 2025.	Upgrade sections of 33 kV cable where existing cable is underrated	New sub transmission circuit to Clevedon would only defer this project by two years.
Maraetai Whitford-Maraetai Road - 11 kV feeder reinforcement	The Beachlands area is rapidly growing with the existing 11 kV feeder supplying this area forecast to exceed capacity. In addition, this feeder will have the capacity backstop to the adjacent feeders at peak load.	Install 11 kV cable to provide additional capacity and backstop in this area.	The existing feeder supplying the Beachlands area is forecasted to exceed capacity in 2025.
Waiheke - 11 kV feeder reinforcement	70% of the load on Waiheke is supplied by two 11 kV feeders which also backstop each other. Demand is forecast to grow in this area and additional capacity is required	Install a new 11 kV feeder from Waiheke zone substation to supply further capacity to the developing areas.	This feeder will add capacity and improve security to the existing network.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Kawakawa Bay Micro grid	2.00										2.00
Maraetai – 33 kV subtransmission reinforcement					3.60	3.60					7.20
Maraetai - 11 kV feeder reinforcement -							2.70				2.70

Whitford-Maraetai Road											
Waiheke - 11 kV feeder reinforcement										3.10	3.10
Total	2.00	0.00	0.00	0.00	3.60	3.60	2.70	0.00	0.00	3.10	15.00

5.1.16 ZONE SUBSTATION AND DISTRIBUTION FEEDER PROGRAMMES

ZONE SUBSTATION POWER QUALITY, FIRE AND SECURITY IMPROVEMENTS

As part of our programme of continuous improvement we are installing card-access security and improving fire monitoring systems across all zone substations. The intention is to bring all zone substations up to the same standard to ensure that operationally and functionally they are the same. This improves operational familiarity and maintenance requirements.

Approximately 50% of our zone substations are equipped with PQM capability. The intention is to roll out this capability to all new zone substations. Power quality monitoring allows us to benchmark background levels of harmonics and monitor voltage sags and swells present on the network. With the increased connection of power electronics particularly through the increasing prevalence of inverters, there is the possibility of changes to background levels of harmonics. The presence of the current monitoring capability has proved invaluable when we are attempting to identify the source of voltage abnormalities on behalf of customers. Replacement power quality metering has been identified under Section 5.2 in the AMP

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
PQM rollout to new sites	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	1.40
Northern network zone substations - fire system and security upgrades	0.34	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	3.22
Auckland network zone substations - fire system and security upgrades	0.34	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	3.22
Total	0.78	0.74	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	7.84

LV REINFORCEMENTS AND CAPABILITY IMPROVEMENT

Increasing demand whether due to incremental increases in load by existing customers or through infill sometimes initiates LV network reinforcement. Most of these projects are small in scope. Most of the LV reinforcements are identified less than one year in advance and planning, design and delivery is reactive. The budget for future years is estimated from historic trends and load forecasts.

This year a programme has been included to gain improved visibility of the performance of the LV network, to enable the uptake of EVs, solar and customers' DERs. The intention is to install sensors on the LV network at key locations to improve our knowledge of loading and voltage.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Northern network - LV reinforcements	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.00
Auckland network - LV reinforcements	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.00
Northern network - LV network capability improvements		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	4.50
Auckland network - LV network capability improvements		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	4.50
Total	2.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	29.00

DISTRIBUTION FEEDER INVESTMENT

Budgets have been included to allow for the inclusion of HV reinforcement projects that may arise during the year but were unforeseen at the time this AMP was written. The budget is provisional only.

A similar budget has been included for the installation of cable ducts where the opportunity arises through roading alterations. The criteria associated with the use of this provisional budget is that there must be a foreseeable use for the ducts within the next ten years and there is some benefit such as avoiding re-excavating recently reinstated streets or reduces future project investment.

A budget has been included to increase our ability to remotely switch the 11 kV network from our EOC. The intention is to install remote control to at key locations on the network that will enable faster isolation and restoration of supply to customers that are not within the faulty section of the network. Its purpose is to reduce SAIDI.

The proposed areas to be targeted are remote control of the network open-points so that load can be rapidly switched from one zone substation to another. Priorities are 11 kV feeders associated with single transformer zone substations, feeders that experience frequent faults, and those feeders that supply large numbers of customers and incur high SAIDI during an outage

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland 11 kV feeder reinforcements - unspecified	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	7.50
Northern 11 kV feeder reinforcements - unspecified	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	7.50
Auckland future-proofing ducts- unspecified	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.00

Northern future-proofing ducts-unspecified	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	5.00
Auckland 11 kV feeder remote control	1.50	1.50	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	11.50
Northern 11 kV feeder remote control	2.50	2.50	2.00	2.00	1.50	1.50	1.50	1.50	1.50	1.50	18.00
Total	7.00	7.00	6.50	6.00	5.50	5.50	5.50	5.50	5.50	5.50	59.50

5.1.17 CUSTOMER CONNECTIONS

The interface with the customer is managed by Vector's Customer Excellence Team. Requests for new connections or changes to existing connections are forwarded to the Customer Excellence Team from our FSPs for small projects and from developers or consultants for subdivision and customer substation works. Provisional budgets are then developed. Work on customer connections also include the connection (and disconnection) of smaller customers to Vector's network as well as minor extensions to the LV mains to allow connection and installation of service pillars. The service main inside the customer's property is the responsibility of the customer. Activities also include the livening of the service on receipt of a Certificate of Compliance. Expenditure on each service is variable depending on the complexity and scope of the works to be carried out. For the purposes of estimating the budget for the investment summary the average cost of a connection has been applied to the expected connection numbers for the year and regulatory period.

NEW CUSTOMER CONNECTIONS

NEED

Vector is not obligated to provide new customer connections. However, the provision of new customer connections is part of Vector's core business and it is good business practice. As part of the process to establish new connections alternative technology solutions are also considered. The number of new connections on Vector's network for the AMP planning period has been forecasted as reflected in the service level metric in Section 2.3.1. The investment summary below shows the whole spectrum of customer connections that includes subdivision developments and substations for customers.

OPTIONS CONSIDERED

The following options are considered for new customer connections

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not invest in new customer connections	No cost	Rejected:	The risk of reputational damage to Vector's brand
2	Invest in new customer connections	$57m per year on average	Selected: This is in line with Vector's core business	Low risk of reputational damage

PREFERRED OPTION

Invest in new customer connections.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland subdivisions - residential	12.17	12.17	10.82	10.82	9.47	9.47	9.47	8.12	8.12	8.12	98.75
Northern subdivisions – residential	20.11	20.11	17.88	17.88	15.64	15.64	15.64	13.41	13.41	13.41	163.12
Auckland subdivisions – business	1.00	0.99	0.98	0.69	0.69	0.69	0.69	0.69	0.67	0.67	7.75
Northern subdivisions – business	1.12	0.87	0.62	0.54	0.54	0.54	0.54	0.54	0.52	0.52	6.32
Auckland new connections	8.89	9.31	9.73	9.73	9.73	9.73	9.73	9.73	9.73	9.73	96.06
Northern new connections	7.20	7.91	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	84.18
Northern customer substations	2.00	2.00	2.00	2.00	1.00	1.00	2.50	2.50	2.50	2.50	20.00
Auckland customer substations	4.50	4.50	4.50	4.50	2.00	2.00	4.50	4.50	4.50	4.50	40.00
Auckland capacity changes	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	27.15
Northern capacity changes	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	20.87
Northern network streetlighting	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	3.51
Auckland network streetlighting	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	2.39
Newmarket 11 kV supply 277&309 Broadway	0.30										0.30
CRL New Station Supplies	1.80	1.50	0.70								4.00
America's Cup Village	1.00	1.00									2.00
Commercial Bay Precinct Redevelopment New Supply EBD	0.54										0.54
Second Waitemata Harbour Crossing Tunnel Supply			0.03	0.05	3.00	4.00					7.08
Light Rail Transit station supply			1.50	1.50	2.00						5.00
WRR Lincoln Road interchange to Westgate	0.18										0.18
Total	66.20	65.76	62.78	61.73	58.09	57.09	57.09	53.51	53.47	53.47	589.19

5.1.18 RELOCATIONS

OUTDOOR TO INDOOR SWITCHGEAR CONVERSIONS AT TRANSPOWER GXPS

NEED

Transpower is undertaking a program to convert ageing outdoor 33 kV bulk oil CBs at GXPs in Auckland. The Transpower owned and operated bulk oil CBs have been in service since the 1960s and there has been a number of catastrophic failures of the bulk oil CBs. Under agreement with Transpower, Vector will undertake the relocation of its subtransmission circuits to the new indoor switchgear.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual – do not undertake the works	On-going and increasing maintenance costs	Rejected: Risk of failure of assets	Ageing bulk oil subtransmission CBs poses a risk to personnel and will impact SAIDI
2	Undertake capital works	$9.96m	Selected	Risk of harm to plant, personnel and the public is reduced. Compliance with statutory seismic standards

PREFERRED OPTION

Under agreement with Transpower, Vector will undertake the relocation of its subtransmission circuits from Transpower's outdoor switchgear to new Transpower installed and owned indoor switchgear.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Mount Roskill Transpower 33 kV switchboard	1.50	1.00									2.50
Takanini Transpower 33 kV switchboard	1.50										1.50
Wiri Transpower 33 kV switchboard		0.20	2.04								2.24
Mangere Transpower 33 kV switchboard		1.00	1.50								2.50
Wellsford Transpower 33 kV switchboard			0.20	1.02							1.22
Total	3.00	2.20	3.74	1.02	0.00	0.00	0.00	0.00	0.00	0.00	9.96

CUSTOMER RELOCATIONS

NEED

Vector is obliged to provide customer relocations in accordance with Section 32 of the Electricity Act. The number of new customer relocations on Vector's network for the AMP planning period has been forecasted, as reflected in the service level metric (see Section 2.3.2).

OPTIONS CONSIDERED

This is an obligatory project so no options are considered.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Invest in customer relocations	$11.6m per year on average	This is an obligatory requirement.	N/A

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

The investment requirements for customer relocations is based on historic relocation costs.

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland relocations	4.56	6.10	5.05	6.81	7.16	6.71	6.50	6.50	6.50	6.50	62.39
Northern relocations	5.32	4.32	4.02	4.90	5.40	5.70	6.00	6.00	6.00	6.00	53.66
Total	**9.88**	**10.42**	**9.07**	**11.71**	**12.56**	**12.41**	**12.50**	**12.50**	**12.50**	**12.50**	**116.05**

5.2 OPERATE, MAINTAIN, RENEW AND REPLACE

The safe and reliable operation of the network relies upon renewal and replacement of assets together with a sound maintenance regime. Vector's ultimate aim for operations and maintenance is to meet the service level targets set out in Section 2.2, in particular the reliability indices (SAIDI, SAIFI and Number of Customer interruptions). This includes ensuring asset safety and ensuring assets meet any associated environmental requirements.

Projects or programmes are initiated to address gaps in service level targets that are either already apparent or are forecast in the next 5-10 years. The current gap in the reliability indices, with SAIDI and SAIFI exceeding targets, is currently a main focus area of our renew / replace programme. In addition, there is an emphasis on improving the safety of network assets through improving visibility of assets.

This section provides details on all the renew, replace or maintain projects proposed for the next 10-year period for the continued safe and reliable operation of the network. Programmes of work have been created where expenditure is planned across a number of years. We are accelerating our rate of replacement of certain assets from a safety and reliability perspective. An example among others, described in the section below, is the replacement of small diameter OH conductors for which there is a trend of increasing failure. Another example described below is our program to replace certain types of oil filled ring main units where there is evidence of a trend of poor asset health in high criticality locations.

Vector's forecast expenditure for Routine and Corrective Maintenance and Inspections is set out in Schedule 11b in Appendix 7 as part of the disclosure Report on Forecast Operational Expenditure. Asset replacement and renewal is forecast in Schedule 11a in Appendix 6 as part of the disclosure Report on Forecast Capital Expenditure. A typical breakdown of Vector's expenditure on Routine and Corrective Maintenance and Inspections across the primary asset categories is shown in Table 5-1, reflected as a percentage of the value forecast in Schedule 11b.

ROUTINE AND CORRECTIVE MAINTENANCE AND INSPECTIONS	FY19 – FY28
Distribution feeders	61%
Distribution substations and transformers	13%
Secondary systems	5%
Subtransmission feeders	6%
Zone substations	15%

Table 5-1 Routine and corrective maintenance and inspections expenditure allocation

NETWORK MAINTENANCE

NEED

Analysis of Vector's asset management service levels in Section 2.2 highlights a number of performance issues developing within our asset base. Our performance gap analysis and root cause analysis shows:

- SAIFI and number of customer interruptions metrics: both these service level metrics have been affected by asset related failures occurring on distribution feeder assets. The failure of components of overhead lines and underground cables and joints are significant contributing factors to the interruptions on distribution feeders. Third party damage to our assets is contributing significantly to service level outcomes. Further details of this analysis can be found in Section 2.3.3 and Section 2.3.4;
- Accident safety incident rate: this service level metric has shown some random deviation from target over recent years that root cause analysis attributes to distribution feeder assets. In particular, overhead line components and cable boxes were found to be the primary contributor to this performance deviation. Further details of this analysis can be found in Section 2.3.8; and
- Environmental breaches: no current performance gaps were found with this service level metric. See Section 2.3.9 for details.

There are current performance gaps with SAIFI, number of customer interruptions, and the accident safety incident rate metrics that are attributable to distribution feeder assets. Vector's analysis shows that these service level gaps will widen over the timeframe of this AMP under current asset management practices. Accordingly, intervention is indicated to correct the performance of Vector's distribution feeder assets. The pool of outstanding corrective work is prioritised by risk. Work is deemed high priority when observed condition indicates distribution assets, such as crossarms, transformers, switchgear enclosures and pillars, are near end of serviceable life but there is still work to be done in the next planning period.

OPTIONS CONSIDERED

Vector has considered a number of options to correct the service performance of Vector's distribution feeder assets as identified above. These options are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual – continue current maintenance practices in accordance with Vector's asset maintenance strategy (see Section 4.2) and at current work volumes	$887.6m	Rejected: while this is the lowest cost solution it will not address current service level gaps or maintain expected service level performance. The risk of service levels deterioration is greatest under this option	SAIFI and customer interruption performance will exceed target levels. Asset safety incidents may occur
2	Alter our existing maintenance practices to increase corrective maintenance to adopt increased works volumes to target the root causes of the identified service level gaps	$982.9m	Selected: this is the lowest cost solution that addresses the current service level gaps and corrects performance to re-establish and maintain the expected service level	Distribution feeder contribution to asset service levels for SAIFI, customer interruption breaches, and accident safety incident rate are expected to reduce and move these service performance levels closer to target levels

PREFERRED OPTION

The preferred option is to amend Vector's current maintenance practices to increase corrective maintenance to target the root causes of the identified service level gaps. We will maintain current planned maintenance practices of routine inspections, testing, and servicing, in accordance with our maintenance standards, and will continue with current reactive maintenance practices that respond to in-service asset failures. However, our corrective maintenance practices will be altered to adopt increased works volumes to target the root causes of the identified service level gaps.

Adopting the preferred option increases spending on corrective maintenance as shown in the options table above. As service level performance returns to target in future years, Vector will reduce corrective maintenance to accord with historical work volumes. Preventative and reactive maintenance will remain consistent with historical work volumes, although an allowance for 2% p.a. network growth has been assumed to apply to the reactive maintenance programme. Consideration of the impact of Auckland's growth is discussed in Section 1.5.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

The following tables set out the proposed network maintenance CAPEX and OPEX investment.

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Corrective maintenance (CAPEX)	30.20	30.20	32.20	32.20	35.20	35.20	35.20	35.20	35.20	35.20	336.00
Reactive maintenance (CAPEX)	16.10	16.18	16.26	16.34	16.42	16.50	16.58	16.66	16.75	16.83	164.62
Total	**46.30**	**46.38**	**48.46**	**48.54**	**51.62**	**51.70**	**51.78**	**51.86**	**51.95**	**52.03**	**500.62**

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Planned maintenance (OPEX)	15.62	15.76	16.12	16.26	16.41	16.55	16.70	16.85	16.99	17.15	164.40
Corrective maintenance (OPEX)	15.30	15.36	19.77	19.85	19.94	20.02	20.11	18.12	17.16	16.20	181.84
Reactive maintenance (OPEX)	12.86	12.95	13.46	13.55	13.64	13.73	13.83	13.92	14.02	14.11	136.06
Total	43.79	44.08	49.34	49.66	49.98	50.31	50.63	48.89	48.17	47.46	482.30

VEGETATION MANAGEMENT

NEED

Effective vegetation management practice is essential to ensure reliable but also safe operation of the network. Gap analysis between service level performance and target performance levels has identified outages caused by vegetation contribute 15% of SAIDI and 13% of SAIFI on distribution feeders (see Sections 2.3.3 and Section 2.3.4). This in turn adversely impacts the service level for Customer Interruptions (see Section 2.3.5). While Asset Safety Incidents have not occurred in relation to vegetation, having physical contact between network assets and vegetation poses a significant risk to safety as well as the potential to cause fires. Experience also shows the that the contribution of vegetation to network faults is greatly magnified when high winds are present.

Our approach is consistent with our vegetation management strategy (see Section 4.2.8).

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do nothing	$0m	Rejected: Does not address existing service performance level gaps	The network continues to be significantly impacted by vegetation which will negatively impact reliability indices. Risk to public safety continues to exist
2	Proactively identify trees that are high risk and work with affected tree owners to address the risk	$58.6m	Selected: This solution addresses the current service level gaps and corrects performance to re-establish and maintain the expected service levels	Distribution feeder contribution to reliability indices will reduce and move these service performance levels closer to target levels. Risk to public safety minimised

PREFERRED OPTION

A proactive programme is required to identify trees that have a high risk of causing an outage thereby affecting the reliability service levels or pose a safety risk. These high-risk trees include not only trees in the growth limit zone, but also trees susceptible to shedding debris or falling across lines. Sufficient resources are then required to prioritise and mitigate the identified risks. For out of zone trees, the most cost-effective long-term solution is typically removal of the tree.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

The following table sets out the proposed vegetation management investment.

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Vegetation management	6.52	6.52	5.69	5.69	5.69	5.69	5.69	5.69	5.69	5.69	58.60
Total	**6.52**	**6.52**	**5.69**	**5.69**	**5.69**	**5.69**	**5.69**	**5.69**	**5.69**	**5.69**	**58.60**

5.2.1 SUBTRANSMISSION FEEDERS

Investment in subtransmission feeders is predominantly driven by reliability targets. While subtransmission feeders currently make up a relatively small proportion of network interruptions, increased failures can result in a large impact to SAIDI, particularly for underground circuits with low physical accessibility. It is therefore important to closely monitor the condition of feeders and maintain risk profiles to an acceptable level.

The following section describes the project and investment proposals for subtransmission cables:

SUBTRANSMISSION CABLE REPLACEMENT PROGRAMME

NEED

Asset health conditions show that a number of 33 kV and 22 kV subtransmission cables, more specifically PILC cables and a gas-filled cable, are reaching end of life (see Section 4.1.2 for an age profile of Vector's subtransmission cable circuits). On certain circuits, reactive repair of PILC cables is reaching a stage where large tracts of cables need to be replaced rather than continuing with piecemeal repairs and installations of new sections and joints.

Vector also has a large number of ageing oil filled cables of similar age but the construction of this type of cable is such that they can be retained in service for a number of years to come under Vector's existing maintenance regime (maintenance requirements are described in Vector standard ESM301 Maintenance of Cables). However, there are specific sections of this type of cable that require extensive repairs on oil joints to keep the cables in service. There are also a number of sections of oil-filled cables where over time with the development of new road corridors that cables can only be accessed with difficulty or not at all. In some instances, excavations of up to 4m deep are required. There is a need to replace such sections of cables.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Retain subtransmission cables that are at risk in continued service	Continued maintenance costs	Rejected. Based on the fault history of certain subtransmission cables it is uneconomical to retain such subtransmission cables in service	Failure of ageing subtransmission cables result in a risk to reliability (SAIDI, SAIFI), risk to security of supply and are costly to repair. There is a risk of escalating maintenance costs
2	Undertake a staged and scheduled programme of works to replace subtransmission cables that are at risk	$51.80m	Selected option. Undertaking a staged and scheduled programme of works will ensure the integrity of the subtransmission network for the future	Risks to reliability indices (SAIDI, SAIFI) and security of supply will be reduced. The risk of continuing and expensive maintenance will be avoided

PREFERRED OPTION

Due to the construction of PILC cables it is very difficult to access where cable circuits might fail and with this type of asset complete replacement is the only sensible option to avoid continuing repair and replacement costs.

Where oil-filled cable sections are inaccessible the preferred option is to replace such sections with new XLPE on accessible routes. The preferred option is to undertake a staged and programmed replacement programme of subtransmission cables based on asset health, history of faults and the ability to access cable routes.

The replacement programme for subtransmission circuits align with Vector's asset strategy EAA301 Underground Cables.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Takanini cable replace		2.73									2.73
Glen Innes cable replace	7.50	10.00									17.50
Ponsonby cable replace	4.00	1.70									5.70
Chevalier cable replace		4.07	1.74								5.81
Westfield cable Replace				0.10	3.00						3.10
Onehunga cable replace					3.06	4.80					7.86
Mount Albert cable Replace					0.10	3.00					3.10
Auckland cable replace							0.50	0.50	1.00	1.00	3.00
Northern subtransmission cable replace							0.50	0.50	1.00	1.00	3.00
Total	11.50	18.50	1.74	0.10	6.16	7.80	1.00	1.00	2.00	2.00	51.80

5.2.2 ZONE SUBSTATIONS

Similar to subtranmission feeders, zone substations do not currently have a significant impact on SAIDI due to their N-1 design criteria. Zone substations are subject to regular inspections as set out in Section 4.3.2 and use SCADA for real time monitoring. Through this inspection and monitoring regime, several projects have been identified that could impact on SAIDI in the future. This is mainly due to the age of the zone substation assets (switchgear and transformers) reaching the end of life and therefore being subjected to increased maintenance and / or experiencing a higher number of failures and a lack of support in terms of spare parts.

The following sections set out the project proposals for zone Substations:

33 KV AND 22 KV OIL-FILLED PRIMARY SWITCHGEAR REPLACEMENT (ZONE SUBSTATIONS)

NEED

Vector's 33 kV and 22 kV oil-filled switchgear dates from the 1960s and 1970s; population as shown in Section 4.1. In RY17 there was only one failure of a 33 kV CB (failure of a current transformer in a 33 kV gas CB bushing) so in terms of reliability indices the failure of 33 kV switchgear contributed less than 1% to SAIDI in RY17. Catastrophic failure of an oil CB in November 2013 resulted in high SAIDI and extensive collateral damage. The low rate of failure can certainly be attributed in part to the fact that this switchgear is well maintained. Vector has also replaced a number of outdoor oil-filled CBs with gas filled CBs. However, the 60s and 70s vintage oil-filled switchgear is closing in on its expected engineering life but more importantly the maintenance requirements are intensifying to retain them in good and safe working condition and spares can only be cannibalised from similar CBs that were taken out of service under replacement projects in the past.

It must be noted that if a 33 kV oil-filled CB fails it is usually catastrophically and they do present a risk to maintenance personnel as well as personnel that undertake inspections in close proximity to this plant. Because of the volume of oil that these CBs contain they also present a risk to the environment.

There is a need to continue with a long-term programme to replace Vector's ageing 33 kV oil-filled switchgear based on asset health. This replacement programme will not result in a visible and immediate impact or improvement to SAIDI but will rather reduce the risk of catastrophic failure and prevent the high levels of SAIDI that will go with a failure of this type of plant, from happening in the first instance.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage and retain 60s and 70s oil-filled 33 kV switchgear in service	Continued and escalating maintenance costs in addition to the costs of unplanned catastrophic failure	Rejected: Based on the scarcity of spares, escalating maintenance costs, health and safety risks as well as the environmental risk, the option to not undertake a replacement programme is rejected	The asset health of these assets will continue to deteriorate to a point where catastrophic failure(s) become a high risk. A catastrophic failure will impact on SAIDI and will impact on the security of supply to customers. Catastrophic events also hold risk to personnel and will impact Vector's reputation.
2	Undertake a staged and scheduled programme of works to replace 33 and 22 kV oil-filled switchgear	$26.14m	Selected: This option is selected to ensure that zone substations are equipped with primary switchgear that have low maintenance requirements and that present a low risk to reliability indices, low risk to the health and safety of personnel and a low risk to the environment.	Low risk to SAIDI, low risk to security of supply, low risk to the environment and plant with low maintenance requirements that will result in reduced operating expenditure

PREFERRED OPTION

The preferred option is to undertake a staged and long-term programme of works, based on asset health, to replace outdoor oil-filled primary switchgear in Vector's zone substations. In most cases, especially urban areas, outdoor switchgear will be replaced with low maintenance fixed pattern indoor switchgear. In rural areas with low numbers of switches, installation of low maintenance outdoor switches will be a consideration. This is in line with Vector's Asset Strategy for primary switchgear, report number EAA101 Zone Substation Switchgear.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Browns Bay 33 kV switchboard	0.34										0.34
Belmont 33 kV switchboard	1.93										1.93
Pacific Steel 33 kV switchboard			1.17								1.17

New Lynn 33 kV switchboard			2.50								2.50
Sabulite 33 kV switchboard			1.38								1.38
Hobson 22 kV switchboard			0.20	3.16							3.36
Henderson Valley 33 kV switchboard			0.20	1.73							1.93
Orewa 33 kV switchboard					3.53						3.53
33 kV switchboard						2.00	2.00	2.00	2.00	2.00	10.00
Total	**2.27**	**0.00**	**5.46**	**4.89**	**3.53**	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**26.14**

11 KV SWITCHGEAR REPLACEMENT

NEED

Vector's large population of 11 kV oil-filled switchgear dates from the 1960s and 1970s. A new failure mode is being observed in 1970s vintage New South Wales and Reyrolle switchgear in which bushings manufactured with synthetic resin bonded paper are failing increasingly. We have also recently, Nov 2017 and Jan 2018, experienced failure of a 1985 vintage vacuum CB and a failure of a 1982 vintage vacuum interrupter. Notwithstanding these failures, at this point in time Vector's 11 kV switchgear has a very low impact on SAIDI because they are well maintained and we have been able to salvage and hold parts from 1960s vintage switchgear that were taken out of service. However, obtaining certain types of spares is becoming an increasing challenge. As we move forward in time the risk of lengthy outages because certain spares cannot be sourced, will increase. The risk presented by ageing oil-filled switchgear to operating and maintenance staff will also increase as we go forward.

OPTIONS CONSIDERED

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual - do not address the identified need at this stage. Continue to maintain the switchgear by salvaging parts and fabricating parts where practicable	Continued and escalating maintenance costs in addition to the costs of unplanned catastrophic failure	Rejected: Continued maintenance of the switchgear will not address the increasing risk to service level compliance. Obtaining spare parts is becoming a challenge and maintenance costs will continue to increase as switchgear maintenance becomes increasingly impractical	Risk of unacceptable outages and an increasing and continued health and safety risk to personnel
2	Undertake a staged and scheduled programme of works	$102.37m	Selected: This option will reduce the risk of lengthy outages due to non-availability of spares and thus remove the commensurate risk of high SAIDI The increasing health and safety risks posed by oil filled switchgear will be removed	Low risk to the SAIDI index Reduced health and safety risk to personnel

PREFERRED OPTION

Undertake a staged and scheduled long term programme to replace 11 kV oil-filled switchgear and 1980s vintage vacuum CBs over the AMP planning horizon. The proposed scope of this programme accords with Vector's asset strategy EAA101 Zone Substation Switchgear.

The proposed replacement will be in accordance with a condition-based risk assessment and considers amongst other matters condition assessments, history of faults and failures, and criticality of the zone substation.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Orakei 11 kV switchboard replace	0.22										0.22
Manurewa 11 kV switchboard replace	0.40										0.40
South Howick 11 kV vacuum CBs retrofit	0.55										0.55
Waiheke 11 kV vacuum CBs retrofit and upgrade protection	1.12										1.12
Drive 11 kV switchboard replace	1.82										1.82
Mount Wellington 11 kV switchboard replace	2.50										2.50
Mangere Central 11 kV switchboard replace	1.85	2.50									4.35
Hobson 11 kV switchboard replace	1.50	1.50	1.00								4.00
Freemans Bay 11 kV switchboard replace		1.00	3.48								4.48
Wiri 11 kV vacuum CBs retrofit and upgrade protection		2.68									2.68
White Swan 11 kV switchboard replace		4.48									4.48
Manukau 11 kV switchboard replace			3.06	0.51							3.57
Pakuranga 11 kV switchboard replace			0.20	3.98							4.18
Quay Street 11 kV switchboard replace			0.20	3.54							3.74
Hobsonville 11 kV switchboard replace			0.20	3.37							3.57

Sandringham 11 kV switchboard replace				5.10							5.10
Te Papapa 11 kV switchboard replace			0.20	4.08							4.28
James Street 11 kV switchboard replace				0.20	3.88						4.08
Kingsland 11 kV vacuum CBs retrofit					0.25						0.25
Rosebank 11 kV vacuum CBs retrofit					0.45						0.45
St Heliers 11 kV vacuum CBs retrofit					0.45						0.45
Rockfield 11 kV vacuum CBs retrofit					0.50						0.50
Hillcrest 11 kV vacuum CBs retrofit					0.61						0.61
Northern switchboard replacement						4.50	4.50	4.50	4.50	4.50	22.50
Auckland switchboard replacement						4.50	4.50	4.50	4.50	4.50	22.50
Total	9.96	12.16	8.34	20.77	6.14	9.00	9.00	9.00	9.00	9.00	102.37

GAS MONITORING INSTALLATION LIVERPOOL 110 KV SWITCHGEAR

NEED

The 110 kV switchgear at Liverpool zone substation in the Auckland CBD has been in service since 1998. The switchgear is fitted with two stage gas density switches per SF_6 gas compartment and these are signalled to Vector's EOC at bay level but there is no visibility of a compromised gas compartment until alarms levels are reached.

The switchgear is reaching a stage in its asset life where accelerated gas leaks can develop rapidly with weaknesses in seals over time. To avoid unexpected shut-downs manual inspections are undertaken every two months as part of the station maintenance regime where the gas is checked to be above the alarm points. Manual inspections are of course labour intensive and readings from inspection to inspection do not provide any trends due to the macro scale of the fitted pressure gauges with slow leaks being virtually imperceptible between periods.

In 2012 a refurbishment project was undertaken on the Liverpool Merlin Gerin 110 kV switchboard to replace the most vulnerable components through which gas was leaking (e.g. switch position indicating windows and fragile carbon disk pressure relief devices) as well as overhauling the hydraulic systems of all CBs. The opportunity offered by the refurbishment was further taken to install milliampere output pressure transducers to make the switch ready for a comprehensive gas monitoring system to be installed.

The layout of the 110 kV switch is such that a gas monitoring system can be installed and this needs to be undertaken. Without such a system, the switch could be shut down unnecessarily resulting in a negative impact to SAIDI/SAIFI and Security of Supply.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need and continue to rely on the single global gas alarm for this strategic 110 kV subtransmission switch	Continued maintenance costs	Rejected. This strategic switch is ageing and the reliance on a global gas alarm requires intensive manual monitoring and there is no visibility of gas trending	A lack of gas-trending and reliance on a single alarm means there is a risk that the whole switch could be shutdown unnecessarily and this will have a negative impact on the SAIDI/SAIFI reliability index, security of supply to Auckland's CBD and will impact Vector's reputation
2	Install a gas monitoring and trending system at Liverpool that will report to the EOC via Vector SCADA	$0.15m	Selected option. A system that provides comprehensive reporting on gas-trending and gas-alarms will provide full visibility to the EOC and negate the need for constant manual monitoring	Reduce the risk of a high impact on the SAIDI/SAIFI index and reduce the risk of a high impact on the security of supply to the Auckland CBD

PREFERRED OPTION

The preferred option is to procure and install gas monitoring and trending hardware complete with software for comprehensive reporting capability to Vector's EOC. Outputs already exist on the 110 kV switchgear from the individual gas compartments thus limiting a high level of physical works on the 110 kV switchgear.

This investment is in line with Vector's asset strategy EAA101 Zone Substation Switchgear.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Liverpool 110 kV gas monitoring system		0.15									0.15
Total		0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15

POWER TRANSFORMER REPLACEMENT PROGRAMME

NEED

Vector has a number of power transformers that dates from the 1960s. As described in Section 4.1, the engineering design life of a power transformer is about 40 years but if the unit is not subject to excessive loading or high winding temperatures and if well maintained its life can be extended well beyond 40 years. Depending on the condition of transformers, mid-life refurbishment is an option to extend the lives of transformers. We take care not to subject our transformers to excessive loading and they undergo regular testing in accordance with our maintenance regime. The availability of spare parts especially for tap changers will also impact the decision on whether to refurbish a transformer or to replace a transformer. We are finding replacement parts for certain tap changers almost impossible to source. Notwithstanding our maintenance and testing regime, the condition of a number of older power transformers have now reached a stage where mid-life refurbishment is not an economical option and the risk of failure is real and present. Transformer failure poses a risk to security of supply due to the long lead times for procurement, as well as a risk to Health and Safety. In extreme cases, transformer failures can be catastrophic and result in serious collateral damage. Replacement of a number of transformers in our network is warranted.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Retain transformers at risk for continued operation in the network	On-going maintenance and repair costs	Rejected. Continuing operation of power transformers that are at risk of failure present a risk to reliability indices and also present a Health and Safety risk to personnel and the risk of collateral damage in the event of a catastrophic failure. Because of the long lead time to procure and install a power transformer there is also a risk to the security of supply	The risk of breach of reliability indices and a risk to the Health and Safety of personnel will continue. The risk to security of supply will continue
2	Consider the use of BESS to offset the requirement to replace transformers	Detailed estimates not compiled	Rejected. BESS will assist to reduce the peak demand of zone substations but will not remove the risk posed by ageing transformers	Risk of high capital cost of BESS system. Furthermore, this option will not remove the risks posed by ageing and failing transformers
3	Undertake a staged and scheduled programme of works to replace power transformers	$37.11m	Selected option. Undertaking a staged and scheduled programme of works will reduce the risk to the Health and Safety of personnel, reduce the risk to reliability indices and reduce the risk to security of supply	The risk that reliability indices will be breached will reduce. The risks posed to the Health and Safety of personnel and the risk of collateral damage will reduce. The risk that SoSS will be breached will reduce

PREFERRED OPTION

The preferred option is to replace a power transformer if industry standard condition based tests, undertaken in line with Vector's standard for testing transformers as prescribed in Vector standard ESM201, Maintenance of Power Transformers, prove that a transformer can no longer be safely operated. The scope of works for new power transformers consist of the procurement, testing, installation and commissioning of new units and at the same time upgrading of transformer enclosures to New Zealand seismic standards.

The replacement programme for power transformers align with Vector's asset strategy EAA201 Power Transformers.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Browns Bay 33 kV/11 kV replace T2	0.00										0.00
Glen Innes 22 kV/11 kV replace T1&T2	0.30										0.30
Parnell 22 kV/11 kV replace and refurbish	2.70										2.70
Helensville 33 kV/11 kV replace T1		1.50									1.50
Takanini 33 kV/11 kV replace T2			1.46								1.46

Triangle 33 kV/11 kV replace T1			1.64								1.64
Takanini 33 kV/11 kV replace T1			1.46								1.46
McNab 33 kV/11 kV replace T1			1.28								1.28
Triangle 33 kV/11 kV replace T2				1.64							1.64
McNab 33 kV/11 kV replace T2				1.28							1.28
Otara 33 kV/11 kV replace T1				1.15							1.15
Waimauku 33 kV/11 kV replace T1				1.12							1.12
McNab 33 kV/11 kV replace T3					1.28						1.28
Otara 33 kV/11 kV replace T2					1.15						1.15
Mount Wellington 33 kV/11 kV replace T1					1.04						1.04
Mount Wellington 33 kV/11 kV replace T2						1.04					1.04
Northern zone substations transformers refurbish	0.31	0.31	0.31	0.31	0.31	1.25	1.25	1.50	1.50	1.50	8.53
Auckland zone substations transformers refurbish	0.31	0.31	0.31	0.31	0.31	1.25	1.25	1.50	1.50	1.50	8.53
Total	3.62	2.11	6.46	5.80	4.07	3.54	2.50	3.00	3.00	3.00	37.10

THE DRIVE ZONE SUBSTATION SEISMIC UPGRADE

NEED

The existing 11 kV switchroom at The Drive zone substation, is currently listed as a Historic Place Category 2 protected building. The switchroom was constructed in 1930 and is seismically at risk due to its construction methodology of the time. This building was also identified as a potential risk during a recent safety audit in terms of NZS7901, Public Safety.

A separate project is currently underway to replace the existing 11 kV switchboard at The Drive, which will be installed in a new building onsite and will render the existing building redundant. Due to its Historic Places listing the now vacant building is to be retained and strengthened to meet the appropriate seismic standards for this type of building.

A project is required to revisit the seismic strengthening and the project outcome is to implement an appropriate solution to ensure the building is in a seismically safe condition for Vector personnel, and the adjacent public spaces in accordance with NZS7901 Public Safety.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual - retain the existing building and do not complete the required seismic strengthening	Nil	Rejected: The existing Heritage building does not comply with the necessary seismic standards	The building in its current stated poses a potential risk to the health and safety of personnel and adjacent public spaces
2	Complete structural reinforcement to achieve a Vectors seismic compliance requirement and those of the new New Zealand Building Standard	$0.9m	Selected option Improves the building safety for Vector personnel, and adjacent public spaces in accordance with NZS7901 Public Safety. Meets the obligations of a Historic Places listed building	The existing substation building seismic performance will now meet the appropriate Vector, NZ Building Code, and Auckland Council requirements under the Resource Managemet Act and Ministry of Business, Inovation and Employment (MBIE)

PREFERRED OPTION

Complete structural reinforcement to achieve Vector's seismic compliance requirements and those of the new New Zealand Building Standard.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland Seismic rebuild The Drive	0.50	0.40									0.90
Total	0.50	0.40									0.90

ZONE SUBSTATIONS CIVIL AND STRUCTURAL UPGRADES

NEED

Vector has a number of ageing zone substation buildings and although these are maintained in accordance with a planned maintenance regime there are instances where normal maintenance is simply not sufficient to remedy larger civil and structural defects. In such cases a capital project must be undertaken to remedy any issues. Examples of larger defects are seismic non-compliance and deterioration of a building due to soil movement where structural strengthening is then required and/or deficient construction methodologies that might have been applied in years gone by.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual – do not undertake capital works	On-going and increasing maintenance costs	Rejected: By not undertaking the works this could result in issues becoming more extensive and more costly to remedy over time. Vector is obliged to comply with Council seismic standards	Risk to plant, personnel and the public. Failure of plant will impact SAIDI

2	Undertake capital works	$2.81m	Selected	Risk of harm to plant, personnel and the public is reduced. Compliance with statutory seismic standards

PREFERRED OPTION

Undertake the capital investments to ensure the civil and structural integrity of Vector's zone substations are maintained.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland civil structures upgrades	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	1.41
Northern civil structures upgrades	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	1.41
Total	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	2.81

NEUTRAL EARTHING RESISTOR INSTALLATIONS IN ZONE SUBSTATIONS

NEED

Neutral earthing resistors are used to limit earth fault currents in power systems. The primary effect of the installation of neutral earthing resistors is a very large decrease in the fault current when an earth fault occurs on the system. On some urban 11 kV systems earth fault currents are up to 15% higher than phase fault currents and can be higher than the 250 MVA (13.1 Kiloampere) rating of typical ring main units. Vector still operates a fair number of older 11 kV distribution cables with low rated earth fault screens and this limits Vector's options to operate 11 kV zone substations with closed bus couplers to ensure security of supply to key customers.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual - do not address the identified need and continue to operate zone substations without neutral earthing resistors in place	$0 capital investment Increased reactive spend because of damage caused by high fault currents	Rejected: High fault currents exceed the ratings of ageing distribution switchgear and the earth screens of some 11 kV distribution cables	High earth fault currents hold a higher risk of damage to equipment. High earth fault currents pose continued risk to people, telecommunications plant, computers and delicate electronic equipment
2	Undertake a programme to install neutral earthing resistors in the 11 kV neutral points of power	$3.71m	Selected option This option is selected because it will reduce the risk of injury to people and reduce the risk of damage to cables and equipment. It will also reduce the cost of procurement of 11 kV cables	A reduction in earth fault current results in a reduced risk of injury to people and damage to plant. A reduction in fault current will also reduce step and touch voltages and reduce stray currents Risk of additional investment in protection equipment to operate on lower fault currents

transformers at zone substations	Risk of additional investment to replace surge arrestors with units that have increased voltage ratings

PREFERRED OPTION

Neutral earthing resistors are required to limit fault currents and allow bus couplers to be operated closed.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland neutral earthing resistors	0.07	0.08	0.16	0.20	0.20	0.20	0.20	0.25	0.25	0.25	1.86
Northern neutral earthing resistors	0.07	0.08	0.16	0.20	0.20	0.20	0.20	0.25	0.25	0.25	1.86
Total	0.13	0.16	0.32	0.40	0.40	0.40	0.40	0.50	0.50	0.50	3.71

5.2.3 DISTRIBUTION FEEDERS (HV & LV)

Distribution feeders were the largest contributor to SAIDI in 2017 (see Section 2.3.3). Analysis of SAIDI indicated that the major causes were overhead equipment, predominantly conductors and crossarms, and underground equipment, predominantly cable and cable termination failures. Addressing the high failure rate and duration of outages related to failures in these assets is key to reducing SAIDI performance.

The following sections set out the project proposals for HV and LV distribution feeders, with a particular focus on overhead conductors. In addition to these specific projects and programmes, there will be some further expenditure on distribution feeders as part of the general Network Maintenance programme (see Section 5.2.3).

OVERHEAD CONDUCTOR RENEWAL

NEED

Vector's 11 kV overhead network for the combined Auckland and Northern networks is 3,802 km in route length of which over 600 km consists of small diameter conductors. Age profiles of the small conductors in the network are not available for all areas but a substantial portion of the network is in excess of 60 years old (age profile details of conductors in the Auckland region are not complete – available details are provided in Section 4.1).

The increasing rate of failure of small diameter 11 kV conductors has impacted reliability (see Section 2.3.4), its poor health is also starting to pose a risk to operational staff and the public in general. Many portions of the network with small diameter conductors exist in high density urban areas with a high congregation of people and the risk of conductor failure and falling to ground presents a hazard to the public. Furthermore, according to a National Institute of Water and Atmospheric Research study in 2017 extreme rainfall, severe droughts, wildfires and wind with increased speeds could hit Auckland in years to come and conductors in poor condition and little resilience will result in further outages and thus an increase in SAIDI unless investment to renew conductors is undertaken.

Conductors with poor health and high criticality should be replaced to reduce the risk to SAIDI and reduce the risk to our people, service providers and the public. Our CBARM model shows that to meet our service level standards and to reduce the health and safety impact of conductors we will need to replace most of the 600 km of small diameter 11 kV conductor in the AMP period.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual - do not address the identified need to replace conductors with poor health and high criticality	Continued and escalating remedial costs	Rejected: There is an increasing trend of failure of small diameter conductors.	Continued impact on reliability and thus worsening customer experience of the quality of Vector's electricity supply. Conductor failures, especially in urban areas will continue to present a health and safety risk and as conductor health deteriorates this risk will increase.
2	Replace small diameter conductors based on asset health and criticality.	$103.5m	Selected option Our investment program below will see roughly 550 km of overhead line replaced over the 10-year AMP period. This will alter the average population age of Vector's 22 kV overhead conductors from an average 38 years to an average 32 years at the end of the AMP period. The estimated potential number of customer interruptions avoided over the 10-year period is 318,720. This avoids an estimated 6% per annum increase in customer interruption.	Roughly 14% of the 11 kV overhead conductors will be replaced under this program. This will result in a post investment decreased risk of public harm and improved resilience and reliability of the 11 kV overhead network

PREFERRED OPTION

The preferred option is to undertake the works to replace small diameter conductors based on asset health and criticality.

It is highly likely that in areas that have been identified for conductor replacement that some poles will need to be replaced especially in some parts of the Auckland area where lower strength poles were used in years gone by. Standard AS/NZS7000 requires that engineering assessments of major overhead line components be undertaken when the mechanical load is being altered. The need for replacement of some or all poles will be determined during detail design of conductor replacement projects. All crossarms and insulators will be replaced as part of reconductoring projects.

The capital investment proposed for this asset is in line with Vector's asset strategy for overhead line renewal, strategy document EAA401 Overhead Lines.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland overhead conductor renewal	1.00	1.50	3.00	4.00	6.00	6.00	6.00	6.00	6.00	6.00	45.50
Northern overhead conductor renewal	1.00	1.50	4.50	5.00	7.50	7.50	7.50	7.50	8.00	8.00	58.00
Total	2.00	3.00	7.50	9.00	13.50	13.50	13.50	13.50	14.00	14.00	103.50

NETWORK RESILIENCE IMPROVEMENTS

NEED

As stated in the introduction to SECTION 5, extreme weather events can have a significant impact on Vector's network, resulting in increased outages. To address this and support our Overhead Conductor Renewal programme, Vector is planning additional renewal programmes to replace other aspects of the overhead network, in order to improve network resilience. Examples include mid-span insulators, changes in span lengths, improved stays, etc. We will also install additional lightning arrestors in strategic locations in the network to improve the performance and resilience during storm events. We have also experienced that certain parts of our underground network are more prone to inundations and flooding during king tides: resilience for certain parts of the underground network will also require investment to improve network resilience.

OPTIONS CONSIDERED

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual – do not improve the resilience of the network	On-going and increasing maintenance costs	Rejected: The performance of the network will deteriorate	Risk to plant, personnel and the public. Failure of plant will impact SAIDI
2	Undertake a program to design and build resilience into the network	$10.5m	Selected: To establish a resilient network	A network that is able to withstand the anticipated detrimental environment in which it will be expected to perform in the future

PREFERRED OPTION

Undertake the capital investment to build resilience into the network as and where required to ensure it performs to customer's expectations and Vector's and industry standards.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland resilience improvements	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	5.50
Northern resilience improvements	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	5.00
Total	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	10.50

OVERHEAD 11 KV SWITCHGEAR RENEWAL

NEED

Vector's overhead network includes 715 rocking-post type air break switches of various designs (see Table 4-7 in Section 4.1.4). Of these, approximately two thirds are on the Northern network, with the remainder in the Auckland network. Until the year 2000 rocking-post type air break switches were the primary type of switch used for field switching. From 2000 to 2015 fully enclosed (SF_6 gas) switches were predominantly used. Since 2015, air break switches with integral arc-interrupting devices are now the Vector standard because they are more robust and simpler to maintain.

Our performance data shows there is an increasing rate of failures associated with overhead switches. To address this, at least 365 overhead switches need to be replaced over the 10-year AMP period to prevent a deterioration of service levels. However, analysis undertaken in 2017 of air break switches against the SAIDI benefit they offer, showed that a number of switches are no longer in optimal locations in the network to offer optimum SAIDI benefit. Therefore, it is expected that rather than replacing all 365 switches, improved SAIDI benefit can be obtained by replacing 265 switches in optimum locations in the network.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Retain the network with aging air break rocking-post type switches in service	Continued and escalating remedial costs	Rejected. Looking forward we are expecting that the overhead network with air break rocking-post type switches will continue to deteriorate and have a continued negative impact on SAIDI and asset safety incident rates	Continued impact on SAIDI and thus worsening customer experience of the quality of Vector's electricity supply. Failure of air break switches, most likely during operation, will continue to present a Health and Safety risk and as the switches age this risk will increase. Will result in increase to asset incident safety rate metric
2	Undertake a staged and scheduled programme of works to replace aging air break rocking-post type switches.	$3.36m	Selected option. Undertaking a staged and scheduled programme of works will improve SAIDI and reduce the Health and Safety risks to the public and personnel	The SAIDI reliability index will improve and Health and Safety risks to the public will reduce

PREFERRED OPTION

The preferred option is to undertake a staged and scheduled programme over the 10-year AMP period to replace rocking-post type air break switches with a focus on areas of the network where asset health are showing worsening performance trends. Replacements will not necessarily be in the same location, but optimised at a network level to deliver the maximum SAIDI benefit.

The works programme covered in this needs requirement is in line with Vector's asset strategy for overhead distribution switchgear described in EAA501 Distribution Network.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland overhead 11 kV switch renewal	0.04	0.04	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	1.04
Northern overhead 11 kV switch renewal	0.08	0.08	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	2.32
Total	0.12	0.12	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	3.36

OVERHEAD IMPROVEMENT PROGRAMME

NEED

Vector has a deed in place with its major shareholder Entrust, to provide Energy Solutions Programme Investment. This programme is focused on improved energy efficiency and visual amenity around Vector's assets. Projects have largely focused on undergrounding of overhead lines which reduces the exposure of assets to environmental risks such as vegetation and third party damage. Other projects have included:

- Sustainable substations, where solar panels and battery packs have been used to displace or reduce energy consumption and dependence on the grid
- Energy efficiency community programmes, where BESS have been installed in the community, energy audits have been conducted at residential homes resulting in energy efficiency improvements.

The Entrust deed requires Vector to invest an average of $10.5m annually on these energy solutions. This ties in with the Environmental service level (see Section 2.3.9), where Vector is committed to improving the environment impact of our assets.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Invest in undergrounding of overhead lines and new technologies	$5.0m annually on average	This is a requirement of Vector's deed with Entrust and an obligatory spend	N/A

PREFERRED OPTION

This specific projects for overhead improvement in this programme are agreed on an annual basis with Entrust.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland various overhead to underground improvements	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	50.00
Total	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	50.00

LIGHT DETECTION AND RANGING TO DETECT LOW LINES AND VEGETATION

NEED

Low lines and vegetation have proved to be major contributors to faults and thus major contributors to SAIDI and SAIFI. This was highlighted during the recent storms in Auckland and surrounding areas. The vegetation problem is greatly magnified during high winds as was experienced especially during recent storm events. Traditionally overhead lines would have been surveyed from the ground but this method is expensive and time consuming and will not suffice for the large volumes of data that are needed to plan and prioritise the program of work to rectify low lines and control vegetation.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual – do not address the identified	Continued maintenance costs as per existing	Rejected: Vector will not be able to prioritise and plan priorities to control vegetation and rectify low lines	Continued risk to the public presented by low lines and continued outages to the network by vegetation. This will in turn have a detrimental impact on SAIDI and SAIFI and impact negatively on the customer's experience

	need at this stage	expenditure patterns		
2	Undertake a staged and scheduled LiDAR programme to ascertain the status of the network	$5.0m	Selected: Rectify low lines and control vegetation	Reduced risk of harm to the public. Reduced risk of outages due to vegetation Improved SAIDI and SAIFI

PREFERRED OPTION
PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland Overhead Network LIDAR Survey	0.50	0.50	0.50	0.50	0.50						2.50
Northern Overhead Network LIDAR Survey	0.50	0.50	0.50	0.50	0.50						2.50
Total	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	5.00

RIGHT OF WAY POLES

NEED

In mid-2014, an increasing rate of deterioration and failure of non-Vector owned assets deployed along Right of Ways within the Auckland region was identified. Poles and conductors make up the majority of these assets and can cause significant damage and harm to people and property when they fail.

Vector has experienced an increase in costs and customer outages as a result of these customer assets being in poor condition. Customers typically do not either realise they are responsible for these assets and/or call Vector for advice. This incurs an increase in operational costs including the costs of sending a reactive crew to confirm the state of the asset and/or whether it is part of our network. Additionally, when Vector is made aware of an immediate safety issue, our safety procedures require us to immediately de-energise the area remotely until we can physically attend and assess whether the asset is safe. This is done at the HV level as there is currently no way to remotely de-energise the LV network. This results in increased outages to customers, negatively impacts quality measures such as SAIDI and SAIFI and incurs costs to manage and inform customers who are affected by the resulting safety outage.

In addition to information gathered from attending sites that have resulted in failure, Vector has inspected a number of properties across the region to assess the size of the problem. We have estimated that there are approximately 5,000 shared driveways in the Auckland region that have non-Vector overhead assets and that there could be approximately 15,000 structures in total. Based on these survey results Vector has assessed that the majority of these are likely to be well beyond their economic life and in poor condition.

Vector estimates that the cost to remediate and make safe customer owned service lines would cost between $45M-$75M. The cost of repairs at each site can vary substantially, but it is not uncommon for costs to exceed $3,000 and can go as high as $15,000. Our experience to date is that many property owners cannot afford these costs which could expose them to protracted disconnection. In addition, when there is an issue it is often complicated by absentee land owners.

This problem of unmanaged and unsafe customer structures is an industry problem and is not isolated to urban areas. Vector has engaged with a number of other Electricity Lines Businesses who have confirmed they have similar concerns and issues across their network footprints. On 14 February 2018, the Electricity Networks Association held a workshop to highlight industry concerns to a number of government agencies including MBIE, the Electricity Authority and Energy Safety. At this workshop, Vector indicated that if it was given the right liability protections and confirmation of an increase in its regulated allowable CAPEX and OPEX, that it would be prepared to proactively identify and remediate structures down shared right of ways to ensure public safety. Once the assets were up to network standards Vector would take ownership and assume maintenance responsibilities.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Continue to engage with other EDBs and the Electricity Networks Association to highlight industry concerns to a number of government agencies including MBIE, the Electricity Authority and Energy Safety	$0	Selected	Proactive engagement on industry solution

PREFERRED OPTION

Continue to engage with other EDBs and the Electricity Networks Association to highlight industry concerns to a number of government agencies including MBIE, the Electricity Authority and Energy Safety to ensure public safety is maintained.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

Nil

5.2.4 DISTRIBUTION SUBSTATIONS AND VOLTAGE REGULATORS

The following sections set out the project proposals for distribution substations and voltage regulators.

GROUND MOUNT DISTRIBUTION SWITCHGEAR (OIL) RENEWAL

NEED

Vector's population of ground mounted oil filled distribution switchgear is approximately 9,589 tanks (discrete oil tanks), these tanks make up 4,100 distribution substation sites. Of these, 80% are in the Auckland network.

The present replacement strategy relies on a deterioration in condition being identified by routine maintenance inspections and replacement undertaken as required based on the identification of risks under the corrective maintenance programme. In addition, approximately 2% of the population also ends up replaced due to customer initiated growth or relocation projects. The concern is with a population of similar age profiles all approaching the end of expected service life together. The risk of a sudden increase in deterioration of a large population group is likely and may encompass a greater number of assets that can be attended to under the budgeted corrective maintenance programme, resulting in increased asset failures.

As of 2018, approximately 720 tanks are already older than 50 years. The oldest unit dates from 1959 and a number of units date from 1960, 1961 and 1962. By 2028 another 2000 units will also be 50 years old. The average age of our RMU population is 26.5 years. Additionally, there are presently 1,291 SD Series 1 units in service on the network which have a known risk of failure inherent with their original design (see Section 4.1.5). These units also need to be replaced in the next 10 years to remove the SD Series 1 risk of catastrophic failure from the network. It is highly questionable that we can continue to stretch the service life of our ageing distribution switches beyond 60 years through the existing maintenance programme, due to the risk of material fatigue leading to equipment failure, especially as there are parts in the switches which cannot be maintained or replaced individually. The planned program will see replacement of ~ 3,250 tanks over the AMP period that will reduce the population age to an average of 20 years. The program of works will be based on condition and criticality.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Retain current programme of condition related replacement alone	Escalating maintenance costs	Rejected: High risk of sudden increase in deterioration / asset failures is likely and may encompass a greater number of assets that can be attended to under the budgeted corrective maintenance programme. This will have a negative impact on SAIDI and Asset Safety Incident rate service level.	Continued impact on SAIDI and thus worsening customer experience of the quality of Vector's electricity supply. Risk of catastrophic failure of oil switchgear resulting in a risk to operational staff and the public
2	Undertake a staged and scheduled programme of works to renew oil switchgear prioritised by condition and criticality	$113.0m	Selected: The program of works will see ~ 3250 tanks replaced which represents ~ 34% of the assets. The average population age of 26.5 years will reduce to 20 years by the end of the AMP period	Compared to the 'Do Nothing' option, the number of potential customer interruptions due to avoided RMU failures is 235,277 over the 10-year AMP period. This avoids an estimated 4% per annum increase in customer interruption. This program of works will thus improve SAIDI and will reduce the health and safety risk to the public and operational staff

PREFERRED OPTION

The preferred option is to undertake a staged and scheduled programme that will extend over a number of years to renew ground mounted oil filled distribution switchgear prioritised by condition and criticality.

The works programme covered in this needs requirement is in line with Vector's asset strategy for this asset type, strategy document EAA501 Distribution Network.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland RMU replacement	6.40	6.40	7.00	8.50	9.50	10.00	10.00	10.00	10.00	10.00	87.80
Northern RMU replacement	1.60	1.60	2.00	2.50	2.50	3.00	3.00	3.00	3.00	3.00	25.20
Total	8.00	8.00	9.00	11.00	12.00	13.00	13.00	13.00	13.00	13.00	113.00

5.2.5 SECONDARY SYSTEMS AND OTHER NETWORK ASSETS

The following sections set out the project proposals for Vector's secondary systems and other network assets.

AUCKLAND AND NORTHERN DC SYSTEMS REPLACEMENT

NEED

Proper functioning of protection systems and reinstatement of electricity in zone substations post a fault are reliant on able and trustworthy 110 V DC systems. The 110 V DC system is continuously charged as a back-up power supply in the event of an AC outage on site.

In 2016, a DC charger failure incident occurred at Keeling Road substation, which failed to alert the SCADA master station (at the EOC) and locked out the substation protection and control system. It was identified that the DC system alarms were not correctly calibrated to the master SCADA station. Following the incident, a comprehensive assessment was completed on DC systems at all zone substations in the Northern region.

Additionally, similar asset observations have recently been identified at zone substations within the Auckland region. A comprehensive DC system assessment shall be completed at all zone substations in the Auckland region, as for the assessments completed in the Northern region. All corrective actions identified during the DC assessments shall be completed in both the Northern and Auckland regions to ensure DC systems, and associated SCADA alarms, meet their functional requirements for the successful operation of zone substations.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual - do not address the identified need for the DC system assessments and associated corrective actions	Nil	Rejected: Failure to assess and subsequently correct potential issues with DC systems and associated SCADA alarms, may result in extended unplanned outage events	Customers are at risk of extended unplanned events. Zene substation assets at risk of maloperation, failure, fire
2	Undertake a scheduled programme of works to complete DC system assessments in the Auckland region and complete all corrective actions in both Auckland and Northern regions	$2.5m	Selected option: Complete assessments on DC Systems in the Northern region and correct all identified asset observations in both Auckland and Northern regions	Significantly improve DC Systems' asset reliability and security of supply to customers, and the avoidance of consequent SAIDI risk

PREFERRED OPTION

Undertake a scheduled programme of works to complete DC System assessments in the Auckland region and complete all corrective actions in both Auckland and Northern regions.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland DC systems replacement	0.25	0.25	0.25	0.25	0.25						1.25
Northern DC systems replacement	0.25	0.25	0.25	0.25	0.25						1.25
Total	0.50	0.50	0.50	0.50	0.50						2.50

REPLACE AUCKLAND LOAD MANAGEMENT PC85 LOAD CONTROLLERS

NEED

Vector regularly offers into the New Zealand Electricity Market tranches of up to approximately 80 MW of a total available 100 MW controllable hot water load within the Auckland electricity network. This assists with peak power shifting and allows for deferral of CAPEX projects.

The 1980's Plessey/GPT PC85 load controller provides the local and remote SCADA control interface at the 13 Auckland zone substations that have this load management function. A Landis+Gyr power line carrier ripple plant then adds a 475 Hertz signal onto the substation 22 kV and 33 kV subtransmission circuits to signal customers hot water cylinders and Auckland Transport's street lights on and off. This system has a minimum 15-year projected life before a new technology solution would be completely rolled out across the network.

All PC85 controllers require replacement, with the first completed in FY18. They are at the end of their life, are an unsupported product, with no spares available from the supplier. Units have been failing over the last 3 years, only 3 of the original 12 units are fully functioning and further failures will result in permanent loss of load control. Replacement will also allow decommissioning of the similarly end of life and unsupported Nokia-based communication system.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need and continue to rely on the existing system	$0 capital investment but continued maintenance costs and callouts for Vector and Auckland Transport.	Rejected: Reliance on the existing controller holds unacceptable risks to performance for the Auckland network customers and Auckland Transport	Unpredictable failure with no recovery option. Non-control of street lighting is a risk to Public safety and reputation for Auckland Transport and Vector Loss of ability to offer controllable load into the Energy Market risks loss of reputation and revenue
2	Replace the PC85 controller with a modern equivalent configured for the Auckland ripple control system	$0.78M	Selected option. To remove the risk of single mode failure of the load control system in the Auckland network	Very low post investment risk. Product operationally proven at Rosebank zone substation in FY18. Reduced risk of wide spread network non-availability of load management. Reduced risk to public safety of street lighting not being available. Removal of end of life and unsupported Nokia-based communication system. Assists in deferring CAPEX to later years.

PREFERRED OPTION

Vector will undertake a programme of works to upgrade the reliability of the load management system within its Auckland network by replacing the PC85 controller. The work will consist of the installation of new controllers at the twelve zone substation ripple plant sites.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Ripple plant PC85 controller replacement	0.39	0.39									0.78
Total	0.39	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78

PENROSE - HOBSON TUNNEL SYSTEMS UPGRADE PROGRAMME

NEED

The Penrose to Hobson Tunnel contains Vector's 110 kV, 33 kV and 22 kV subtransmission cables from Transpower GXPs and between Vector's CBD bulk supply zone substations. The tunnel also contains Transpower's 220 kV North Auckland and Northern cable from Penrose GXP to Vector's Hobson Street zone substation. Transpower has shared access rights for the tunnel.

The tunnel was commissioned in 2001 and the auxiliary systems necessary for personnel safety and performance of the power cables are now progressively starting to fail having reached end of life. To also ensure maintenance and emergency access these systems cannot be run to failure. This includes the service train within the tunnel, that is subject to New Zealand Transport Authority regulations for rail safety. Furthermore, the tunnel is classed as a confined space that requires strict entry requirements and these specified auxiliary systems to be operational 24/7.

For an auxiliary system failure there is a health and safety risk, which could result in the Asset Safety Incident Rate being increased (see Section 2.3.8). To ensure the integrity and safe operation of personnel and plant within this strategic asset there is a need to replace and refurbish auxiliary systems inclusive of the rail and its anchor systems.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Retain ageing and failing auxiliary systems including rails and rail anchors	Continued and escalating maintenance costs	Rejected: Not undertaking replacement or refurbishment works will result in continued and escalating maintenance costs and the risk that plant will be operated to failure. This runs the risk that that the tunnel cannot be safely operated and entered for regular maintenance or emergencies. Failure of auxiliary systems poses a risk to the continued operation of Vector and Transpower primary plant required for supply to Auckland CBD, North Auckland and Northern customers	A Health and Safety risk to personnel and contravention of the New Zealand Transport Authority statutory Rail Act. Failure of primary plant has the potential to seriously impact reliability indices and SoSS should auxiliary plant fail. Reputational risk with Transpower, Electricity Commission, New Zealand Government and Councils
2	Undertake a staged and scheduled programme of works to replace and refurbish auxiliary systems in the tunnel	$4.17m	Selected option Undertaking a staged and scheduled programme of works will ensure continued operation and maintenance of the primary plant in the tunnel. It will also correctly manage the Health and Safety risks to personnel that work in the tunnel	Low risk of contravening New Zealand Transport Authority statutory rail safety regulations Low risk of a HILP event of failure of primary plant and consequently a low risk of an impact on SAIDI Low risk of a reputational HILP event

PREFERRED OPTION

The preferred option is to continue a proven programme of works to replace auxiliary systems in the tunnel based on performance condition, history of failures, and the ability of vendors to provide continued and reliable product and software support. The option includes a long-term programme to replace rails and rail anchors for safe operation of the light rail train.

Further details of the programme for the Penrose tunnel can be found in a suite of asset strategy and operational documents: EOS 018.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Tunnel - rail track and anchor replace	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.47
Tunnel - control room new	0.10										0.10
Tunnel - Newmarket egress ladder compliance new	0.15										0.15
Tunnel - Nokia radio system replace	0.40										0.40
Tunnel - Penrose portal replacement of cable supports	0.03	0.38									0.41
Tunnel - lift replacement	0.05	0.60									0.65
Tunnel - ventilation motor replace	0.11								0.45		0.56
Tunnel - atmospheric sensors replace		0.09				0.09					0.19
Tunnel - UPS replace				0.09							0.09
Tunnel - train, generator, rolling stock replace			0.05					0.05			0.09
Tunnel - SCADA EOC HMI replace					0.09						0.09
Tunnel - PLC replace					0.18						0.18
Tunnel - Newmarket plant room lv reinforce					0.20						0.20
Tunnel - drainage system										0.10	0.10
Tunnel - fire main valve replace						0.14					0.14
Tunnel - Newmarket plant room exterior replace										0.05	0.05
Tunnel - airlock security new						0.09					0.09
Tunnel - ventilation variable speed drive replace										0.20	0.20
Total	0.88	1.12	0.09	0.14	0.52	0.38	0.05	0.09	0.50	0.40	4.17

QUAY STREET 22 KV CIRCUIT BREAKER FAIL PROTECTION INSTALLATION

NEED

Quay Street 22 kV substation is a critical node within Auckland's CBD and supplies amongst others electricity to Ports of Auckland and Parnell. It is not able to have suitable protection settings applied to the bus section CB to allow grading with adjacent protections. This means that if an outgoing feeder CB fails to clear a fault, all 22 kV incomers will trip to clear the fault, resulting in the loss of Quay Street 22 kV, Quay Street 11 kV and Parnell 22 kV. This would result in widespread critical failure for a vital region for New Zealand's economy with the potential to compromise national productivity with the loss of supply to the country's largest CBD.

The current standard for new substations is to install circuit breaker fail (CBF) protection. However, Quay Street 22 kV predates CBF being applied as standard and does not have it installed.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Do not install CBF protection	Nil	Rejected. This will result in increased risk widespread outage for failure of a CB	Risk of losing multiple zone substations following CB failure impacting on SAIDI and reputational damage
2	Retrofit CBF protection to existing numerical protection relays	$0.2m	Selected option. Reduces SAIDI and reputational risk	The amount of demand lost following a CB failure is drastically reduced, resulting in reduced SAIDI and reputational risk

PREFERRED OPTION

The preferred option is to retrospectively install CBF protection at Quay Street 22 kV. CBF responds to a failed CB by only disconnecting the minimum circuits to clear the fault. This means that only one busbar section at Quay Street 22 kV substation would be cleared, leaving the remainder in service. If all other circuits were previously in service prior to the fault, there would be no loss of supply at Quay Street 11 kV and Parnell 11 kV and a reduced loss of supply at Quay Street 22 kV.

CBF protection also has the advantage of faster fault clearance than relying on backup protection, hence reducing the stress on equipment in the event of a CB failure.

CBF can be implemented within existing protection relays at Quay Street 22 kV. This would require reconfiguration and testing of the existing protection relays.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Quay Street zone substation 22 kV CBFail installation	0.20										0.20

Total	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20

UPGRADE OF SCADA COMMUNICATIONS AND CONTROLLERS TO 11 KV POLE-MOUNTED SWITCHES

NEED

There are 295 11 kV network switches with SCADA remote control ability on Vector's 11 kV overhead network. Of these units 56 use Very High Frequency (VHF) radio for communications and the remainder use 2G cellular communications. The EOC can remotely control pole mounted 11 kV switches to isolate faulted sections of the network and restore healthy sections of the network. The ability to operate 11 kV network switching devices decreases outage times because it negates the requirement for operating personnel to drive from switch to switch.

Data and communications between the EOC and the communications modules on 11 kV network switches are via the Conitel protocol and VHF analog radio. The VHF radio system has reached its end of life and the Conitel protocol is obsolete and firmware and software cannot be updated. Intermediate protocol convertors are required and this has resulted in loss of information and loss of SCADA visibility in the EOC of the status of 11 kV switches.

Furthermore, the 2G cellular network does not provide sufficient coverage and there is a need to upgrade the 2G network.

Generally, there is a need to replace the communications system and controllers to existing 11 kV pole mounted network switches in Vector's 11 kV overhead distribution network.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need and continue to use the existing communications systems and controllers	Continued maintenance costs	Rejected: The existing communications system is not fit for purpose any longer and the protocol is not technically supported	A risk of no visibility of the status of 11 kV switches and the risk of not being able to remotely operate switches. Non-visibility poses a health and safety risk to field personnel. Not being able to operate switches remotely poses a risk to the SAIDI reliability index
2	Repurpose the VHF voice frequency allocation and upgrade the existing analog radio repeaters with modern Ethernet enabled digital radios. Upgrade 2G units with dual SIM capable of communicating to multiple service providers and convert to 5G in the longer term	$4.21m	Selected option A proper communications system to pole mounted 11 kV switches will ensure safe and reliable operation	Low risk of no visibility of the states of 11 kV pole mounted switches. Reduced impact on SAIDI because of ability to undertake remote SCADA switching

PREFERRED OPTION

Vector will undertake a scheduled and staged programme to upgrade the communications to its 11 kV pole mounted distribution network switches on its 11 kV overhead network. The works will consist of the repurposing of VHF radio frequency allocation, upgrade of five analogue radio repeaters and instatement of a digital voice communications network and replacement of controllers.

Vector will upgrade its 2G cellular devices to dual SIM enabled units that will give Vector the ability to switch between service providers during periods of poor communications from one service provider. In the longer term the network will be upgraded to 5G.

Vector will continue to use the communications network of Vector Communications and will leverage of new initiatives that are currently under way to deploy new technologies that will improve coverage areas. This programme of works is in line with Vector's asset strategy EAA807 SCADA and SICAM PAS Systems.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland upgrade SCADA communications to 11 kV pole mounted switches	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	1.75
Northern upgrade SCADA communications to 11 kV pole mounted switches	0.20	0.20	0.22	0.26	0.26	0.26	0.26	0.26	0.26	0.26	2.46
Total	0.38	0.38	0.40	0.44	0.44	0.44	0.44	0.44	0.44	0.44	4.21

AUCKLAND AND NORTHERN PQM REPLACEMENT PROGRAMME

NEED

The purpose of power quality indexes and measurement is to record power system disturbance levels. Power quality monitoring is a mixture of data gathering and measurement of power quality items such as frequency distortions, supply interruptions, voltage dips, sags and swells, supply voltage variations, flicker and transients. PQM meters are used to analyse faults, peak demand and also act as a check meter for energy flow through zone substation revenue meters.

Vector's main measuring points are at zone substation nodes. The PQM metering population median age is approaching 17 years and meters cannot be upgraded with the latest PQM reporting software. Some older PQM meters have failed and the software versions in older meters are unsupported. To ensure continued visibility of the quality of the power supply at zone substation busbars PQM meters must be replaced.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Continue to use existing first generation PQM meters for which software is not supported anymore	Nil	Rejected. Some older meters have failed and the software used in older meters is not supported anymore	Risk of not being able to measure and analyse the quality of power and peak demand at the source of supplies to the distribution network
2	Undertake a staged and scheduled programme of works to replace PQM meters	$2.28m	Selected option. Improves visibility of the network peak demand, provides a check of energy flow through revenue meters, allows post incident network parameter analysis and allows reporting on power quality	Allows Vector to monitor its compliance with power quality standards

PREFERRED OPTION

Undertake a staged and scheduled long term programme to replace PQM meters in 28 zone substations. The proposed scope of this programme accords with Vector's asset strategy EAA803 Power Quality Metering.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland PQM replacements	0.26	0.33	0.07	0.07	0.07	0.07	0.13	0.13	0.13	0.13	1.37
Northern PQM replacements	0.07	0.07	0.07	0.07	0.07	0.07	0.13	0.13	0.13	0.13	0.91
Total	0.33	0.39	0.13	0.13	0.13	0.13	0.26	0.26	0.26	0.26	2.28

WIDE AREA NETWORKS ROUTERS AND COMMUNICATIONS CABLES UPGRADE

NEED

Vector's zone substations are interfaced to the WAN and the SCADA master station in the EOC via routers in SCADA panels at zone substations. Routers were previously owned by Vector Communications but under a recent agreement ownership of these units was transferred to Vector networks so the asset strategy for this class of equipment is not yet fully developed. What is known is that the majority of routers are Cisco model 2811 routers for which there is very little software support, replacement spares are becoming an issue to source and software security updates cannot implemented to an appropriate level to ensure breach of SCADA is a low risk.

Notwithstanding the rollout of a fibre optic communications network that has been going for a number of years there are still communications channels, for SCADA and unit differential protection communications, between a number of zone substations and from zone substations to wide area network primary nodes that consist of copper cables. These copper communications and differential protection cables have been in service for circa 50 to 60 years and are thus aged, failing and heavily committed, i.e. little or no spare channels. A major risk to Vector is loss of communications and visibility due to deterioration of the insulation of individual cores to a point where they come in contact with other cores. Cable joints are also a source of failure where moisture ingress causes low resistance between cores and then result in failures of joints.

Going into the future there is a need to replace copper cables with fibre optic networks not only for the sake of replacement of the ageing copper based assets but to make the network ready for future communications requirements. In conjunction with replacing copper pilot cables with a fibre optic network there is also a need to replace first generation routers with modern communications network routers.

There is a need to replace the existing routers with new generation routers notwithstanding that the asset strategy for this plant is still a work in progress.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Business as usual - do not address the identified need and continue to use the existing unsupported routers and continue to rely on	Continued and escalating maintenance costs	Rejected: The existing routers are not supported technically and no security updates are available. Copper communications cables are failing	Unreliable WAN connections at zone substations holds the risk of no visibility of the status of zone substation plant and the risk of not being able to remotely operate CBs.

	ageing copper communications cables			This in turn holds a health and safety risk to field personnel. Furthermore, not being able to operate switches remotely poses a risk to the SAIDI reliability index as there will be reliance on field staff to provide information
2	Replace existing routers with new generation routers Replace copper communications cables with fibre optic cables	$8.30m	Selected option Modern technically supported routers and fibre optic communications channels will ensure a reliable SCADA network for the future	Low risk of non-visibility of the state of zone substation equipment. New routers will also reduce the risk of hacking into the communications and data network. Visibility and the ability to remotely control plant will reduce the risk to SAIDI and SoSS

PREFERRED OPTION

Vector will undertake a scheduled and staged programme to replace WAN routers in its zone substations and replace failing copper communications cables with fibre optic cables.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland WAN routers and communications cables upgrade	0.44	0.49	0.54	0.54	0.54	0.57	0.59	0.43			4.15
Southern WAN routers and communications cables upgrade	0.44	0.49	0.54	0.54	0.54	0.57	0.59	0.43			4.15
Total	0.89	0.99	1.09	1.09	1.09	1.14	1.19	0.85	0.00	0.00	8.30

UPGRADE NORTHERN SCADA MICROWAVE WIDE AREA NETWORK

NEED

The WAN for SCADA in the northernmost region of Vector's supply area consists of digital microwave radio communications links. The system provides voice over IP and data communications. The existing digital microwave radio WAN consists of a star configured network with very limited redundancy and if the digital mobile radio link between Vector's Albany Heights repeater station in the northern suburbs and its Kraacks Hill repeater station further north in the rural precincts should fail, the northernmost region will be without SCADA visibility and reliant on field staff to switch the network. It must be noted that the upper reaches of Vector's network is also the area in which Vector will install two large BESS, at Warkworth South and in Snells Beach. This places even more importance on the requirement to have robust and redundant SCADA connectivity and communications in place to optimize the use of the battery storage systems in the network.

There is a need to address the limitations of the northern WAN to ensure reliable network visibility, robust communications channels and control from the SCADA master station. There are implications to SAIDI and health and safety if this is not addressed as the non-visibility of the network leads to longer restoration times, with switching needing to be undertaken by field staff rather than remote control.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need and continue to rely on the existing star configured single mode failure digital mobile radio network in the northern supply region	$0 capital investment but continued maintenance costs. Also, the additional cost of personnel for manual switching	Rejected: Reliance on the existing star configured digital microwave radio system with single mode failure holds unacceptable risks	Single communications paths with no redundancy holds the risk of no visibility of the northern region network should a failure occur. This holds a Health and Safety risk because switching will have to be undertaken by field staff. Non-visibility of the network also holds risk to the SAIDI reliability index because of longer times to restore the network for a loss of communications
2	Install a redundant digital mobile radio system between Albany Heights and Kraacks Hill. Install fibre optic communications network in certain segments	$0.5m	Selected option To remove the risk of single mode failure installation of a 2nd digital microwave radio link is the selected option	Reduced risk of non-availability of SCADA of the northern network. A reduced risk of impact on SAIDI because remote control will be available

PREFERRED OPTION

Vector will undertake a programme of works to upgrade the reliability of the digital mobile radio system in its northern network. The work will consist of the installation of redundant digital microwave radio links and the installation of fibre optic cables on certain segments of the WAN in the region. This is in line with Vector's asset strategy EAA804 Communication Systems.

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Northern microwave communications link alternative link	0.05	0.15	0.30								0.50
Total	0.05	0.15	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50

AUCKLAND AND NORTHERN ZONE SUBSTATION RTU REPLACEMENT PROGRAMME

NEED

The RTU located at Vector's zone substations provide an essential part of the SCADA system to collect status information from site and allow remote control of plant at site.

The maximum anticipated life of an RTU is 20 years. As an RTU approaches end of life, reliability suffers, requiring more frequent maintenance. Also, older RTUs are no longer supported by suppliers and spares are difficult to get hold of.

When an RTU fails, situational awareness of what is happening at site is lost, so EOC is unable to receive updates of events from the site or remotely control equipment. Hence, the controller is unable to effectively respond to any emerging emergency. Coincidental failure of RTUs across a number of sites will exacerbate the situation.

There are implications to SAIDI as well as Health and Safety if there is no remote visibility of zone substations. This will lead to longer restoration times because of manual switching undertaken by field staff rather than remote control. Manual switching holds increases the risk to the safety of personnel.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Do not replace RTUs until failure	Nil	Rejected: This will result in loss of situational awareness whilst a new RTU is installed	Risk of RTUs failing, resulting in loss of situational awareness at site which may coincide with emergency situations in the field. This presents a risk to SAIDI and the Health and Safety of operating personnel Increased OPEX
2	Undertake a staged and scheduled programme of works to replace RTUs	$2.70m	Selected option: Allows continued reliable monitoring and control of substations and the ability to effectively respond to emergency situations	The risk of failure is reduced, giving reliable remote operation of the power system. Reduced risk of negative impact on SAIDI and reduced Health and Safety risk to operating personnel

PREFERRED OPTION

Vector have an ongoing programme to proactively replace RTUs approaching end of life to ensure adequate reliability is maintained hence remote control of substations in not impaired and the preferred option is to continue with this programme to replace RTUs.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland RTU replacement	0.20	0.70	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2.50
Northern RTU replacement	0.10	0.10									0.20
Total	0.30	0.80	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	2.70

AUCKLAND AND NORTHERN SUBTRANSMISSION PROTECTION UPGRADE PROGRAMME

NEED

There are two scenarios for subtransmission protection in Vector's network:

Auckland network: subtransmission circuits are generally radial feeds (duplicated or triplicated) to zone substations and historically used pilot wire protection

Northern network: which is a reconfigurable meshed network that historically used distance protection at GXPs and directional protection at individual zone substations

The Auckland network currently uses electromechanical pilot wire protection schemes, which are reliant on aged copper pilots that are reaching the end of life in addition to the protection relays also approaching or past anticipated end of life (40 years). Also, electromechanical pilotwire protection does not have supervision facilities, so asset observations can only be found through routine maintenance. As the pilot wires degrade and the relays age, there is an increasing risk that the protection relays may not operate when required to do so or may operate for out-of-zone faults. This gives an increased risk of wider-spread disturbance to the power system and potential to lose supply to entire zone substations.

The Northern network currently uses distance/directional protection schemes. The Northern network has large sections of overhead lines where two subtransmission circuits share the same pole, often with underbuilt distribution circuits. This results in potential mal-operation of protection caused by mutual coupling between the circuits, or the fault spreading from one circuit to the other adjacent circuits, resulting in genuine operation of the protection. There have been a number of high SAIDI outages caused by these scenarios in recent years as there is potential to lose supply to multiple zone substations due to the meshed nature of the Northern network. Also, most of the existing distance protection relays are approaching end of life (20 years) and a number of failures have been experienced recently.

There are implications to SAIDI and Health and Safety if this need is not addressed as failure of ageing copper protection communications channels result in non-visibility of the network and undue tripping of subtransmission circuits.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Do not upgrade the scheme	Nil	Rejected: This will result in increased risk failure of the protection relays to operate correctly	Risk of protection relays failing, or unwanted operation resulting in unplanned high SAIDI outages
2	Undertake a staged and scheduled programme of works to replace existing protection schemes with modern fibre based differential protection schemes	$4.88m	Selected option: Reduces risk of failure of protection relays	The risk of failure is reduced, therefore reducing the risk of unplanned outages to replace and the risk of incorrect operation when protection is required. Risk of mutual coupling in Northern network removed. Overall risk of wider spread network outages reduced

PREFERRED OPTION

Differential protection is immune to mutual coupling and may reduce the risk of faults spreading between adjacent circuits through faster operation. New protection types also have further advantages, such as increased functionality, self-monitoring, remote event and fault record retrieval and greater sensitivity to earth faults. Self-monitoring gives the advantage of doubling maintenance intervals, hence OPEX saving.

The preferred option is to undertake a staged and scheduled programme to replace/upgrade protection systems for affected subtransmission feeders.

The proposed scope of this programme accords with Vector's asset strategy EAA801 GXP and Zone Substations and EAA804 Communications Systems.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland subtransmission protection upgrade	1.00	1.00	0.91	0.35							3.26
Northern subtransmission protection upgrade	0.92	0.01	0.40	0.30							1.63
Total	1.92	1.00	1.31	0.65	0.00	0.00	0.00	0.00	0.00	0.00	4.88

AUCKLAND AND NORTHERN TMS REPLACEMENT PROGRAMME

NEED

The TMS in Vector's zone substations provide the essential functions to automatically maintain substation busbar voltages within predetermined limits. This allows Vector to meet statutory requirements for voltage levels at customers' premises. This also protects Vector's equipment from overvoltage.

There are three types of legacy TMS systems on the network, which have different drivers for replacement: electromechanical, static (electronic components) and PLC. As any of these device types reach end of life, they become unreliable, requiring more frequent emergency maintenance. Electromechanical and static systems are proving increasingly unreliable. Also, older TMSs are no longer supported by suppliers, spares are difficult to get hold of and there is a lack of knowledge in FSP's. The PLC type in particular lacks support, including knowledge within Vector.

When a TMS fails, the ability to automatically regulate busbar voltage is lost. This requires EOC to manually tap transformers to maintain busbar voltages or place in fixed tap. This increases the risk of violating statutory voltage limits or causing damage to Vector equipment, especially if there is a system event causing rapid change in voltage.

There are implications to SAIDI if this need is not addressed as loss of voltage control could lead to damage of long lead primary plant such as zone substation power transformers.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Do not replace TMSs until failure	Nil	Rejected. This will result in increased risk of failure of the TMSs and increased OPEX costs	Risk of TMSs failing, resulting in loss of automatic voltage control, resulting in greater risk of violation of statutory voltage levels and damage to equipment
2	Undertake a staged and scheduled programme of works to replace TMSs	$8.90m	Selected option. Allows ongoing reliable automatic control of busbar voltage levels and reduced OPEX costs	The risk of failure is reduced, reducing the risk of violation of statutory voltage levels and damage to equipment

PREFERRED OPTION

Vector has an ongoing programme to proactively replace TMSs approaching end of life to ensure adequate reliability is maintained hence voltages are maintained within statutory levels and the risk of damage to Vector's equipment is reduced. New TMSs also have further advantages, such as integral thermal monitoring and protection of the transformer, self-monitoring, remote diagnostics and increased situational awareness of the transformer status.

The preferred option is to undertake a staged and scheduled long term programme to replace TMSs in zone substations.

The proposed scope of this programme accords with Vector's asset strategy EAA802 Transformer Management Systems.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland TMS replacement	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.40	4.45

Northern TMS replacement	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.40	4.45
Total	**0.90**	**0.90**	**0.90**	**0.90**	**0.90**	**0.90**	**0.90**	**0.90**	**0.90**	**0.80**	**8.90**

AUCKLAND AND NORTHERN ZONE SUBSTATION PROTECTION UPGRADE PROGRAMME

NEED

The protection systems located at substations are essential to automatically detect fault conditions on the network and disconnect faulty equipment. This prevents damage to other equipment on the network and isolates equipment quickly that may pose a threat to public health.

There are three types of legacy protection equipment types, which have different asset replacement timescales: electromechanical, static (electronic components) and numerical. As any of these device types reach end of life, they become unreliable, requiring more frequent emergency maintenance or emergency replacement.

Electromechanical and static systems are all past or near end of anticipated maximum life of 40 and 20 years respectively. These systems do not have any self-monitoring and require more frequent planned maintenance to ensure reliability. First generation numerical relays are also approaching end of anticipate maximum life of 20 years and increased failure rate is being witnessed. These systems are more complicated to replace as they have increased (often bespoke) functionality to consider. Also, older protection devices are no longer supported by suppliers and spares are difficult to get hold of.

When a protection relay has failed, the associated circuit usually needs to be removed from service, increasing the risk to SAIDI on the power system. With older device types, like-for-like spares typically aren't available, so this requires prolonged outages whilst a new solution using modern equipment is designed and installed.

Also, operation of older protection may become unreliable and may not respond correctly to fault conditions. This may result in failure to trip, resulting in back-up protection operating and a wide spread disturbance on the network, impacting on SAIDI.

Vector has an ongoing programme to proactively replace protection systems approaching end of life to ensure adequate reliability is maintained. There are implications to SAIDI if this is not addressed as failure of a protection scheme means that the network will be reliant on the remaining circuits. Any failure of backup circuits will impact SAIDI.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Do not replace protection relays until failure	Nil	Rejected: This will result in increased risk of coincidental failure of the protection relays	Risk of protection relays failing, resulting in unplanned outages to replace or failure to operate correctly when required, resulting in wider spread network outages and impact on SAIDI. Increased OPEX costs
2	Undertake a staged and scheduled programme of works to replace protection relays at zone substations	$16.65m	Selected option: Reduces risk of failure of protection relays	The risk of failure is reduced, reducing the risk of unplanned outages to replace or failure to operate correctly when required. Reduced risk of associated wider spread network outages

PREFERRED OPTION

New protection types also have further advantages, such as increased functionality, self-monitoring, remote event and fault record retrieval and greater sensitivity to earth faults. Self-monitoring gives the advantage of doubling maintenance intervals, hence OPEX saving. The preferred option is to undertake a staged and scheduled long term programme to replace protection relays at zone substations.

The proposed scope of this programme accords with Vector's asset strategy EAA801 GXP and Zone Substations.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland zone substation protection upgrade	0.10	0.47	0.74	1.71	1.63	0.98	1.20	0.40	1.40	1.07	9.70
Northern zone substation protection upgrade	0.05	1.10	0.20	1.43	0.10	0.52	1.12	0.77	1.20	0.47	6.95
Total	0.15	1.57	0.94	3.14	1.73	1.50	2.32	1.17	2.60	1.54	16.65

AUCKLAND AND NORTHERN EXTENDED RESERVE

NEED

The provision of Extended Reserve is a statutory requirement in the Electricity Industry Participation Code. The Electricity Authority is replacing the current Automatic Under Frequency Load Shedding (AUFLS) scheme with the new Extended Reserve scheme, which is intended to be a low-cost and more efficient scheme consisting of four demand blocks of load. If load is not shed during frequency excursions, there is a risk of major loss of supply.

The Extended Reserve scheme uses a methodology which centrally selects demand units from the entire North Island and prioritises the disconnection of customers with the lowest cost of interruption. The new scheme may require up to 60% of Vector's demand to be armed for load shedding.

The transition to the Extended Reserve scheme requires the phased decommissioning of the existing AUFLS scheme. It requires the re-programming of existing numerical protection and control relays, and installation of some new protection relays dedicated to Extended Reserve.

In October 2017, the Electricity Authority decided to put the implementation of the Extended Reserve scheme on hold due to a number of technical and design issues. The Authority subsequently advised in April 2018 of its decision to obtain the findings of the System Operator's scheduled technical requirements review, which will inform the resolution of the design issues, prior to any further implementation of the Extended Reserve scheme.

OPTIONS CONSIDERED

Options to address the need identified above have been assessed and are summarised in the following table.

NO	OPTION	EXPECTED COST	REASON FOR SELECTING OR REJECTING	POST INVESTMENT RISK
1	Do not address the identified need at this stage. Do not replace TMSs until failure	Nil	Rejected. This will result in non-compliance of the Code	Non-compliance with the Code and risk of loss of supply during frequency excursions
2	Undertake a staged and scheduled programme of works	$1.80m	Selected option. Allows compliance with the Code	Load will be shed and this will reduce the risk of loss of supply during frequency excursions

PREFERRED OPTION
Comply with the Electricity Industry Participation Code and provide an Extended Reserve scheme

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Auckland extended reserves under frequency relays install	0.50	0.40									0.90
Northern extended reserves under frequency relays install	0.50	0.40									0.90
Total	1.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80

5.3 NON NETWORK ASSETS

5.3.1 INFORMATION SYSTEMS, PROCESSES AND DATA

Today's energy industry is entering a new age, where digital technologies are disrupting how electricity distributors all over the world are monitoring, controlling, and managing their grids. We are entering the age where consumer, device and grid connectivity enables intelligent interaction and orchestration of complex distributed and centralised systems. Exponentially competitive renewable energy sources are disrupting traditional energy distribution. To respond to this, Vector requires an extensive range of information and operational technology systems and platforms to be able to keep processing data and controlling the network to achieve the best outcomes for customers efficiently and safely.

To ensure our network is ready for the requirements of the future, Vector has recognised the current convergence of several technologies. This includes for example Cloud Computing, the IoTs, Machine Learning, and Big Data. Based on this, Vector has revised its technology strategies to better reflect the opportunities these technologies present for an organisation intending to create a new energy future for customers and partners.

We have grouped our Digital Strategy into three platforms;

- Customer Engagement Platform (CEP);
- Business Enablement Platform (BEP); and
- Operational Technology Platform (OT).

Investment horizons have been identified to reflect the changing nature of the industry and the requirement to focus in specific areas of investment over time. The three investment horizons are *Horizon 1* (FY19-FY20), *Horizon 2* (FY21 – FY25) and *Horizon 3* (FY26 – FY28). Detailed explanation of the targeted investments by horizon is provided in Section 5.3.3.

A transitional investment budget has also been identified separately to recognise the fact that the existing complex, legacy technology software platforms require investment to reduce cost of migration as they approach end of life. This cost of migration is associated with existing significant customisation, and reducing this complexity through microservices, will improve our ability to achieve efficient and cost-effective migration when they reach end of life. Further details of the transition investment can be found in Section 5.3.4.

CUSTOMER ENGAGEMENT PLATFORM
The CEP, is the first of three platforms to be developed as part of the Digital Strategy. This portfolio is focused on treating the experience Vector provides as a product, enabling the management, optimisation, and innovation of features to deliver exceptional customer experiences through improved transparency, customer choices and options to engage with Vector across the customer's journey – e.g. new connections, outages and customer support. We intend to use digital technology and platforms to improve the customer's experience by providing them with frictionless multi-channel, bi-directional and secure platforms for engagement with Vector and distribution of accurate, timely and relevant information surrounding network events, leading to a significantly reduced cost to serve and improved customer experiences.

Vector recognises that customer's expectations are rapidly changing and we are no longer being compared only to other Energy providers. Customers utilise Uber, Netflix and similar digital native organisations in their everyday lives, and expect a similar level of personalised and engaging interactions across all of their interactions with service providers. In this new world, customer experience is the currency through which organisations will be successful, and to deliver to these rapidly changing customer expectations Vector must ensure it develops fit for purpose and best in class digital customer engagement services to meet demand.

The technology roadmap for delivering the CEP has been defined in three different horizons, all explained in Section 5.3.3; *Horizon 1* (2019 - 2020) will focus on initial development to establish the foundational components of the platform, utilising customer journey mapping, best in class microservices architecture and agile 'DevOps' delivery methods. Specifically, standard services for customer support and customer operations as well as outage management will be developed, including online and digital-first self-service utilising artificial intelligence, chatbots and guided assistance alongside experienced and skilled service desk agents. Management of the core customer engagement point for Vector today, namely outages, will be improved through a program of work focussed on automating key back end functions and dramatically improving our ability to effectively communicate with customers through personalised and contextual channels, providing choice and transparency surrounding network events. These enhanced customer engagement capabilities will ensure that Vector can meet changing customer expectations for service providers and deliver best in class utility services at a lower cost.

For *Horizon 2* (2021 - 2025), Vector Digital will initially focus on executing a transformation of existing core customer applications towards the developed best in class digital customer services. For the latter part of Horizon 2, the strategic objective is to have completed the transition to digital customer services on the CEP. *Horizon 3* (2026-2028) will see the CEP further develop customer relationships through virtual agent-based channels and more sophisticated social media and distributed, customer controlled channel management. Horizon 3 expects to manage a significant increase in customer demand across more efficient and experience focused channels leading to better customer engagement and a reduced cost to serve. Continuous improvements will be of high importance to ensure that Vector Digital anticipates industry advances and reacts to the ever-changing customer expectations and technology landscape – not only in New Zealand but across the globe.

BUSINESS ENABLEMENT PLATFORM
The BEP is the second of three platforms. The BEP will provide new ways of doing business and is heavily focused on enabling Vector to significantly reduce the cost of complex, customised legacy platform migration and lifecycle maintenance due to the development of best in class micro services and the associated reduction in core system complexity. The platform will not only focus on developing and driving the automation and digitisation of core business processes; it will also develop new capabilities and leverage new technologies such as Gobal Positioning System monitoring, route optimisation, and analytics for field service teams while ensuring adherence to 'best in class' cost to serve and cost to acquire (i.e. new connections) economics. Enhanced digital capabilities will enable improved information flow in significant weather events across dimensions such as prioritisation, field crew logistics, system control and safety procedures, and actual repair times, all of which are inevitably dynamic and relatively hard to predict. In these significant weather circumstances, our focus will be on designing a system that recognises these non-steady state circumstances and optimises our customer channels to provide the best information at hand in such a manner that it allows our customers to plan and prepare adequately, while also operating effectively in largely predictable and steady-state situations.

The BEP will be delivered through the same high-level roadmap as the CEP: Horizon 1 (2019 - 2020) will focus on building the new capabilities and establishing the platform. These capabilities will include the development and definition of a standard service catalogue encompassing all key business enablement capabilities. The service catalogue will take the form of a series of standard behavioural and action oriented Application Programming Interfaces (APIs) encompassing all common business services required to effectively deliver and support network operations, such as field service planning, asset maintenance work order management, route optimisation and customer support. Providing this service catalogue will enable simple and direct access to key information and services to support delivery of customer engagement channels and network outcomes. These APIs will enable the rapid iteration of services, scalable and cost-effective platforms and generate significant improvements in Vector's ability to deliver favourable network outcomes for customers through increased transparency, access and lower cost to serve. The development of these common services will directly support the move away from monolithic and bespoke systems to standardised, scalable and fit for purpose business solutions and ensure that Vector has fit for purpose capabilities that can deliver lower total cost of ownership, faster cycle time and reduced cost of migration of its core platforms.

For Horizon 2 (2021 - 2025), Vector Digital will focus on transitioning the monolithic, legacy applications onto the newly developed microservices architecture and further enhance the core capabilities of the platform. In this context, the BEP provides a lightweight, highly scalable and cost effective digital platform capable of meeting these rapidly changing demands for service providers. In Horizon 3, Vector Digital will complete the integration and upgrades of the core ERP, Billing and Customer Relationship Management (CRM) systems with the common services APIs, and will leverage the positive results from the previous horizons.

OPERATIONAL TECHNOLOGY PLATFORM

The OT is the baseline enabling capability for potential future Energy IoT investments. The OT platform is focused on delivering increased visibility and control of our infrastructure and distributed energy assets and associated operations. The OT platform will ultimately target SAIDI and SAIFI, and other critical operational and customer metrics, however the necessity for this increased visibility will be highly dependent on expected changes in demand across the network.

The baseline investment for the OT platform will focus on upgrading the core SCADA platform as it approaches end of life and implementing a base DERMS. This will enable Vector to begin to connect to energy assets, collect data from them and enable effective real-time control of DERs.

The roadmap of work for the OT platform and the DERMS capability development has been described through the same horizons as the CEP and BEP, with further details in Section 5.3.3. On a high level, the target is to focus the first three years on developing a base OT layer (to connect, collect, and control) while also investing steadily in upgrading SCADA over time. The baseline investment in the OT platform will provide the building blocks for the Energy IoT Platform, which will be required to meet the expected demand growth and will be critical to meet Auckland's unique challenges in the future.

These expected changes in network demand due to continued population growth, rapid uptake of EVs, electrification of transport, distributed generation and increased demand from consumers means that Vector expects to increase IT and Operational Technology investments, as stated in the scenarios under Section 1.9. This additional investment in the Energy IoT platform will enable Vector to optimise the control layer across all touchpoints through DERMS, LV monitoring, residential load control, asset monitoring and management and intelligent networks, providing the ability to meet this expected growth and rapidly pivot towards unexpected growth and demand across the network.

The increased investment will be focused on deployment of sensors and collection of greater volumes of data from these sensors; improved insight capability to drive efficiencies and reduce risk exposure and to drive greater control and (near real-time to real time) automation across the grid and other key energy assets.

Vector believes that the Commerce Commission will play a critical role in enabling the achievement of the new energy future and the enablement of the Energy IoT Platform, through prudent, commercial decisions ensuring that future opportunities for innovation are not lost due to short sighted fixed investment decisions.

PROPOSED INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Information Systems, Processes and Data	18.50	12.21	17.33	18.06	18.72	18.30	14.02	12.99	11.57	11.38	153.09
Total	18.50	12.21	17.33	18.06	18.72	18.30	14.02	12.99	11.57	11.38	153.09

5.3.2 PLATFORM ARCHITECTURE

NETWORKS PLATFORM REFERENCE MODEL

Vector implements and manages its digital systems according to an overall Platform Reference Model (refer to Figure 5-1). This is comprised of the business process domains that are in turn supported by the underlying technology components of the technology reference model. The business domains are shown in greater detail in the following sections alongside an explanation of the capability required to deliver to the Networks business.

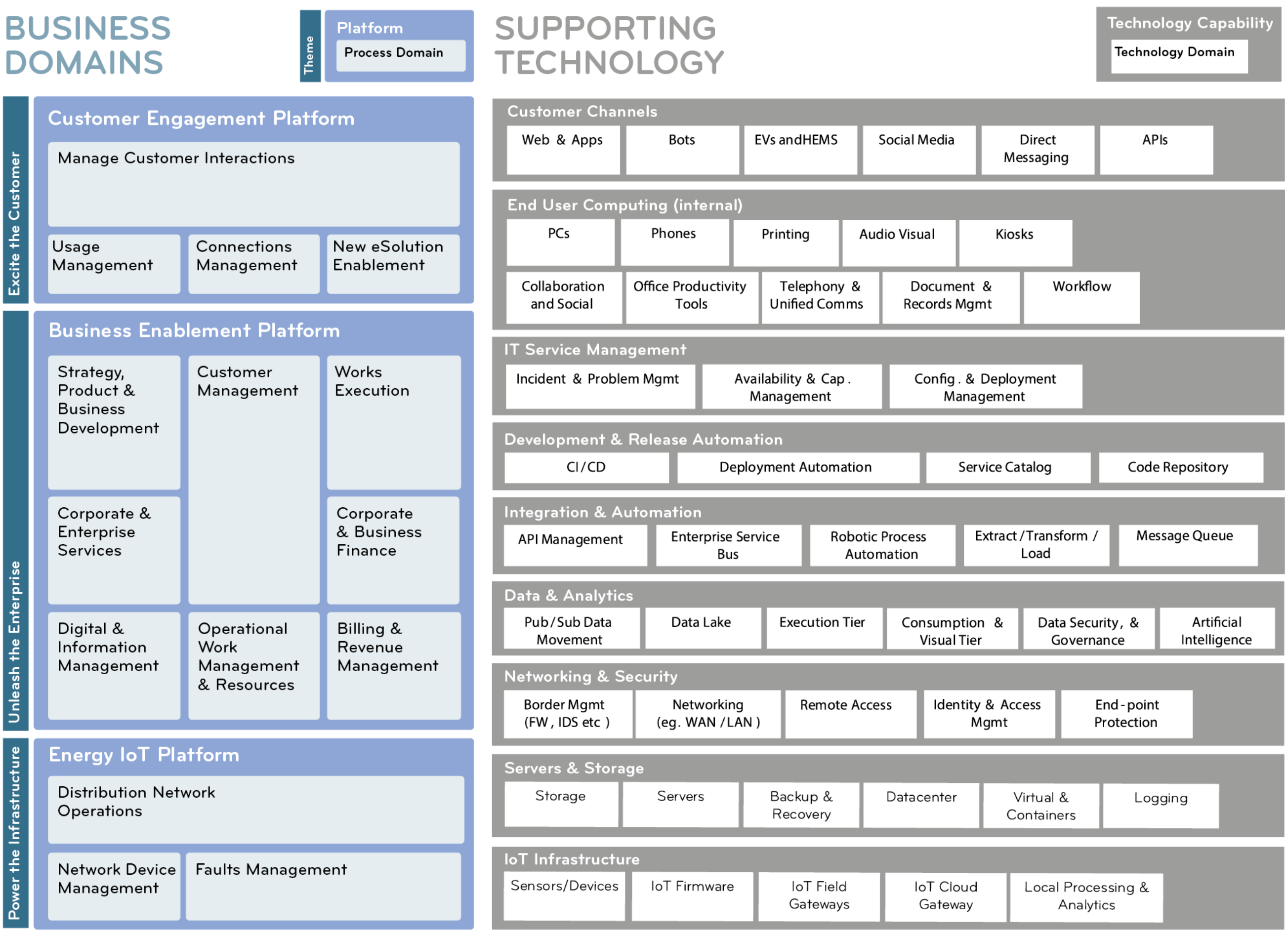

Figure 5-1 Vector's digital platform reference model

5.3.3 INVESTMENT HORIZONS

As defined in Section 5.3.1, strategic investments across the 10-year AMP period have been grouped into three horizons:

- Horizon 1: 2019-2020;
- Horizon 2: 2021-2025;
- Horizon 3: 2026-2028

In the following sections, each horizon is defined through the core digital enablement platforms (CEP, BEP, OT), with reference to the core objectives of each platform and horizon and the associated investment to achieve the objectives. As previously identified, the inherent uncertainty and potential for disruption in the industry through technological advances makes a 10-year prediction inherently challenging, and as such the level of specific detail is reduced over the later parts of Horizon 2 and into Horizon 3.

DIGITAL AUTOMATION OF PLATFORMS - CURRENT STATE (2018)

Figure 5-2 below depicts a summary of how well the business is currently automated and supported through digital technology in each of the business process domains. It shows that there is wide ranging use of technology to support the business but this is provided without high levels of maturity and optimisation in any one specific domain. This represents a good starting point but requires focussed investment and effort to ensure progression occurs to meet changing demand over time.

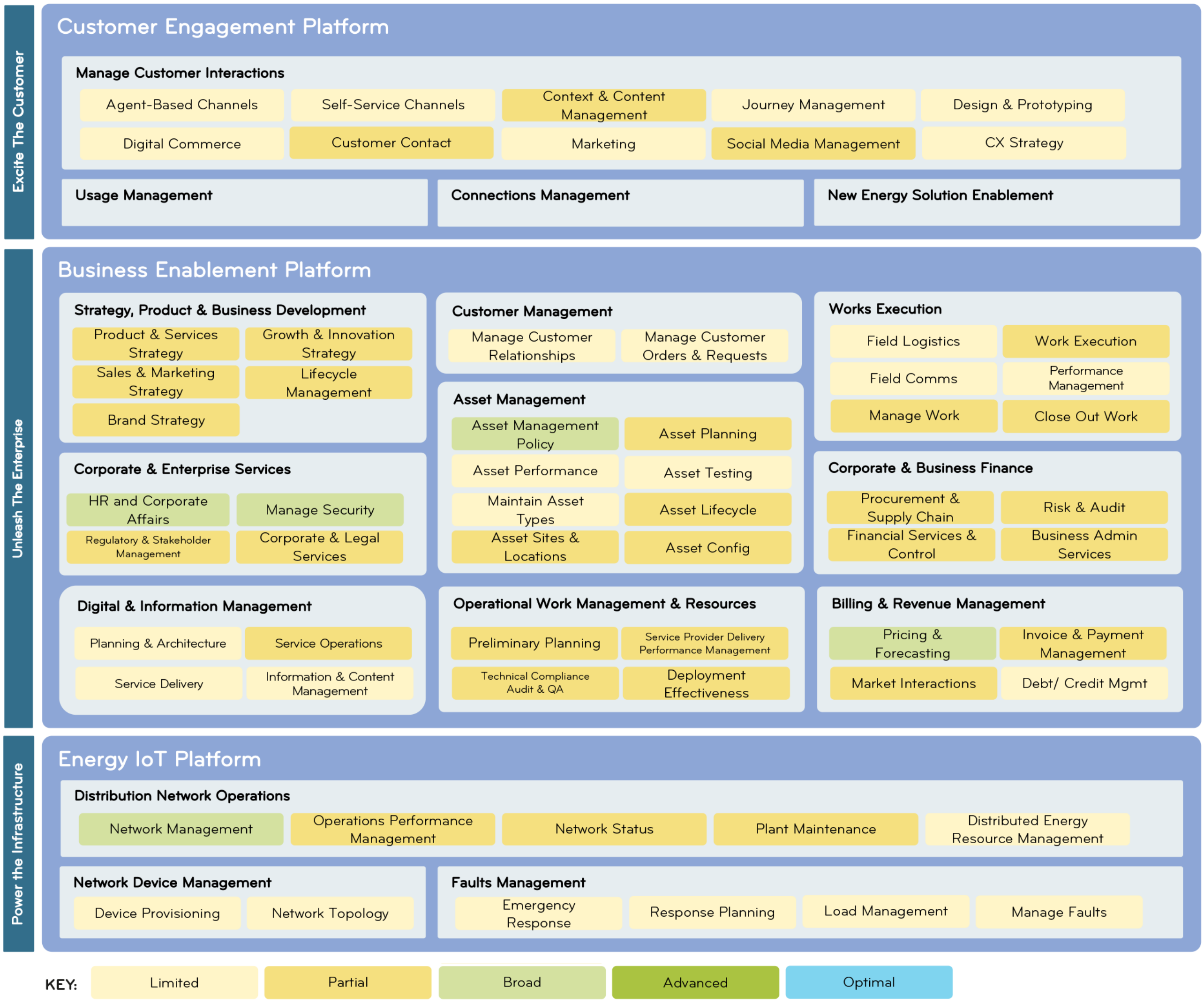

Figure 5-2 Vector's current digital enablement of platforms

DIGITAL AUTOMATION OF PLATFORMS – HORIZON 1 (2019-2020)

Horizon 1 is supported by detailed portfolio planning and broadly focusses on building new technology capability to support new demand areas, and rationalisation of existing legacy technology. The diagram below depicts the changes from the current state diagram above.

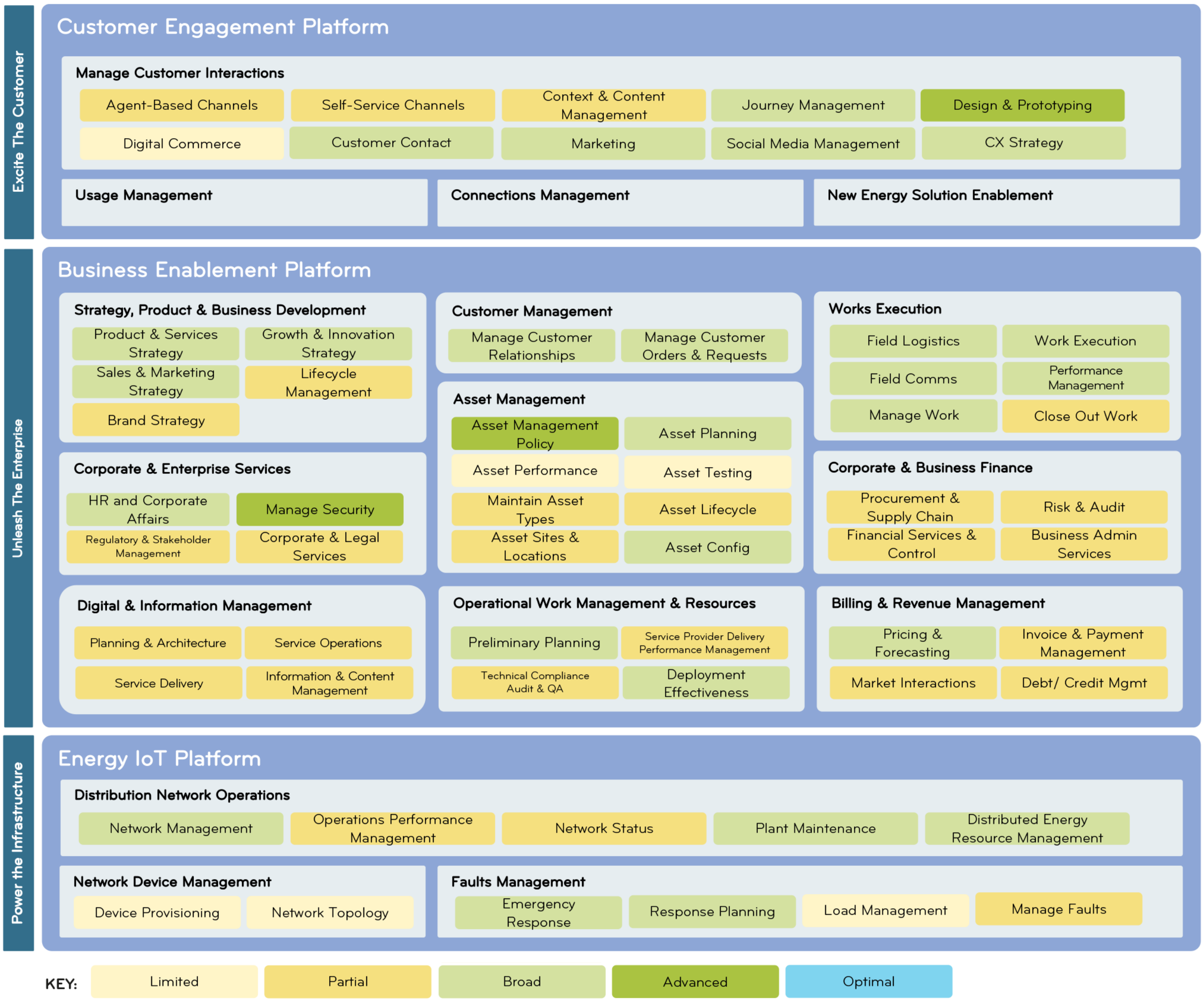

Figure 5-3 Digital automation of platforms – horizon 1 (2019 – 2020)

Customer Engagement Platform

As customer technology and expectations increase, so does the need for Vector to be able to enhance its customer engagement capability. Therefore, the technology roadmap for delivering the CEP will entail building and developing new capabilities in this first horizon. This initial development will establish the foundational components of the platform utilising customer journey mapping, best in class microservices architecture and agile 'DevOps' delivery methods.

The CEP investment will include developing scalable, responsive and multi-channel services for customer support and customer operations. This includes online and digital-first self-service, utilising artificial intelligence, chatbots and guided assistance alongside experienced and skilled service desk agents. Utilising these digital channels and investing in these capabilities will mean that Vector can more effectively deliver accurate, timely and relevant information to customers regarding outages, and any other interactions they have with Vector. The recent storm events provided deep insights surrounding customer behaviour, and validated the fact that customers wish to engage with Vector in multiple channels, for example websites, apps, short message service , social media and contact centre, and expect a best in class level of service across all of them. A significant proportion of the CEP investment in Horizon 1 is targeted towards improving these outcomes based on the lessons learnt following the recent significant storm activity. Advanced monitoring, integration into home energy management and personalised and contextual channels such as apps, websites and communication gateways will improve transparency surrounding significant network events and provide customers with choice as to the channels they engage in. These enhanced customer engagement capabilities will ensure that Vector can meet changing customer expectations for service providers and deliver best in class utility services at a lower cost.

Specifically, some of the challenges and associated outcomes that are achieved through the maturity changes from Current State (Figure 5-2) to Horizon 1 (Figure 5-3) are listed below:

- The initial focus of the Horizon 1 CEP investment on improving our ability to communicate and manage customers during outage events is on 4 key areas:
    - Modernise and automate existing customer facing digital communication channels, that cover outage monitoring and response. This will enable the public to report and view outages as well as track repair times; with an emphasis on security and auto-scaling to cope with heavy demands created by for example weather events;
    - Re-develop the existing Outage App to reflect the fact that it is now our customers' preferred channel of engagement, and was never designed to handle the load that it now receives on a regular basis. This re-development will include automated scaling of supporting infrastructure, improved ability to capture location and outage details and significant automation of the manual work required to provide information in the app that is relevant and timely;
    - Automate the creation of outages based on customer reports from any channel. Given Vector has very limited access to customer and LV network data and must rely heavily on retailers and our customers for this information, we can better capture and utilise the limited information we do have access to, by developing rule based automation platforms that can create unconfirmed outages for investigation based on customer reports;
    - Improved end to end communication with all Vectror stakeholders as Vector can provide much more accurate and up to date outage details between FSPs, customers, Civil Defence and other interested parties during network events such as heavy weather;

- In parallel to this development of the enhanced communication and engagement capabilities there will be significant Horizon 1 investment in re-defining and improving back end, manual and legacy processes under the BEP. This will be focussed on digitisation and automation of touchpoints between the operational centre, contact centre, storm response centre and our field technicians to improve information accuracy and reduce errors and associated information cycle time;
- Further the Horizon 1 CEP investment will provide network management and optimisation through demand side response initiatives focussed on encouraging efficient energy usage through direct customer interaction;
- Modernise and transform the contact centre and service desk operations to enable two way communications through digital channels of the customer's choice, including new and emerging channels such as digital assistants;
- Enable self-service and improved turnaround times for customer requests such as create and decommission ICPs, new connections and automate the management and execution of these;
- Enhance public safety by providing customers the ability to easily retrieve geographical information of Vector's electricity asset network before initiating any works activities;
- Provide the ability to capture customer feedback from various digital channels to better understand pain points and customer friction and make the appropriate corrections, or simply provide better two-way communications;
- Modernise the contact centre interactive voice recording system to provide faster information and resolution times for customers;
- Provide a consistent and valuable experience for customers throughout the interaction journey with Vector. This includes automation and improvements to marketing automation, content management systems, and social media management; and
- Deliver better software faster through adoption of modern delivery methods such as Agile and DevOps.

Business Enablement Platform

The BEP provides much of the capability for Vector staff, partners, and stakeholders to perform their work and thus involves the majority of core systems of record, as well as much of the underlying technology capability. Significant network events during the first half of 2018 have provided learnings as to the scale, capability, platforms and underlying architecture and supporting business processes required to enable success in a digital operating environment. The Horizon 1 investment in the BEP and associated capabilities will provide the business with the baseline technology and architecture to better manage significant network events in today's digital operating environment.

Specifically, some of the challenges and outcomes that are addressed by the shift in maturity from Current State (Figure 5-2) to Horizon 1 (Figure 5-3) are:

- The initial focus of the Horizon 1 BEP investment is directly focussed on improving our ability to improve the flow of data and information with all stakeholders, including FSPs, customers, Civil Defence and other interested parties during network events such as heavy weather;
    - The digitisation and automation of touchpoints between the operational centre, contact centre, storm response centre and our field technicians will enable improved information accuracy through reduced errors and associated information cycle time;
    - The combination of investments in customer engagement channels and the automation and digitisation of business processes across Horizon 1 will lead to faster restoration and response times which ultimately target resilience and reliability measures;
    - Enhanced back end infrastructure and platforms will significantly reduce cost to serve and cost to maintain core platforms, leading to improved ability to meet changing customer and technology demands;
    - Provide better information to customers and network staff around field engineers' location through Global Position System tracking, route optimisation and active Field Service Management (FSM);
- Reduce asset downtime through the use of predictive maintenance models generated from Big Data and advanced analytics techniques;
- Optimising customer relationship management through improved customer data acquisition and analytics, communications, customer invoicing, reconciliation, and payment processes;
- Optimise asset investment and health by better understanding planned and remedial asset maintenance tasks from FSPs. This will involve providing interfaces for updating Vector systems with this information in near real-time;
- Uplift enterprise and asset management visibility and knowledge through better document and records management practices and tooling;
- De-risk the failure of business processes and their associated infrastructure by modernising core systems such as SAP, Siebel, Oracle, and SmallWorld GIS;
- Modernise the 'End User Compute' environment to provide staff and partners the ability to do their jobs effectively and efficiently. This involves providing the best tools to provide frictionless work and the ability to work from anywhere, anytime, on any device;
- Provide better staff, partner, and customer collaboration to solve issues as they arise through fit for purpose digital workspaces;
- Ensure infrastructure is fit for purpose and resilient through a continuous infrastructure lifecycle, and upgrade programme;
- Improve response times and decrease asset failure rates by providing better collection of device status messages and surface the information in real time via channels such as monitoring tools and reporting dashboards;
- Reduce asset and network failure probability by getting better visibility of assets in the field and related hazards such as nearby trees. Solutions include capturing photos and videos from FSPs via mobile apps, and running analytics across these;
- Providing and maintaining more accurate asset address data by consolidating the various address sources such as NZPost and Terradata databases, and ensuring greater consistency and integration between the various systems of record, holding these;
- Ensuring better health and safety by consolidating health and safety and risk systems of record, and creating capability to capture information from workers in the field. Near real time monitoring of events and reporting will need to be enhanced;
- Improve resilience of the network by enhancing disaster planning and response initiatives, including digital system backups and automatic failover capabilities;
- Improve security through modernisation of the IT network across all Vector sites, including on premise and cloud data centres. Specific areas include remote access for staff and partners, perimeter security devices, advanced threat detection and prevention, data leakage prevention, physical site access, antivirus, and operational technology threat detection;
- Increase speed and efficiency of services through automation and optimisation of business process to ensure continuous improvement and efficient use of resources; and
- Increase delivery speed and flexibility to meet fast changing customer needs through making use of cloud infrastructure, integration, and application innovations whilst at the same time rationalising traditional on-premise computing.

Operational Technology Platform

OT is increasingly becoming central to the management of distributed field assets to provide accurate real time information and control in order for the network to perform optimally. As such, Horizon 1 sees Vector creating the building blocks for enhanced OT capabilities to manage the distribution network in preparation for future requirements such as the uptake of DERs, EVs and solar/battery installations. A major part of this modernisation involves initial investment into areas such as mPrest grid automation technology, peak shaving initiatives, plant maintenance, process automation, and fault management.

Specifically, some of the challenges and outcomes that are addressed through the maturity changes from Current State (Figure 5-2) to Horizon 1 (Figure 5-3) are:

- Improve uptime by providing better visibility into the health of network assets and field crews by improving field data capturing capability;
- Build on the enhanced data collection to create the ability for improved insights and automation of actions through the use of modern Big Data and analytics capabilities made available to operations staff and partners;
- Improve communications between network assets, support staff, and field crews through enhancing communications infrastructure such as mobile and voice networks;
- Provide a more resilient network to cater for the possible instability caused by DERs through the use of data collection and control, automated where possible through the use of artificial intelligence algorithms;
- The baseline investment in the OT platform will provide the building blocks for the Energy IoT, which will be required to meet the expected demand growth and will be critical to meet Auckland's unique challenges in the future.
- De-risk failure of core systems and infrastructure through a continued lifecycle management (maintain/upgrade/replace) programme; and
- Enhance visibility and control of the network by developing connections and interfaces for data acquisition and control of new field devices such as network batteries.

DIGITAL ENABLEMENT OF PLATFORMS – HORIZON 2 (2021-2025)

Figure 5-4 below shows a summary of how well the business will be supported by the use of Digital Technology at the end of 2025. Horizon 2 involves significantly maturing and building on the initial investment made in the previous 2 years in order to fully realise the potential of digitisation for the benefit of Vector's customers.

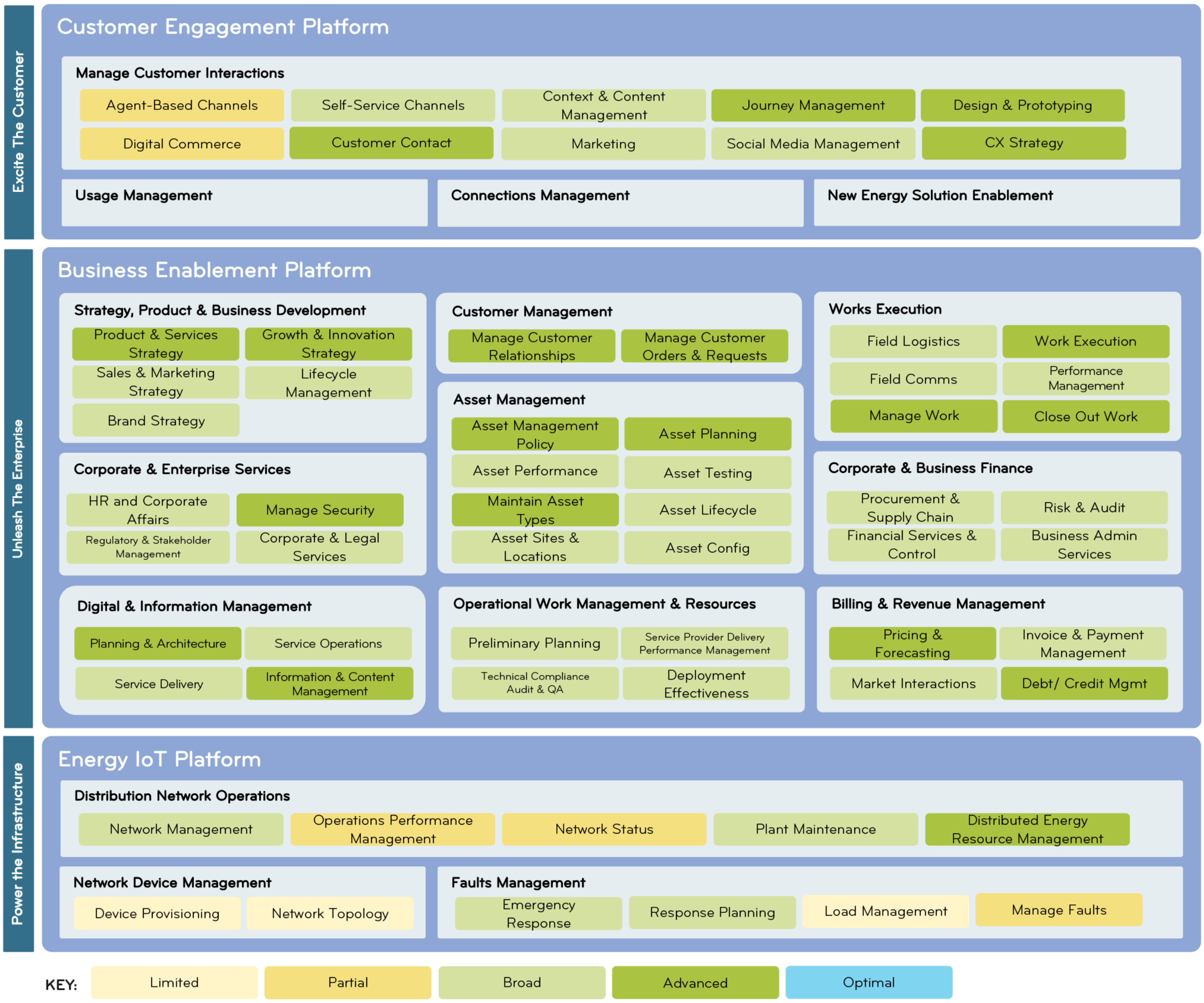

Figure 5-4 Digital enablement of platforms – horizon 2 (2021 – 2025)

Customer Engagement Platform

Over the course of Horizon 2, Vector Digital will focus on executing a transformation of existing core customer applications towards the best in class digital customer services. The CEP will be matured through further refinement of customer self-service channels, and investment in customer experience lead capability. The contact centre will be characterised by a high level of automation in order for customers to get accurate information quickly at a significantly lower cost to serve.

Customer journeys and design thinking processes will be refined in order for pain points to be addressed through the use of technology. We will see increased direct communication with customers in order to provide them with relevant information so they can be aware of things such as their power usage and planned work, as well as provide opportunities for them to save on electricity costs.

Technology focus areas include API product management in order for 3rd parties to integrate with Vector's systems autonomously, a maturing of cloud tooling such as marketing automation to enable better customer journeys, and the adoption of maturing technologies such as 'Natural Language Processing' to enable voice-to-machine channel interactions.

Business Enablement Platform

Horizon 2 for the BEP will involve increasing the maturity of the newly implemented technologies from Horizon 1 and the ongoing consolidation and lifecycle management of core systems of record across billing, CRM, work order management, FSM, asset maintenance, and finance domains.

The foundational capabilities developed in Horizon 1 will provide opportunities to increase the utilisation and effectiveness of our core systems and newly developed microservices and API platforms. Supported by the transitional investment described in Section 5.3.45.3.4 this will increase Vector's ability to migrate away from monolithic, customised legacy applications towards best in class platforms to deliver business value and significantly reduced operational overheads.

Vector's digital infrastructure will transition away from traditional methods and be characterised by the majority of it's workloads being hosted in the cloud, leading to significantly reduced costs and improved ability to scale.

Operational Technology Platform
Horizon 2 sees Vector maturing the IoT capability introduced in the previous 2 years. This will see the stabilising and normalisation of DER management system so that the grid can increasingly be managed by autonomous decision making. Fault management and reaction times will be faster due to an increase in real time visibility across the network. Trials and deployment of new field sensors and associated analytics and control mechanisms will become standard practice.

As well as new technology, Vector will conduct lifecycle upgrades of core technology such as the SCADA and plant information systems.

DIGITAL ENABLEMENT OF PLATFORMS – HORIZON 3 (2026-2028)
Figure 5-5 shows a summary of how well the business processes will be automated and supported by the use of Digital Technology at the end of 2028. This 3rd and final horizon of the AMP is characterised by driving consolidation and efficiencies from the introduction and maturing of new technologies introduced by the previous two horizons, thereby bringing the majority of process domains to digitally supported levels of "Broad", "Advanced", and "Optimal".

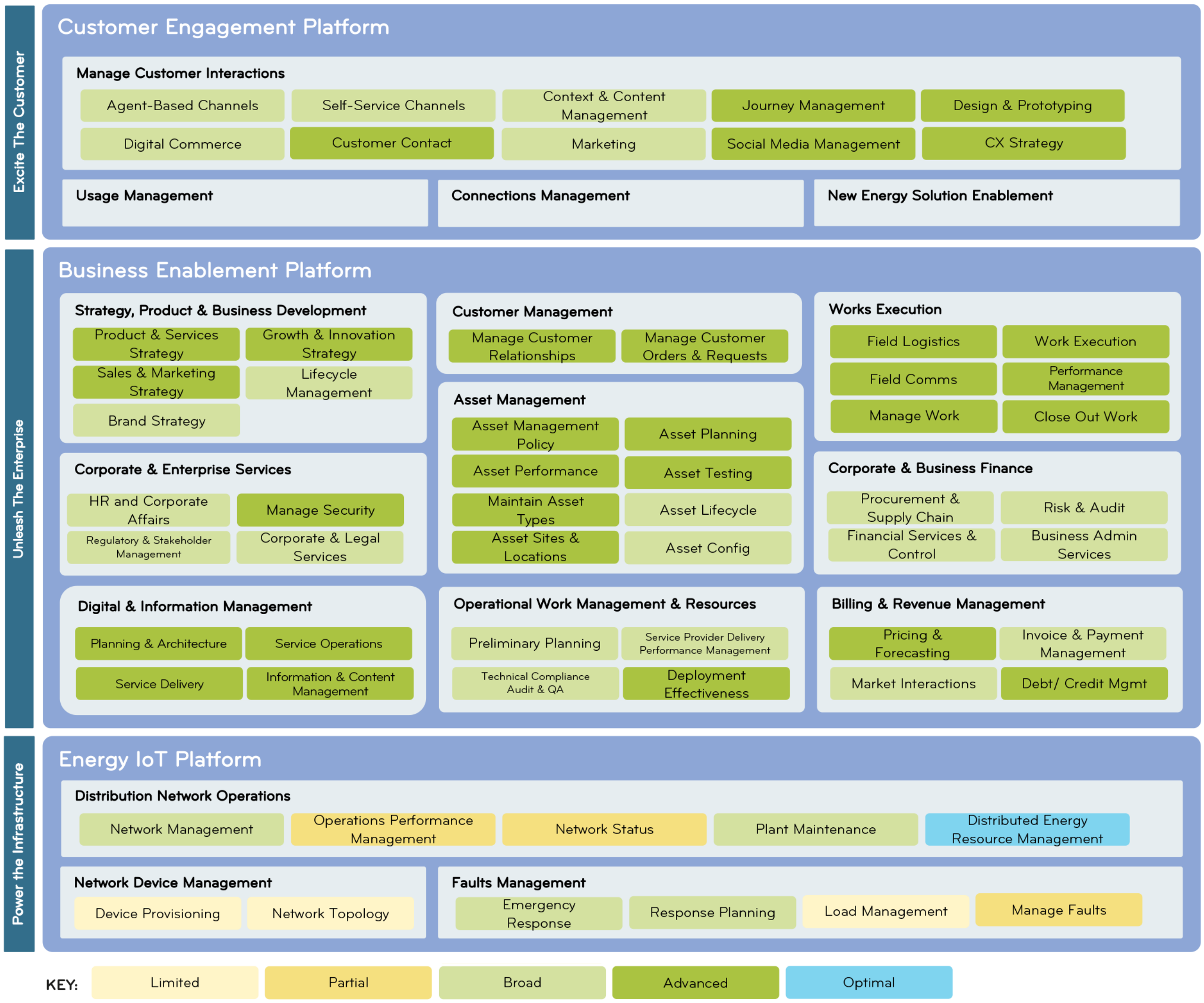

Figure 5-5 Digital enablement of platforms – horizon 3 (2026 – 2028)

Customer Engagement Platform

Horizon 3 will see the CEP further develop customer relationships through virtual agent-based channels and more sophisticated social media and distributed, customer controlled channel management. Vector will continue to push its API strategy leveraging innovation through partners and independent developers, enabling Vector to receive the benefits of investment in advanced technologies that can be utilised on the edge of its core enabling customer platforms. Horizon 3 expects to manage a significant increase in customer demand across more efficient and experience focused channels leading to better customer engagement and a reduced cost to serve.

Business Enablement Platform

In Horizon 3 Vector will complete the integration and upgrades of our core ERP, Billing and CRM systems with the common services APIs. Leveraging the investment across Horizons 1 and 2, the quality of digital service delivery will mature across the organisation as BEP functionality is developed and refined, improving Vector's ability to meet the expected rapid changes in both customer and network demand. Vector's Big Data and analytics capability will be matured in order to provide increased capability such as predictive maintenance (reducing downtime), faster fault response times, and increased visibility and insights for network planning as DERs become normalised.

Operational Technology Platform

In Horizon 3 the Energy IoT platform, specifically mPrest, will be the beneficiary of microservices developed of the BEP in Horizon 1. Vector's participation in the public API economy will mean a greater supply of relevant energy data streams being created by non-Vector parties. These streams will be incorporated into the mPrest platform allowing for greater performance and optimisation of outcomes across the network.

5.3.4 INVESTMENT CONSIDERATION FOR ACHIEVEMENT OF STRATEGIC OBJECTIVES

TRANSITIONAL INVESTMENT

The transitional investment has been identified separately to reflect the expected need to complete end of life and legacy platform migrations outside of digital platform investments and as such is not included in the proposed investment summary under Section 5.3.1. The traditional legacy operating environment includes significant applications and platforms such as Siebel, SAP and Gentrack, all of which deliver core business services and have been heavily customised. In the rapidly changing operating environment these platforms do not provide the strategic agility required to respond to rapid changes expected across the energy industry. Transition and migration of these platforms towards fit for purpose and microservices focussed solutions is required to reduce cost of legacy platform migration as these monolithic platforms reach end of life. If not completed in line with application lifecycle and before end of life is reached, significant investment will be required to deliver like for like migration on these customised platforms as opposed to optimised, fit for purpose microservices migration.

PROPOSED TRANSITIONAL INVESTMENT SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Transition Investment	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	22.57
Total	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	22.57

5.4 NON NETWORK OPEX

Non-network OPEX provides the support services required to ensure the network business can operate as an effective, well-governed business. The networks business benefits from economies of scale with Vector providing shared support services across its group of regulated and non-regulated businesses. Support services include health and safety, finance, legal, human resources, digital and risk management.

PROPOSED EXPENDITURE SUMMARY ($MILLION NOMINAL)

DESCRIPTION	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
System operations and network support	38.49	37.84	36.71	36.94	36.94	37.03	37.11	37.19	37.27	37.32	372.84
Business support	41.24	41.24	41.24	41.24	41.24	41.24	41.24	41.24	41.24	41.24	412.41
Total	79.73	79.08	77.95	78.18	78.18	78.28	78.35	78.43	78.51	78.56	785.25

SECTION

06.

DELIVERING OUR PLAN

SECTION 6. DELIVERING OUR PLAN

This section of the AMP outlines how we develop an optimal portfolio of works from the plans set out in SECTION 5 and how we will deliver these works to maintain service levels and deliver our strategic outcomes. Our approach to project prioritisation, investment optimisation and resourcing is summarised and the CAPEX and OPEX required to deliver our electricity network AMPs for the 2018-2028 period is presented.

6.1 PORTFOLIO OPTIMISATION

The key objectives of asset management, as stated in Vector's asset management policy, relate to safety, reliability and the environment (see Section 3.1), with performance against these objectives captured by the service level metrics (see Section 2.2). The asset management objectives are aligned with Vector's vision and mission to create a new energy future (see Section 1.4).

The portfolio optimisation process aims to ensure that the investment required to meet these objectives and targeted service levels is efficient, bringing the greatest total benefit to our customers. Portfolio optimisation is also an important step towards achieving best industry practise in asset management, as prescribed in ISO 55000.

6.1.1 INVESTMENT PROJECTS PROPOSAL AND APPROVAL PROCESS

Vector employs an investment framework that ensures a consistent approach is applied when assessing investment options. This approach considers the initial CAPEX outlay, cost of maintenance, and the benefit in terms of the risk reduction achieved. The planning process takes place every year and is undertaken as part of Vector's annual budgeting cycle.

The process for Vector's gated investment expenditure proposals is below:

1. **Project proposals:** Once the need for a project has been identified, project proposals are created (see Section 3.5.2). These proposals describe the project need, show the options considered and detail the preferred option (see SECTION 5). Project proposals are prepared by Vector's subject matter experts;
2. **Preliminary investment plan:** Project proposals are peer reviewed to ensure consistency of project proposals before incorporation into the preliminary investment plan. Any synergies and interdependencies between projects are highlighted and incorporated into the preliminary plan;
3. **Portfolio optimisation:** The preliminary investment plan is prioritised and optimised for delivery, with resource and financial constraints applied through the Portfolio Optimisation process. This is an iterative process and is described in more detail in Section 6.1.2;
4. **Draft investment plan:** Once projects have been through the Portfolio Optimisation process, the draft investment plan is formed. This plan is reviewed and approved by the executive management team. The risk associated with projects that have not formed part of the draft investment plan following optimisation is highlighted and acknowledged; and
5. **Final Investment Plan:** Following consideration and approval by the executive management team, the final investment plan is reviewed and approved by the Board.

6.1.2 PORTFOLIO OPTIMISATION PROCESS

Vector's portfolio optimisation process is a two-step process. First the project proposals are ranked based on the value of the project to the business. The projects are then prioritised to ensure the highest business value is achieved given the resource and expenditure constraints presented.

PROJECT RANKING

The following points describe Vector's project ranking process.

The 'business value' of a project proposal is usually expressed in terms of improvements to service level metrics or in terms of risk mitigation. In other words, the degree to which the project prevents any foreseen negative impact on Vector's asset management objectives (safety, reliability and the environment).

A risk matrix aligned with the Network Risk Management standards (see Section 3.5.4) is used to assign a risk score against a project both pre and post project investment. This is used to signal the relative business value between all the proposed projects.

The risk evaluation process considers both the credible event based on the most likely consequences should a risk eventuate, and any catastrophic event that might occur. A multi-dimensional assessment method is then adopted to combine risk scores across multiple business objectives or service levels and the credible / catastrophic scenario.

The ranking process incorporates expert knowledge and experience with the network asset and network system to ensure that the assessed consequences, likelihood and resulting risk score is credible and tested. In addition, an increasingly comprehensive data set is becoming available through condition based monitoring which allows the assessment of the likelihood of failure to become more objective (see Section 3.7.3).

The consistency of this assessment across projects is key to a robust prioritisation and optimisation process that balances risks, performance and costs, and enables Vector to deliver the best outcome for customers.

OPTIMISATION
The following steps set out the optimisation process.

Step 1: Once the business value of project proposals have been assessed, a preliminary plan is formed. In this preliminary plan, projects are staggered to account for the realistic volume of work that can be undertaken in each year. This uses engineering judgement to take into consideration resources available to deliver including the construction and procurement capabilities available.

Step 2: Vector then uses an optimiser algorithm to do more sophisticated planning. The optimiser considers projects, both individually and as combinations, to achieve the optimum cost benefit i.e. the highest accumulative business value for the expenditure constraint set. In simple terms, it considers the option that a combination of smaller projects might have a higher combined business value than one higher cost project. In the multi-year planning process, any change in planning in the preceding year would impact on the planning and optimisation in the subsequent year. The financial constraint applied is based on the DPP, taking into account expected capital contributions and project commission dates.

Obligatory projects (e.g. new connections) and projects that address risks outside of the corporate risk tolerance, are also "forced in" during the optimisation process.

Step 3: Once the initial optimisation algorithm has been run, a panel of subject matter experts participate in a review to check optimisation outputs. This ensures that the output seems reasonable and is in alignment with industry knowledge and experience, which may not be captured by the qualitative inputs in the modelling process.

Step 4: The final investment plan is assessed by the project delivery team for resource availability, as discussed in Section 6.2 and Section 6.3.

6.2 RESOURCE REQUIREMENTS AND CONSTRAINTS

Vector has a MUSA with two key contractors, and they are known as our FSPs. We provide project guidance to our FSPs in monthly meetings where we disclose the upcoming programmes of work. This provides them at least two years of visibility on the upcoming workstream. It is our expectation that the FSPs manage their resource to meet this pipeline of work.

Typically, Vector uses the MUSA as the contract mechanism for delivering projects. However, for civil works depending on the size of the project we directly engage civil contractors using AS/NZS 3910-2013.

Designs for all delivery projects are reviewed and approved by Vector. Further internal engineering support is provided based on the level of effort anticipated. These levels of engineering support are defined as:

- Level 1 – Vector to provide general support to review and approve designs developed by Vector's FSPs;
- Level 2 – Vector to provide general support to review and approve designs developed by external consultants; and

- Level 3 – detailed design delivered by Vector internal engineering resources.

At anytime during the delivery of these projects Vector may engage specialist consultants to assist. For example consultants are used to:

- Compile, submit and facilitate resource consents;
- Define the scope associated with the removal of hazardous material such as asbestos;
- Design substations and substation yards as well as electrical designs; and
- Undertake protection studies.

6.3 DELIVERY

Development of Vector's PDF has been based on industry best practises, and the Projects Management Body of Knowledge. Its function is to provide a framework to ensure projects are delivered to minimise Vector's corporate and asset risk profile.

The PDF essentially provides standard procedures and processes that the project manager must comply with, for example safety in design and standard contract templates. It focuses on core corporate obligations associated with health and safety, environment and time, cost and quality. This is achieved through its alignment with corporate policies.

The PDF is reviewed and updated on a regular basis to ensure that it provides flexibility to deliver the range of projects in the capital programme. This flexibility also allows us to manage projects with varying degrees of risk.

The PDF includes seven distinct phases associated with the project delivery lifecycle which includes pipeline, concept, procurement, development, construction, test and commission and project closure. In addition, the PDF provides Vector's project managers with templates, guidelines and tools relevant to each of these phases.

Inception of a project usually follows three distinct stages:

- Initially project is defined in the AMP;
- When the project is planned to be delivered a CAPEX Justification (business case) is developed which includes a budget estimate. It is submitted to the business for approval to proceed; and
- Following approval a project scope is generated and CAPEX approval is granted and the project handed over to a Vector project manager for delivery.

6.4 INVESTMENT PLAN

This section describes the CAPEX and OPEX forecasts for the electricity distribution network assets for the next 10-year planning period, and provides a comparison with the 10-year forecast prepared and disclosed in the 2017 AMP (disclosed in March 2017).

The CAPEX and OPEX forecasts presented in this section align with Vector's planning process and FY reporting period 1 July to 30 June. The regulatory disclosure forecast, shown in Appendix 6 and Appendix 7, are presented in RY 1 April to 31 March, in both constant and nominal dollars, as per the Information Disclosure requirements.

CAPEX FORECAST

Table 6-1 below shows the forecast CAPEX during the planning period, broken down into the asset categories defined in the Commerce Commission's Electricity Distribution Information Disclosure Amendments Determination 2012. The figures are presented in 2019 dollars. For reference purposes, Vector has also included the corresponding CAPEX forecast disclosed in the 2017 AMP escalated to 2019 prices using an inflator of 2.49% (Table 6-2).

FINANCIAL YEAR ($000)

AMP2018	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Consumer connection	66,203	65,760	62,779	61,731	58,093	57,093	57,093	53,506	53,465	53,465	589,190
System growth	50,241	41,225	32,575	45,190	52,984	37,823	35,675	46,486	54,262	59,762	456,223
Asset replacement and renewal	89,408	96,840	93,509	106,670	103,399	106,056	99,205	98,445	101,011	99,834	994,376
Asset relocations	17,883	17,626	17,807	17,729	17,560	17,410	17,500	17,500	17,500	17,500	176,014
Reliability, safety and environment:	0	0	0	0	0	0	0	0	0	0	0
Quality of supply	0	0	0	0	0	0	0	0	0	0	0
Legislative and regulatory	0	0	0	0	0	0	0	0	0	0	0
Other reliability, safety and environment	2,700	2,450	2,050	2,050	2,250	1,284	1,050	1,050	1,050	1,050	16,984
Non network asset	18,498	12,215	17,332	18,059	18,723	18,299	14,018	12,991	11,573	11,379	153,088
Total Capital Expenditure	**244,933**	**236,116**	**226,052**	**251,429**	**253,009**	**237,965**	**224,541**	**229,978**	**238,861**	**242,990**	**2,385,875**

Table 6-1 2018 Forecast CAPEX

FINANCIAL YEAR ($000)

AMP2017	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27
Consumer connection	43,261	38,754	38,276	38,681	39,085	36,498	36,830	37,181	37,522
System growth	45,195	47,837	44,507	44,911	37,326	36,126	40,133	34,474	34,685
Asset replacement and renewal	90,509	91,023	89,586	86,443	72,249	71,457	66,179	67,036	66,801
Asset relocations	19,857	18,921	14,755	14,743	13,071	13,071	13,071	13,071	13,071
Reliability, safety and environment:	0	0	0	0	0	0	0	0	0
Quality of supply	0	0	0	0	0	0	0	0	0
Legislative and regulatory	0	0	0	0	0	0	0	0	0
Other reliability, safety and environment	1,732	1,732	1,732	1,732	1,732	1,972	1,732	1,732	1,732
Non network asset	19,245	12,724	15,077	12,713	12,750	15,302	14,401	12,900	14,701
Total Capital Expenditure	**219,798**	**210,990**	**203,933**	**199,222**	**176,213**	**174,425**	**172,346**	**166,393**	**168,511**

Table 6-2 2017 forecast CAPEX

COMPARISON TO PREVIOUS AMP

The section highlights the significant changes to the 2017 disclosed expenditure forecasts. Figure 6-1 below shows the difference between the 2017 and 2018 AMP expenditure forecasts, with Table 6-3 breaking down the variance by expenditure categories.

AMP MOVEMENT 2017 V 2018

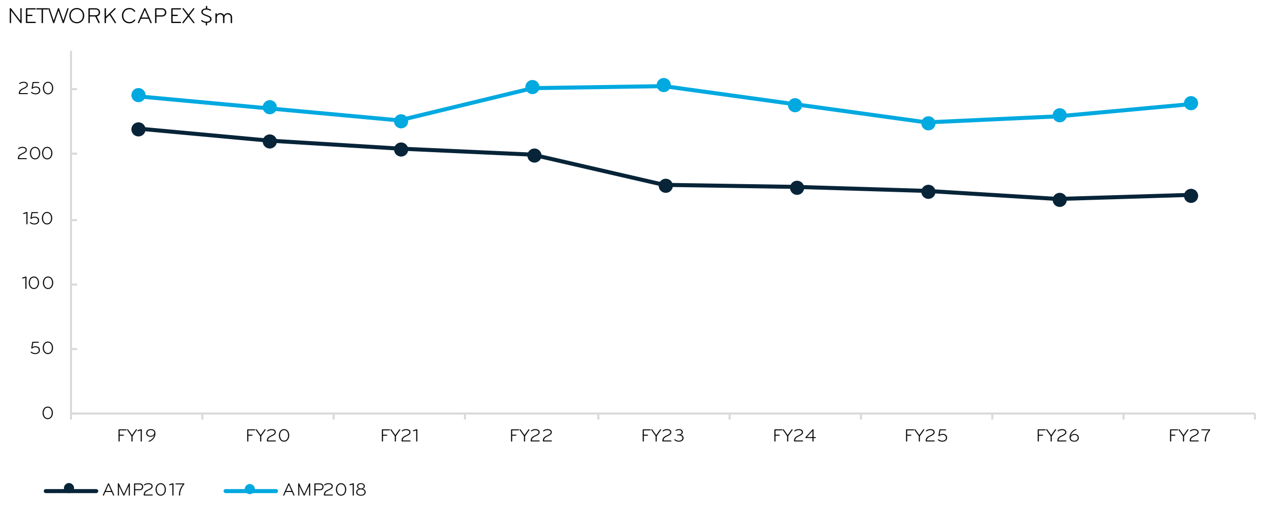

Figure 6-1 CAPEX AMP movement 2017 v 2018

FINANCIAL YEAR ($000)

2017/2018 AMP VARIANCE	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	TOTAL
Consumer connection	22,943	27,005	24,503	23,050	19,009	20,596	20,263	16,326	15,943	189,637
System growth	5,046	(6,612)	(11,932)	279	15,658	1,697	(4,458)	12,012	19,577	31,267
Asset replacement and renewal	(1,101)	5,817	3,922	20,227	31,150	34,599	33,025	31,409	34,210	193,258
Asset relocations	(1,974)	(1,295)	3,052	2,986	4,489	4,339	4,429	4,429	4,429	24,885
Reliability, safety and environment:	0	0	0	0	0	0	0	0	0	0
Quality of supply	0	0	0	0	0	0	0	0	0	0
Legislative and regulatory	0	0	0	0	0	0	0	0	0	0
Other reliability, safety and environment	968	718	318	318	518	(688)	(682)	(682)	(682)	110
Non network asset	(747)	(509)	2,256	5,347	5,973	2,997	(383)	90	(3,129)	11,895
Total Capital Expenditure	**25,136**	**25,124**	**22,119**	**52,206**	**76,797**	**63,540**	**52,195**	**63,584**	**70,350**	**451,052**

Table 6-3 2017 and 2018 variance CAPEX explanation of major CAPEX variances

EXPLANATION OF MAJOR CAPEX VARIANCES

This section highlights the significant changes in CAPEX over the 9-year period for which the 2017 AMP and 2018 AMP overlap. The following are key changes:

- A increase in investment in asset replacement and renewal forecast of $193m to address Vector's aging asset population that poses significant risks to Vector's ability to meet its service levels, health and safety requirements and environmental commitments in the next 10 years. As discussed in SECTION 5 of the AMP several streams of the replacement programme for the distribution network and zone substations have commenced and/or being expedited to improve Vector's ability to meeting these objectives;
- Key increases in distributed network expenditure include a replacement programme for 11 kV distribution RMU ($100m), overhead conductors ($89m), oil filled primary switchboards ($16m) and replacement of subtransmission PILC underground cables ($24m), offset by a reduction in expenditure in asset notification corrective work;
- A $190m increase in customer connection expenditure to reflect the sustained growth in residential development activity exhibited in Auckland in the past few years, and expected to continue over the 10-year horizon. The increase also aligns with Vector's updated forecast methodology that is consistent with the forecast produced by the Auckland Forecasting Network, a Crown and Auckland Council partnership including more than 36 Government and council agencies and Transpower, and supported by MBIE and Stats New Zealand;
- A $31m increase in system growth driven by investment in the automation of HV feeders to improve network performance, and increase in expenditure in zone substations and smart network capability to accommodate expected Auckland growth and forecast acceleration in customer uptake of EVs;
- A $25m increase in asset relocation to reflect the sustained growth in Auckland and related infrastructure activity, in particular in transportation and roading; and
- Non network CAPEX is forecast to increase by $13m to allow for investment required to upgrade Vector's SCADA system, and continual investment in Vector's network management platform to ensure Vector is ready to monitor, analyse and control the network to optimise the energy flow from increasing use of distributed energy generation and storage that is facilitated by rapid evolution in new technology.

OPERATING EXPENDITURE FORECAST

This section describes the OPEX forecasts for the electricity distribution network assets for the next 10-year planning period, and provides a comparison with the 10-year forecast prepared and disclosed in the 2017 AMP (disclosed in March 2016).

OPEX FORECAST

Table 6-4 shows the forecast OPEX during the planning period, broken down into the asset categories defined in the DPP. The figures are presented in 2019 dollars. For reference, Vector has also included the corresponding OPEX forecast disclosed in the 2017 AMP escalated to 2019 prices using a inflation factor of 3.53% (Table 6-5).

FINANCIAL YEAR ($000)

AMP2018	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	TOTAL
Service interruptions and emergencies	12,862	12,952	13,457	13,548	13,640	13,732	13,826	13,920	14,015	14,111	136,063
Vegetation management	6,522	6,522	5,694	5,694	5,694	5,694	5,694	5,694	5,694	5,694	58,599
Routine and corrective maintenance and inspection	15,620	15,764	16,115	16,260	16,406	16,552	16,698	16,846	16,994	17,150	164,404
Asset replacement and renewal	15,303	15,362	19,770	19,853	19,938	20,022	20,108	18,123	17,162	16,196	181,838
System operations and network support	38,487	37,844	36,713	36,937	36,938	37,035	37,111	37,188	37,265	37,322	372,840
Business support	41,241	41,241	41,241	41,241	41,241	41,241	41,241	41,241	41,241	41,241	412,408
Total Operational Expenditure	**130,035**	**129,685**	**132,990**	**133,533**	**133,857**	**134,276**	**134,678**	**133,012**	**132,371**	**131,714**	**1,326,152**

Table 6-4 2018 forecast OPEX

FINANCIAL YEAR ($000)

AMP2017	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27
Service interruptions and emergencies	10,454	10,531	10,609	10,688	10,767	10,846	10,927	11,008	11,090
Vegetation management	5,161	5,201	5,242	5,283	5,324	5,366	5,408	5,451	5,494
Routine and corrective maintenance and inspection	14,338	14,478	14,618	14,758	14,899	15,040	15,182	15,325	15,468
Asset replacement and renewal	17,573	17,663	17,753	17,844	17,408	17,498	17,588	17,679	17,771
System operations and network support	36,098	36,126	36,155	36,184	36,213	36,242	36,272	36,301	36,331
Business support	40,651	40,651	40,651	40,651	40,651	40,651	40,651	40,651	40,651
Total Operational Expenditure	**124,276**	**124,651**	**125,028**	**125,408**	**125,262**	**125,644**	**126,028**	**126,415**	**126,804**

Table 6-5 2017 forecast OPEX

COMPARISON TO PREVIOUS AMP

The section highlights the significant changes to the 2017 disclosed expenditure forecasts. Figure 6-1 below shows the difference between the 2017 and 2018 AMP expenditure forecasts, with Table 6-6 breaking down the variance by expenditure categories.

AMP MOVEMENT 2017 V 2018

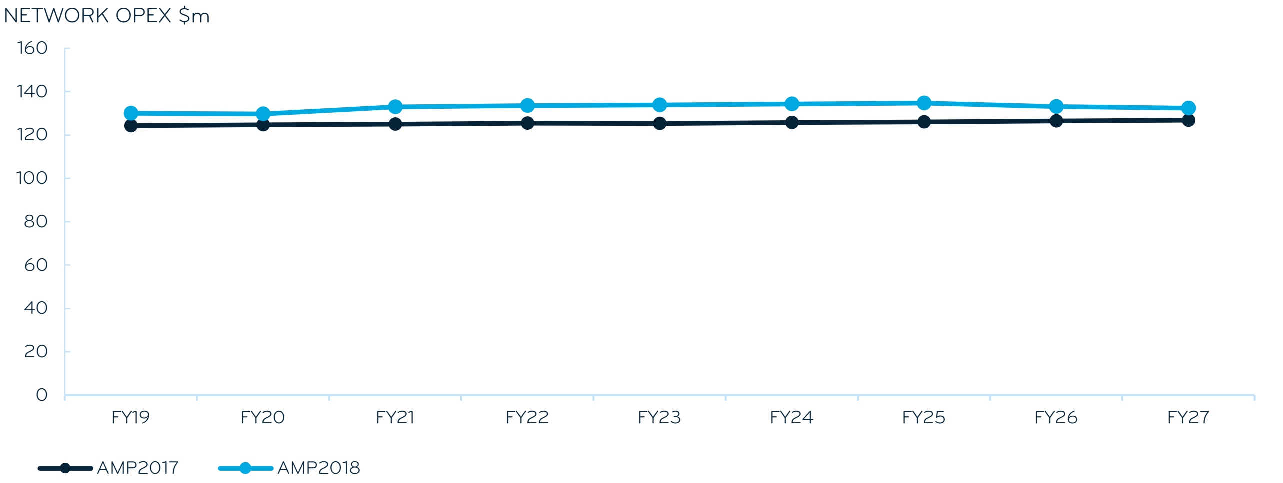

Figure 6-2 OPEX AMP movement 2017 v 2018

FINANCIAL YEAR ($000)

2017/2018 AMP VARIANCES	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	TOTAL
Service interruptions and emergencies	2,408	2,421	2,847	2,860	2,873	2,886	2,899	2,912	2,926	25,032
Vegetation management	1,361	1,321	452	411	370	328	286	244	201	4,974
Routine and corrective maintenance and inspection	1,281	1,286	1,498	1,502	1,507	1,511	1,516	1,521	1,526	13,149
Asset replacement and renewal	(2,270)	(2,301)	2,017	2,009	2,529	2,525	2,520	444	(608)	6,864
System operations and network support	2,389	1,718	558	753	725	793	840	887	934	9,596
Business support	589	589	589	589	589	589	589	589	589	5,305
Total Operational Expenditure	**5,760**	**5,034**	**7,961**	**8,125**	**8,594**	**8,632**	**8,650**	**6,597**	**5,568**	**64,921**

Table 6-6 2017 and 2018 variance OPEX

EXPLANATION OF MAJOR OPEX VARIANCES

This section highlights the significant changes in CAPEX over the 9-year period for which the 2017 AMP and 2018 AMP overlap, reflect the following key changes:

- An increase of $25m in service interruptions and emergencies expenditure due to additional resources allocated to improve fault response, and a change in the OPEX / CAPEX cost split of this work type. The OPEX component of this activity group has increased in FY18, due to the policies for de-energised works and remote isolations. A small offset in the corresponding CAPEX component has been forecast, resulting from the above allocation change and allowances for increase in network size;
- An increase of $13m in routine and corrective maintenance due to initiatives targeting network reliability improvements, and an increase in volume associated with a review of the planned maintenance activities and subsequent improvement to reporting systems;
- An overall increase of $7m in asset replacement and renewal to improve network reliability and performances, with a reduction in within the current pricing period (to end FY21) to offset the increase in routine and corrective maintenance;
- Vegetation management expenditure is broadly in line with the previous AMP with a $5m increase over the comparable period to reflect some increase in vegetation management activities particularly in FY19 and FY20; and
- An increase of $15m in non-network expenditure largely due to higher forecast cost associated with cyber-security, initiatives associated with sustainability and higher legal costs in the near term.

SECTION

07. APPENDICES

SECTION 7. APPENDICES

Appendix 1 Glossary of Terms

A	Ampere
AAC	All aluminium conductor
AAAC	All aluminium alloy conductor
ABC	Aerial bundled cable
AC	Alternating current
ACSR	Aluminium conductor steel reinforced
AMMAT	Asset management maturity assessment tool
AMP	Asset management plan
API	Application programming interfaces
ARM	Active risk manager
AUFLS	Automatic under frequency load shedding
AV	Autonomous vehicle
BEP	Business engagement platform
BESS	Battery energy storage system
CaaS	Car-as-a-service
CAIDI	Customer average interruption duration index
CAPEX	Capital expenditure
CB	Circuit breaker
CBD	Central business district
CBF	Circuit breaker fail
CBARM	Condition based asset risk management
CDEM	Civil Defence and Emergency Management
CEP	Customer engagement platform
CNO	Chief networks officer
CRM	Customer relationship management
DAF	Delegated authorities framework
DC	Direct current
DER	Distributed energy resource
DERMS	Distributed energy resource management system
DFA	Delegated financial authority policy
DPP	Electricity distribution services default price-quality price path determination 2015
EOC	Electricity operations centre
ERP	Enterprise resource planning
EV	Electric vehicle
FMEA	Failure mode and effects analysis
FSM	Field service management
FSP	Field service provider
FY	Vector financial year (year ending 30th June)
GCE	Group chief executive
GXP	Grid exit point: A facility owned by Transpower that directly connects the Vector network to the national grid. A GXP may contain more than one supply bus (of same or different voltages).
GWh	Gigawatt hours

HSWA	Health and safety at work act
HILP	High impact low probability
HV	High voltage: a nominal AC voltage of 1000 volts and more
ICP	Installation control point
IEC	International electrotechnical commission
IED	Intelligent electronic data and/or devices
IP	Internet protocol
IoT	Internet of things
ISO55001	International standard for asset management
IT	Information technology
km	Kilometre
kV	Kilovolt
kVA	Kilovolt ampere
kW	Kilowatt
kWh	Kilowatt hour
LAN	Local area network
LED	Light-emitting diode
LiDAR	Light Detection and Ranging
LV	Low voltage – a nominal AC voltage of less than 1000 volts
MBIE	Ministry of business, innovation and employment
MUSA	Multi utility service agreement
MVA	Megavolt ampere
MW	Megawatt
NZX	New Zealand stock exchange
OPEX	Operational expenditure
OT	Operational technology platform
PDF	Project delivery framework
PILC	Paper insulated lead cable
PLC	Programmable logic controller
PQM	Power quality monitor
PV	Photovoltaic
PVC	Polyvinyl chloride
RAB	Regulatory asset base
RIMS	Risk and incident management system
RMU	Ring main unit
RTU	Remote terminal unit
RY	Regulatory year (year ending 31st March)
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SCADA	Supervisory Control and Data Acquisition system
SF_6	Sulphur hexafluoride
SH	State Highway
SoSS	Security of Supply Standard
TMS	Transformer management system

V	Volts
V2G	Vehicle-to-grid
VHF	Very high frequency
WAN	Wide area network
XLPE	Cross-linked polyethylene

Bulk supply substation	A substation owned by Vector that directly connects the Vector network to the national grid. A bulk supply substation may contain more than one supply bus (of same or different voltages).
Distribution substation	A substation for transforming electricity from distribution voltage (22 kV or 11 kV) to 400V distribution voltage.
Micro grid	Parts of the distribution network that can be isolated and operated in an island state under contingency situations
National grid (or grid)	The 110 kV and/or 220 kV AC network and the DC link between the North Island and the South Island owned by Transpower for connecting electricity generation stations to grid exit points.
N-x security	Subtransmission security class rating.
Reliability	The ability of the network to deliver electricity consistently when demanded.
Resilience	The ability of the network to recover quickly and effectively from an event.
Substation	A network facility containing a transformer for the purpose of transforming electricity from one voltage to another. A substation may contain switchboards for dispatch or marshalling purpose. A substation may also contain more than one building or structure on the same facility.
Switching station	A facility containing one or more switchboards (or switches) for the purpose of rearranging network configuration or marshalling the network through switching operation.
Zone substation	A substation for transforming electricity from subtransmission voltage (110 kV, 33 kV or 22 kV) to distribution voltage (22 kV or 11 kV).

Appendix 2 Key Asset Strategies and Standards

Vector has a set of asset strategies and standards that together define Vector's approach to Asset Management. An overview of the key policies and standards are set out below.

ASSET CLASS	GENERAL
Strategies	Not applicable
Technical Specifications	ENS-0099 General technical requirements
Maintenance Standards	ESM001 General Maintenance Requirements
Engineering Standards	Not applicable

ASSET CLASS	1XX SUBTRANSMISSION SWITCHGEAR
Strategies	EAA101 Zone Substation Switchgear
Technical Specifications	ENS-0005 Specification for 11 kV to 33 kV indoor switchboards ENS-0022 Specification for 110 kV GIS indoor switchboards ENS-0106 Specification for 33 kV outdoor circuit breakers
Maintenance Standards	ESM101 Maintenance of Primary Switchgear – Fixed pattern ESM102 Maintenance of Primary Switchgear – 110 kV GIS ESM103 Maintenance of Indoor and Outdoor Conventional Switchgear
Engineering Standards	ESE101 33 kV/11 kV Indoor Metal Clad Switchgear non-withdrawable ESE102 Instrument Transformers Indoor ESE103 33 kV Switchyard Renewal and Extension Design Criteria

ASSET CLASS	2XX POWER TRANSFORMERS
Strategies	EAA201 Power Transformers
Technical Specifications	ENS-0124 Specification for 110 kV-22 kV two-winding power transformers ENS-0149 Specification for neutral earthing resistors
Maintenance Standards	ESM201 Maintenance of Transformers 22-110 kV
Engineering Standards	ESE201 Power Transformers Zone Substations

ASSET CLASS	3XX HV CABLES
Strategies	EAA301 Underground Cables
Technical Specifications	ENS-0032 Specification for SC-triplex 22-33 kV cable ENS-0110 Thermal backfill for underground cables ENS-0191 Specification for single core 110 kV cable
Maintenance Standards	ESM301 Maintenance of Cables

Engineering Standards	ESE302 Sub transmission and distribution cables ESE303 Installation requirements for cables and ducts

ASSET CLASS	**4XX OVERHEAD LINES**
Strategies	EAA401 Overhead Lines EAA402 Vegetation Management
Technical Specifications	ENS-0094 Specification for prestressed concrete utility services poles ENS-0091 Specification for treated timber utility services poles ENS-0100 Specification for hardwood crossarms ENS-0153 Specification for overhead conductors ENS-0159 Specification for galvanised steel fittings for overhead construction ENS-0160 Specification for LV ABC fittings ENS-0163 Specification for overhead line connectors ENS-0109 Specification for helical fittings and accessories ENS-0084 Specification for pole mounted fuse carriers and links ENS-0088 Specification for overhead insulators ENS-0112 Specification for hazard marking for poles
Maintenance Standards	ESM401 Maintenance of Overhead Lines
Engineering Standards	ESE401 Overhead Line Design Requirements

ASSET CLASS	**5XX DISTRIBUTION NETWORK**
Strategies	EAA501 Distribution Network
Technical Specifications	ENS-0103 Specification for 11 kV and 22 kV distribution switchgear ENS-0154 Specification for LV distribution service pits ENS-0127 Specification for 11 and 22 kV underground distribution cable ENS-0162 Specification for fault passage indicators ENS-0121 Specification for auto-reclosers ENS-0097 Specification for pole mounted SF_6 switches ENS-0098 Specification for sectionalisers and remote switches ENS-0101 Specification for surge arrestors ENS-0079 Specification for ducting of insulating material ENS-0078 Specification for 400V underground cable ENS-0090 Specification for oil filled distribution switchgear ENS-0093 Specification for fluid filled distribution transformers ENS-0102 Specification for polymeric cable protection covers
Maintenance Standards	ESM501 Maintenance of Overhead Switchgear ESM502 Maintenance of Pole Mounted Transformers ESM503 Maintenance of Ground Mounted Distribution Equipment and Voltage Regulators ESM505 Maintenance of LV Distribution System
Engineering Standards	ESE501 Distribution substations in buildings ESE502 Distribution package substations ESE503 Standalone Distribution Switchgear ESE504 Low Voltage Underground Distribution ESE505 Standalone Distribution Transformer ESE506 Distribution Earthing

ASSET CLASS	6XX AUXILIARY SYSTEMS
Strategies	EAA601 Auxiliary Systems
Technical Specifications	ENS-0080 Specification for earthing rods and accessories
Maintenance Standards	ESM601 Maintenance of DC and AC Systems ESM602 Maintenance of Capacitor and Reactor Banks ESM603 Maintenance of Building Security, Air and Fire Management Systems ESM607 Maintenance of Earthing System
Engineering Standards	ESE601 DC Systems ESE602 AC Systems

ASSET CLASS	7XX INFRASTRUCTURE AND FACILITIES
Strategies	EAA701 Infrastructure and Facilities
Technical Specifications	ESE002 Zone substation signage ENS-0206 Specification for crushed rock in switchyards
Maintenance Standards	ESM701 Maintenance of Building, Structures and Facilities ESM711 Maintenance of Minor Tunnels ESM712 Maintenance of Penrose-Hobson Tunnel
Engineering Standards	ESE701 Zone Substation Buildings ESE702 Zone Substation Grounds ESE703 Zone Substation Building Services ESE704 Zone Substation Earthing

ASSET CLASS	8XX PROTECTION AND CONTROL
Strategies	EAA801 Protection Systems GXP and Zone Substations EAA802 Transformer Management Systems EAA803 Power Quality Metering EAA804 Communication Systems EAA805 Automation Systems EAA806 Related IT Systems EAA807 SCADA and SICAM PAS Systems
Technical Specifications	ENS-4003 Protection and control – Technical documentation
Maintenance Standards	ESM801 Maintenance of Protection and Control Systems ESM804 Maintenance of Pilot Cables ESM805 Maintenance of Radio Equipment
Engineering Standards	ESE801 Protection Design Zone Substations & Sub Transmission ESE802 Automation and Control Systems ESE803 Protection and Control for Overhead Distribution Feeders ESE805 Secondary Cabling ESE806 Protection standard for distribution substations

ASSET CLASS	9XX NEW ENERGY SOLUTIONS
Strategies	EAA901 New Energy Solutions
Technical Specifications	Being developed – work in progress
Maintenance Standards	ESM901 Maintenance of Battery Energy Storage Systems. ESM902 Maintenance of EV Charger ESM903 Maintenance of Residential Solar Energy Systems
Engineering Standards	Being developed – work in progress

HEALTH, SAFETY AND ENVIRONMENT KEY REQUIREMENTS

HSEMS01 Management systems framework and HSE policies
HSEMS02 Leadership and Accountability
HSEMS03 Competence and Behaviour
HSEMS04 Engagement, Participation and Consultation
HSEMS05 Contractor HSE Management
HSEMS06 Emergency Management
HSEMS07 Wellness and Fitness to Work
HSEMS08 Risk Management
HSEMS09 Incident Management
HSEMS10 Audits, Reviews and Performance Reporting
HSEMS11 Operational Control
HSEMS12 HSE in Project Management

ELECTRICITY OPERATING STANDARDS

ESH001 Electricity Safety and Operating Plan
EOS001 Operational Control of the Network
EOS002 Release of Network Equipment
EOS003 Procedures for Operations on the Vector Network
EOS004 Switching Schedules and Permits Preparation Use and Operating Terms
EOS006 Live Line Operating Standard
EOS007 Zone Substation Access and Security
EOS009 Commissioning of Network Equipment
EOS010 Operational Numbering of Vector Equipment
EOS011 Protocol for Communications with the Electricity Operations Centre
EOS012 Operation of Ground Mounted Switchgear up to and including 33 kV
EOS013 Standard Operational Terms and Abbreviations
EOS014 Operation of Circuit Breakers and associated Equipment
EOS015 Procedures for Operation of OH Equipment up to 110 kV
EOS018 Tunnel Procedures Rail Maintenance Planning
EOS019-001 Vector Mobile Generator Connection Units
EOS020 Procedures for Management and Operations on the Vector Low Voltage Network
EOS026 Managing Asset Rating Changes

Appendix 3 Typical Load Profiles

Figure 7-1, Figure 7-2 and Figure 7-3 show typical demand profiles for residential, commercial and CBD customer segments.

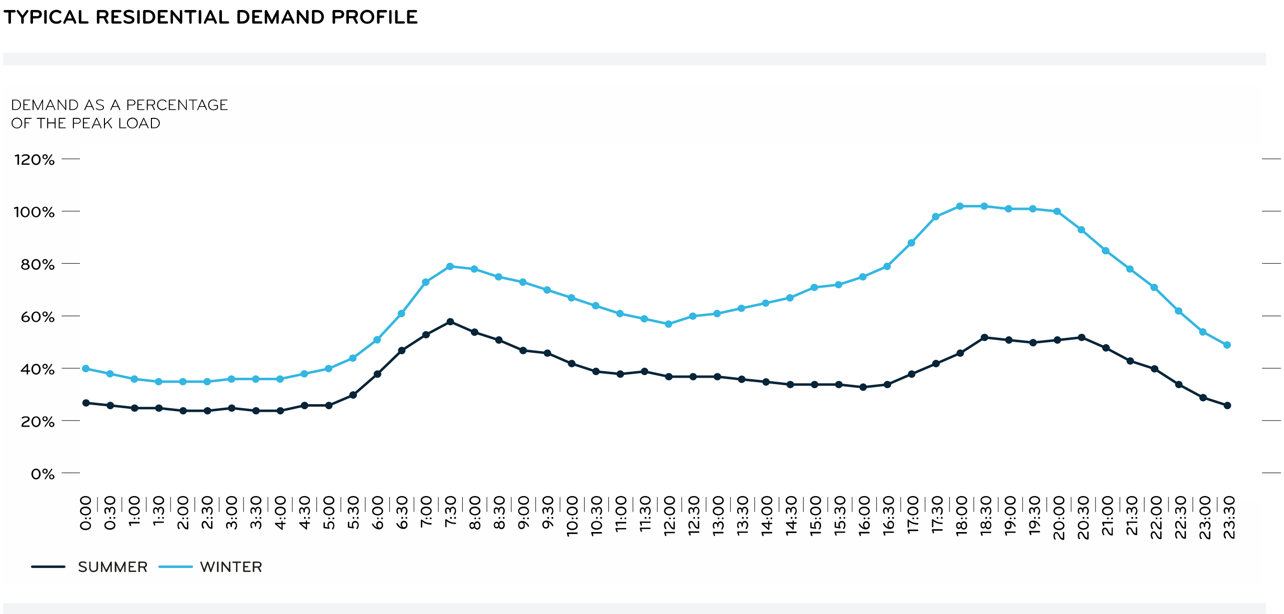

Figure 7-1 Typical residential demand profile

The key characteristics of the residential demand profile are the distinct morning and evening peaks and the significant difference in demand between summer and winter profiles, the latter almost double the former. The profiles show the characteristics at an 11 kV distribution feeder level rather than an individual customer profile.

Capturing the profiles at this level in the network hierarchy shows a diversified demand profile illustration clearly the length of the evening winter peak which can extend upwards of three hours. There is no evidence of significant solar/PV in the summer profile which would show up as significantly reduced demand from late morning until late afternoon.

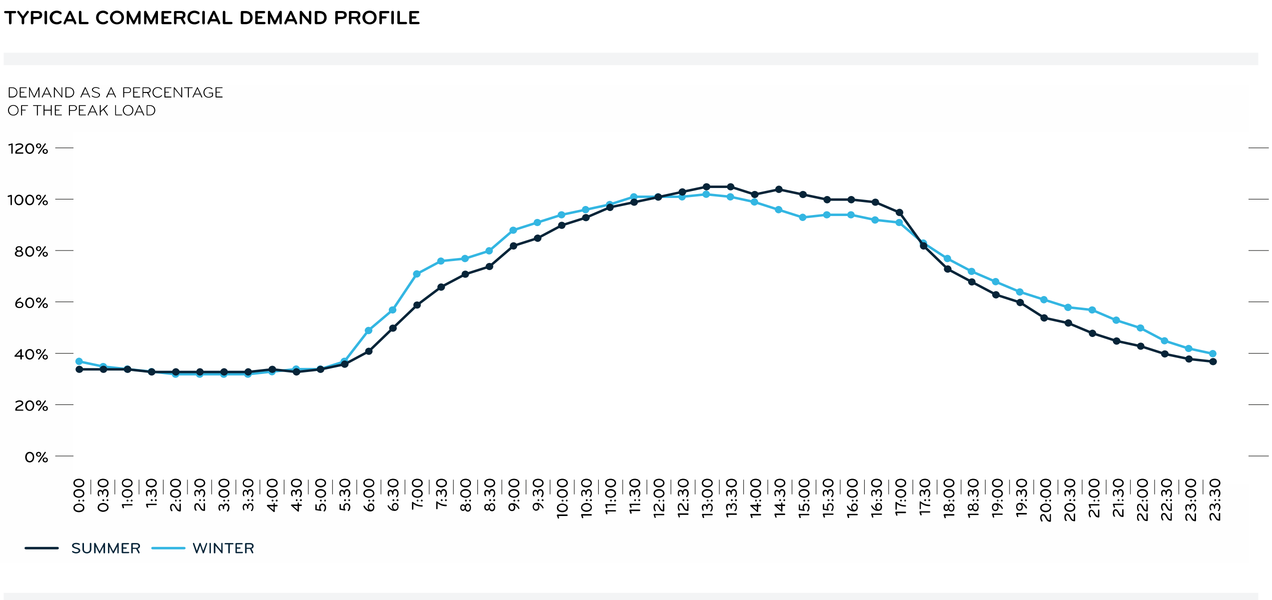

Figure 7-2 Typical commercial demand profile

Commercial demand follows a similar profile and loading for both winter and summer.

TYPICAL CBD DEMAND PROFILE

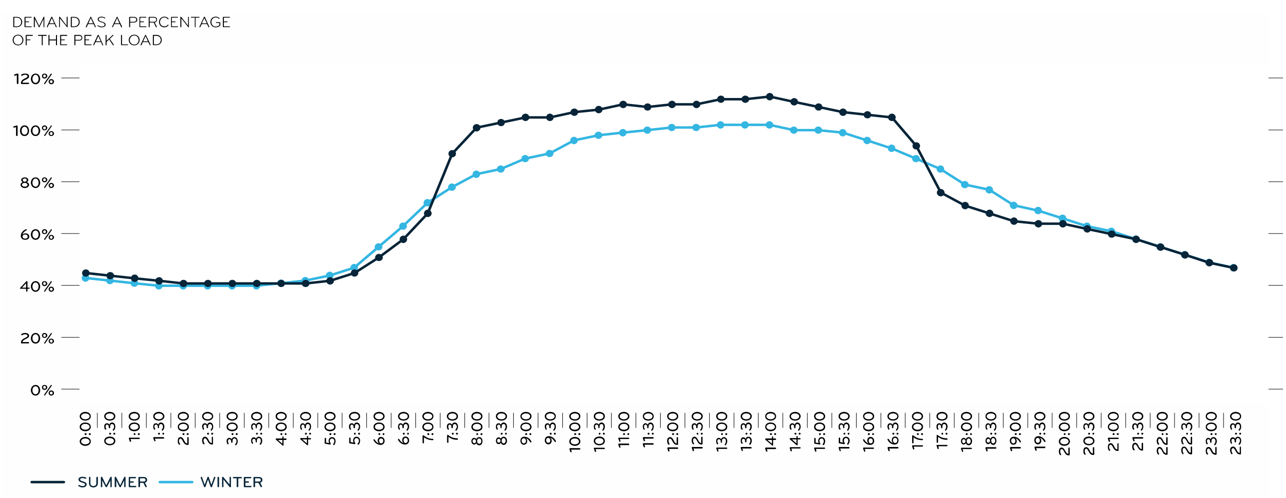

Figure 7-3 Typical CBD demand profile

The Auckland CBD load is characterised by the summer profile where load rises quickly in the morning and drops off equally as rapidly in the evening. The winter load profile demonstrates a similar characteristic to the summer although less aggressive uptake after 7:00am and a slower ramp-down in the evenings. The peak load in summer is driven mainly by air-conditioning, adding an extra 10% load above the winter demand profile.

LARGE CUSTOMERS THAT HAVE A SIGNIFICANT IMPACT ON NETWORK

Vector has a number of large customer sites at various locations in its network. The following are those customer sites with individual demand above 5 MVA, which are considered to have a significant impact on network operations and asset management:

- Fonterra at Lichfield;
- Auckland International Airport;
- Mangere Waste Water Treatment Plant;
- Bluescope Steel at Mangere
- Pacific Steel at Mangere;
- Auckland Hospital at Newmarket;
- Carter Holt Harvey at Penrose
- Owens Illinois at Penrose

Appendix 4 AMP Information Disclosure Compliance

The following table This set will set out a mapping of the requirements of the "Electricity Distribution Information Disclosure Determination 2012 (consolidated 2015) 24 March 2015" and the contents of the AMP.

INFORMATION DISCLOSURE DETERMINATION REQUIREMENT				AMP SECTION REFERENCE
Contents of the AMP				
3.	The AMP must include the following-			
	3.1	A summary that provides a brief overview of the contents and highlights information that the EDB considers significant;		Executive Summary and Section 1.10
	3.2	Details of the background and objectives of the EDB's asset management and planning processes;		Section 1 and Section 3.1
	3.3	A purpose statement which-		
		3.3.1	makes clear the purpose and status of the AMP in the EDB's asset management practices. The purpose statement must also include a statement of the objectives of the asset management and planning processes;	Executive Summary and Section 3.1
		3.3.2	states the corporate mission or vision as it relates to asset management;	Section 1.4
		3.3.3	identifies the documented plans produced as outputs of the annual business planning process adopted by the EDB;	Section 3.4
		3.3.4	states how the different documented plans relate to one another, with particular reference to any plans specifically dealing with asset management; and	Section 3.4
		3.3.5	includes a description of the interaction between the objectives of the AMP and other corporate goals, business planning processes, and plans;	Section 3.1
	3.4	Details of the AMP planning period, which must cover at least a projected period of 10 years commencing with the disclosure year following the date on which the AMP is disclosed;		Executive Summary, Section 1.1 and Section 3.2
	3.5	The date that it was approved by the directors;		Appendix 14
	3.6	A description of stakeholder interests (owners, consumers etc.) which identifies important stakeholders and indicates-		Section 2.1

	3.6.1	how the interests of stakeholders are identified	Section 2.1
	3.6.2	what these interests are;	Section 2.1
INFORMATION DISCLOSURE DETERMINATION REQUIREMENT			**AMP SECTION REFERENCE**
	3.6.3	how these interests are accommodated in asset management practices; and	Section 2.1
	3.6.4	how conflicting interests are managed;	Section 2.1
3.7	A description of the accountabilities and responsibilities for asset management on at least 3 levels, including-		Section 3.3
	3.7.1	governance—a description of the extent of director approval required for key asset management decisions and the extent to which asset management outcomes are regularly reported to directors;	Section 3.3
	3.7.2	executive—an indication of how the in-house asset management and planning organisation is structured; and	Section 3.3
	3.7.3	field operations—an overview of how field operations are managed, including a description of the extent to which field work is undertaken in-house and the areas where outsourced contractors are used;	Section 6.2
3.8	All significant assumptions-		
	3.8.1	quantified where possible;	Section 1.9
	3.8.2	clearly identified in a manner that makes their significance understandable to interested persons, including-	Section 1.9
	3.8.3	a description of changes proposed where the information is not based on the EDB's existing business;	N/A
	3.8.4	the sources of uncertainty and the potential effect of the uncertainty on the prospective information; and	Section 1.9
	3.8.5	the price inflator assumptions used to prepare the financial information disclosed in nominal New Zealand dollars in the Report on Forecast Capital Expenditure set out in Schedule 11a and the Report on Forecast Operational Expenditure set out in Schedule 11b;	Appendix 13
3.9	A description of the factors that may lead to a material difference between the prospective information disclosed and the corresponding actual information recorded in future disclosures;		Section 1.9
3.10	An overview of asset management strategy and delivery;		Section 4.2 and Section 6

3.11	An overview of systems and information management data;		Section 3.5, Section 3.6 and Section 3.7
3.12	A statement covering any limitations in the availability or completeness of asset management data and disclose any initiatives intended to improve the quality of this data;		Section 3.7
3.13	A description of the processes used within the EDB for-		
	3.13.1	managing routine asset inspections and network maintenance;	Section 4.2.6
	3.13.2	planning and implementing network development projects; and	Section 6.1
	3.13.3	measuring network performance;	Section 2.3
INFORMATION DISCLOSURE DETERMINATION REQUIREMENT			**AMP SECTION REFERENCE**
3.14	An overview of asset management documentation, controls and review processes.		Section 3.4 and Section 3.5
3.15	An overview of communication and participation processes;		Section 1.7
3.16	The AMP must present all financial values in constant price New Zealand dollars except where specified otherwise; and		Compliant
3.17	The AMP must be structured and presented in a way that the EDB considers will support the purposes of AMP disclosure set out in clause 2.6.2 of the determination.		Compliant
Assets covered			
4.	The AMP must provide details of the assets covered, including-		
4.1	a high-level description of the service areas covered by the EDB and the degree to which these are interlinked, including-		Section 4.1
	4.1.1	the region(s) covered;	Section 4.1
	4.1.2	identification of large consumers that have a significant impact on network operations or asset management priorities;	Appendix 3
	4.1.3	description of the load characteristics for different parts of the network;	Section 4.1 and Appendix 3
	4.1.4	peak demand and total energy delivered in the previous year, broken down by sub-network, if any.	Section 4.1.1

4.2	a description of the network configuration, including-		Section 4.1
	4.2.1	identifying bulk electricity supply points and any distributed generation with a capacity greater than 1 MW. State the existing firm supply capacity and current peak load of each bulk electricity supply point;	Section 4.1 and Appendix 9
	4.2.2	a description of the subtransmission system fed from the bulk electricity supply points, including the capacity of zone substations and the voltage(s) of the subtransmission network(s). The AMP must identify the supply security provided at individual zone substations, by describing the extent to which each has n-x subtransmission security or by providing alternative security class ratings;	Section 4.1 and Appendix 9 (Schedule 12b)
	4.2.3	a description of the distribution system, including the extent to which it is underground;	Section 4.1
	4.2.4	a brief description of the network's distribution substation arrangements;	Section 4.1
	4.2.5	a description of the low voltage network including the extent to which it is underground; and	Section 4.1
	4.2.6	an overview of secondary assets such as protection relays, ripple injection systems, SCADA and telecommunications systems.	Section 4.1
4.3	If sub-networks exist, the network configuration information referred to in clause 4.2 must be disclosed for each sub-network.		N/A

Network assets by category

INFORMATION DISCLOSURE DETERMINATION REQUIREMENT			AMP SECTION REFERENCE
4.4	The AMP must describe the network assets by providing the following information for each asset category-		
	4.4.1	voltage levels;	Section 4.1
	4.4.2	description and quantity of assets;	Section 4.1
	4.4.3	age profiles; and	Section 4.1
	4.4.4	a discussion of the condition of the assets, further broken down into more detailed categories as considered appropriate. Systemic issues leading to the premature replacement of assets or parts of assets should be discussed.	Section 4.2 and 4.3
4.5	The asset categories discussed in clause 4.4 should include at least the following-		
	4.5.1	the categories listed in the Report on Forecast Capital Expenditure in Schedule 11a(iii);	Section 3.2

	4.5.2	assets owned by the EDB but installed at bulk electricity supply points owned by others;	N/A
	4.5.3	EDB owned mobile substations and generators whose function is to increase supply reliability or reduce peak demand; and	Section 4.1
	4.5.4	other generation plant owned by the EDB.	N/A
Service Levels			
5.	The AMP must clearly identify or define a set of performance indicators for which annual performance targets have been defined. The annual performance targets must be consistent with business strategies and asset management objectives and be provided for each year of the AMP planning period. The targets should reflect what is practically achievable given the current network configuration, condition, and planned expenditure levels. The targets should be disclosed for each year of the AMP planning period.		Section 2.2
6.	Performance indicators for which targets have been defined in clause 5 must include SAIDI values and SAIFI values for the next 5 disclosure years.		Section 2.2
7.	Performance indicators for which targets have been defined in clause 5 should also include-		
	7.1	Consumer oriented indicators that preferably differentiate between different consumer types; and	Section 2.3.5 and 2.3.7
	7.2	Indicators of asset performance, asset efficiency and effectiveness, and service efficiency, such as technical and financial performance indicators related to the efficiency of asset utilisation and operation.	Section 2.3 and Appendix 9
8.	The AMP must describe the basis on which the target level for each performance indicator was determined. Justification for target levels of service includes consumer expectations or demands, legislative, regulatory, and other stakeholders' requirements or considerations. The AMP should demonstrate how stakeholder needs were ascertained and translated into service level targets.		Section 2.2
9.	Targets should be compared to historic values where available to provide context and scale to the reader.		Section 2.3
10.	Where forecast expenditure is expected to materially affect performance against a target defined in clause 5, the target should be consistent with the expected change in the level of performance.		N/A
INFORMATION DISCLOSURE DETERMINATION REQUIREMENT			**AMP SECTION REFERENCE**
Network Development Planning			
11.	AMPs must provide a detailed description of network development plans, including—-		
	11.1	A description of the planning criteria and assumptions for network development;	Section 1.4 and Section 3.5

11.2	Planning criteria for network developments should be described logically and succinctly. Where probabilistic or scenario-based planning techniques are used, this should be indicated and the methodology briefly described;		Section 3.5
11.3	A description of strategies or processes (if any) used by the EDB that promote cost efficiency including through the use of standardised assets and designs;		Section 3.5
11.4	The use of standardised designs may lead to improved cost efficiencies. This section should discuss-		Section 3.5
	11.4.1	the categories of assets and designs that are standardised; and	Section 3.5
	11.4.2	the approach used to identify standard designs;	Section 3.5
11.5	A description of strategies or processes (if any) used by the EDB that promote the energy efficient operation of the network;		Section 3.5 and Section 6.1
11.6	A description of the criteria used to determine the capacity of equipment for different types of assets or different parts of the network;.		Section 4.3
11.7	A description of the process and criteria used to prioritise network development projects and how these processes and criteria align with the overall corporate goals and vision;		Section 6.1
11.8	Details of demand forecasts, the basis on which they are derived, and the specific network locations where constraints are expected due to forecast increases in demand;		
	11.8.1	explain the load forecasting methodology and indicate all the factors used in preparing the load estimates	Section 1.9 and Section 3.5
	11.8.2	provide separate forecasts to at least the zone substation level covering at least a minimum five year forecast period. Discuss how uncertain but substantial individual projects/developments that affect load are taken into account in the forecasts, making clear the extent to which these uncertain increases in demand are reflected in the forecasts;	Section 2.3, Section 5 and Appendix 10
	11.8.3	identify any network or equipment constraints that may arise due to the anticipated growth in demand during the AMP planning period; and	Section 5.1
	11.8.4	discuss the impact on the load forecasts of any anticipated levels of distributed generation in a network, and the projected impact of any demand management initiatives;	Section 1.9
11.9	Analysis of the significant network level development options identified and details of the decisions made to satisfy and meet target levels of service, including-		SECTION 5
	11.9.1	the reasons for choosing a selected option for projects where decisions have been made;	SECTION 5

INFORMATION DISCLOSURE DETERMINATION REQUIREMENT			AMP SECTION REFERENCE
		11.9.2 the alternative options considered for projects that are planned to start in the next five years and the potential for non-network solutions described; and	SECTION 5
		11.9.3 consideration of planned innovations that improve efficiencies within the network, such as improved utilisation, extended asset lives, and deferred investment;	SECTION 5
	11.10	A description and identification of the network development programme including distributed generation and non-network solutions and actions to be taken, including associated expenditure projections. The network development plan must include-	SECTION 5
		11.10.1 a detailed description of the material projects and a summary description of the non-material projects currently underway or planned to start within the next 12 months;	SECTION 5
		11.10.2 a summary description of the programmes and projects planned for the following four years (where known); and	SECTION 5
		11.10.3 an overview of the material projects being considered for the remainder of the AMP planning period;	SECTION 5
	11.11	A description of the EDB's policies on distributed generation, including the policies for connecting distributed generation. The impact of such generation on network development plans must also be stated; and	N/A
	11.12	A description of the EDB's policies on non-network solutions, including-	Section 5.1
		11.12.1 economically feasible and practical alternatives to conventional network augmentation. These are typically approaches that would reduce network demand and/or improve asset utilisation; and	Section 5.1
		11.12.2 the potential for non-network solutions to address network problems or constraints.	Section 5.1
Lifecycle Asset Management Planning (Maintenance and Renewal)			
12.	The AMP must provide a detailed description of the lifecycle asset management processes, including—		
	12.1	The key drivers for maintenance planning and assumptions;	Section 4.2.6
	12.2	Identification of routine and corrective maintenance and inspection policies and programmes and actions to be taken for each asset category, including associated expenditure projections. This must include-	Section 4.2.6 and Section 5.2

	12.2.1	the approach to inspecting and maintaining each category of assets, including a description of the types of inspections, tests and condition monitoring carried out and the intervals at which this is done;	Section 4.2.6 and Section 4.3
	12.2.2	any systemic problems identified with any particular asset types and the proposed actions to address these problems; and	Section 4.2 and Section 4.3
	12.2.3	budgets for maintenance activities broken down by asset category for the AMP planning period;	Section 5.2
12.3	Identification of asset replacement and renewal policies and programmes and actions to be taken for each asset category, including associated expenditure projections. This must include-		Section 4.2 and Section 4.3

INFORMATION DISCLOSURE DETERMINATION REQUIREMENT			AMP SECTION REFERENCE
	12.3.1	the processes used to decide when and whether an asset is replaced or refurbished, including a description of the factors on which decisions are based, and consideration of future demands on the network and the optimum use of existing network assets;	Section 4.2.5
	12.3.2	a description of innovations that have deferred asset replacements;	Section 4.2.5 and Section 4.2.4
	12.3.3	a description of the projects currently underway or planned for the next 12 months;	SECTION 5
	12.3.4	a summary of the projects planned for the following four years (where known); and	SECTION 5
	12.3.5	an overview of other work being considered for the remainder of the AMP planning period; and	SECTION 5
12.4	The asset categories discussed in clauses 12.2 and 12.3 should include at least the categories in clause 4.5.		Compliant
Non-Network Development, Maintenance and Renewal			
13.	AMPs must provide a summary description of material non-network development, maintenance and renewal plans, including—		
13.1	a description of non-network assets;		Section 4.1.7
13.2	development, maintenance and renewal policies that cover them;		Section 4.2.12 and Section 5.3
13.3	a description of material capital expenditure projects (where known) planned for the next five years; and		SECTION 5
13.4	a description of material maintenance and renewal projects (where known) planned for the next five years.		SECTION 5
Risk Management			
14.	AMPs must provide details of risk policies, assessment, and mitigation, including—		
14.1	Methods, details, and conclusions of risk analysis;		Section 3.5.4 and Section 5.2
14.2	Strategies used to identify areas of the network that are vulnerable to high impact low probability events and a description of the resilience of the network and asset management systems to such events;		Section 3.5.4

	14.3	A description of the policies to mitigate or manage the risks of events identified in clause 14.2; and	Section 3.4.1 and Section 3.4.2
	14.4	Details of emergency response and contingency plans.	Section 3.8
Evaluation of performance			
15.	AMPs must provide details of performance measurement, evaluation, and improvement, including—		
	15.1	A review of progress against plan, both physical and financial;	Section 6.4 and Appendix 5
	15.2	An evaluation and comparison of actual service level performance against targeted performance;	Section 2.3
	INFORMATION DISCLOSURE DETERMINATION REQUIREMENT		**AMP SECTION REFERENCE**
	15.3	An evaluation and comparison of the results of the asset management maturity assessment disclosed in the Report on Asset Management Maturity set out in Schedule 13 against relevant objectives of the EDB's asset management and planning processes.	Section 3.7
	15.4	An analysis of gaps identified in clauses 15.2 and 15.3. Where significant gaps exist (not caused by one-off factors), the AMP must describe any planned initiatives to address the situation.	Section 2.3 and Section 5
Capability to deliver			
16.	AMPs must describe the processes used by the EDB to ensure that-		
	16.1	The AMP is realistic and the objectives set out in the plan can be achieved; and	Section 6.1
	16.2	The organisation structure and the processes for authorisation and business capabilities will support the implementation of the AMP plans.	Section 3.3, Section 6.1 and Section 6.2

Appendix 5 Significant Changes from 2017 AMP

2018 AMP SCHEDULE DATE	SUBSTATION	PROJECT AND PROGRAMME DESCRIPTION	2017 AMP SCHEDULE DATE	REASON FOR CHANGE
FY19	Browns Bay	Browns Bay 33 kV switchboard	FY18	Change to larger scope of work
FY19	Browns Bay	Browns Bay 33 kV/11 kV transformer replace T2	FY18	Change to larger scope of work
	Coatesville	Coatesville powerpack	FY19	Cancelled due to alternative solution
FY21	Freemans Bay	Freemans Bay 11 kV switchboard replace	FY20	Revised risk assessment
FY19	Hobson	Hobson - Quay Street 110 kV subtransmission cable	FY20	To coordinate with major road works
FY22	Hobsonville	Hobsonville 11 kV switchboard replace	FY21	Revised risk assessment
	Newmarket	Hospital capacity reinforcement	FY18	Completed
FY23	James	James Street 11 kV switchboard replace	FY21	Revised risk assessment
FY19	Manurewa	Manurewa 11 kV switchboard replace	FY18	Delay in civil works
	Various	Network powerwalls - Northern	FY18	Scope included in other development projects
FY21	New Lynn	New Lynn 33 kV switchboard	FY22	To coordinate with subtransmission replacement
	Newmarket South	Newmarket South land purchase for zone substation	FY18	Cancelled due to alternative solution
FY23	Orewa	Orewa 33 kV switchboard	FY21	Revised risk assessment
FY22	Sandringham	Sandringham 11 kV switchboard replace	FY21	Revised risk assessment
	Takanini	Takanini powerpack	FY19	Cancelled due to alternative solution
FY20	Takanini	Takanini subtransmission cable replace	FY22	Revised risk assessment
FY19	Takanini GXP	Takanini Transpower 33 kV switchboard	FY18	Revised risk assessment
FY23	Te Papapa	Te Papapa 11 kV switchboard replace	FY21	Revised risk assessment
	Warkworth South	Warkworth South powerpack	FY18	Completed
FY25	Brickworks	Brickworks 2nd 33 kV/11 kV transformer	FY20	Revised load forecast

FY21	Chevalier	Chevalier subtransmission cable replace	FY20	Revised risk assessment
FY21	Hobson	Hobson 11 kV switchboard replace	FY19	Increase in civil scope of works
FY20	Hobsonville Point	Hobsonville Point zone substation	FY19	Delay in consenting
FY28	Keeling Road	Keeling Road 2nd 33 kV supply	FY23	Revised load forecast
	Kingsland	Kingsland - CRL supply Mount Eden station	FY19	Combined with other projects
FY22	Liverpool	Liverpool 110 kV switchboard extension	FY20	Revised risk assessment
FY20	Mangere Central	Mangere Central 11 kV switchboard replace	FY19	Change to larger scope of work
FY24	Millwater	Millwater zone substation	FY21	Revised load forecast
FY20	Orewa	Orewa 11 kV switchboard replace	FY19	Change to larger scope of work
FY23	Red Hills	Red Hills zone substation	FY25	Revised load forecast
FY24	Takapuna	Second Waitemata Harbour crossing tunnel supply	FY22	Pending decision by New Zealand Transport Authority
FY21	Mangere GXP	Mangere Transpower 33 kV switchboard	FY22	To coordinate with Transpower programme
FY20	Mount Roskill GXP	Mount Roskill Transpower 33 kV switchboard	FY19	To coordinate with Transpower programme
FY21	Wiri GXP	Wiri Transpower 33 kV switchboard	FY20	To coordinate with Transpower programme
FY27	Warkworth South	Warkworth South zone substation	FY21	Alternative solutions
	Warkworth South	Warkworth South subtransmission reinforcement	FY27	Revised load forecast
FY28	Whenuapai	Whenuapai zone substation	FY25	Alternative solutions
FY28	Woodford	Woodford 2nd 33 kV/1 1kV transformer and 33 kV cable	FY23	Revised load forecast
	Auckland International	Airport - new transformer and cable	FY23	Improve security of supply
FY28	Kaukapakapa	Kaukapakapa zone substation	FY27	Revised load forecast
	Kumeu	Kumeu zone substation	FY27	Revised load forecast
FY25	Mangere South	Mangere South zone substation	FY23	Revised load forecast
	Southdown GXP	Southdown - GXP	FY23	On hold while under review
	Various	Various translay protection replacement	FY20	Combined with other projects

FY22	Waimauku	Waimauku 2nd 33 kV supply and 33 kV switchboard	FY25	To coordinate with subtransmission replacement
FY24	Wiri West	Wiri West zone substation	FY25	Revised load forecast
FY20	Glen Innes	Glen Innes subtransmission cable replace	-	New project
FY20	Highbury	Highbury 2nd 33 kV/11 kV transformer and cables	-	New project
FY19	Penrose	Penrose 22 kV containerised switchboard	-	New project
FY22	Various	Auckland subtransmission protection upgrade	-	New project
FY23	Manukau	Mill and Redoubt Road relocation	-	New project
FY24	Te Atatu	Te Atatu 33 kV/11 kV transformer capacity replace	-	New project
FY21	Sabulite	Sabulite 33 kV/11 kV transformer capacity replace	-	New project
FY28	Greenhithe	Greenhithe 2nd 33 kV/11 kV transformer	-	New project
FY24	Mount Albert	Mount Albert subtransmission cable Replace	-	New project
FY27	Takanini South	Takanini South zone substation	-	New project
FY26	Warkworth	Wellsford-Warkworth 33 kV upgrade stage 2	-	New project
FY28	Warkworth	Wellsford-Warkworth SH1 future-proofing ducts	-	New project
FY25	Maraetai	Maraetai-Whitford Road 11 kV feeder reinforcement	-	New project
FY24	Glenvar	Glenvar zone substation	-	New project
FY25	Henderson valley	Henderson Valley 33 kV/11 kV transformer capacity replace	-	New project
FY26	Manly	Manly 33 kV/11 kV transformer capacity replace	-	New project
FY28	Milford	Milford 2nd 33 kV/11 kV transformer	-	New project
FY22	Sunset Road	Sunset Road 33 kV/11 kV transformer capacity replace	-	New project
FY23	Various	Light rail transit station supply	-	New project
FY27	Belmont	Belmont 33 kV/11 kV transformer upgrade	-	New Project
FY25	Forrest Hill	Forrest Hill 33 kV/11 kV transformer upgrade	-	New Project

FY26	James Street	James Street 33 kV/11 kV transformer upgrade	-	New Project
FY26	Triangle Road	Triangle Road 33 kV/11 kV transformer upgrade	-	New Project
FY25	Wairau	Wairau 33 kV/11 kV transformer upgrade	-	New Project
FY27	Wellsford GXP	Wellsford GXP -Wellsford 33 kV upgrade	-	New Project
FY25	Helensville	South Head micro grid	-	New Project
FY21	Helensville	Kaukapakapa micro grid	-	New Project
FY23	Henderson Valley	Piha micro grid	-	New Project
FY22	Gulf Harbour	Gulf Harbour 11 kV reinforcement	-	New Project
FY27	Snells Beach	Tawharanui 11 kV reinforcement	-	New Project

Appendix 6 Forecast Capital Expenditure (Schedule 11a)

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 to 31 March 2028**

SCHEDULE 11a: REPORT ON FORECAST CAPITAL EXPENDITURE

This schedule requires a breakdown of forecast expenditure on assets for the current disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms. Also required is a forecast of the value of commissioned assets (i.e., the value of RAB additions)

EDBs must provide explanatory comment on the difference between constant price and nominal dollar forecasts of expenditure on assets in Schedule 14a (Mandatory Explanatory Notes).

This information is not part of audited disclosure information.

sch ref												
7		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
8		**RY18**	**RY19**	**RY20**	**RY21**	**RY22**	**RY23**	**RY24**	**RY25**	**RY26**	**RY27**	**RY28**
9	**11a(i): Expenditure on Assets Forecast**	**$000 (in nominal dollars)**										
10	Consumer connection	67,721	65,603	66,647	65,871	65,884	64,269	64,017	65,325	63,797	64,270	65,858
11	System growth	26,665	46,516	43,100	35,291	43,770	54,463	45,513	40,592	50,301	61,603	70,461
12	Asset replacement and renewal	93,398	86,096	95,714	97,439	109,431	113,063	117,185	115,004	115,201	120,146	122,842
13	Asset relocations	22,350	19,386	17,808	18,324	18,766	19,075	19,379	19,896	20,417	20,925	21,446
14	Reliability, safety and environment:											
15	Quality of supply	4,239	1,143	-	-	-	-	-	-	-	-	-
16	Legislative and regulatory	81	373	-	-	-	-	-	-	-	-	-
17	Other reliability, safety and environment	1,120	3,354	2,512	2,203	2,153	2,368	1,683	1,253	1,216	1,247	1,278
18	**Total reliability, safety and environment**	5,440	4,870	2,512	2,203	2,153	2,368	1,683	1,253	1,216	1,247	1,278
19	**Expenditure on network assets**	215,574	222,471	225,781	219,128	240,004	253,238	247,777	242,070	250,932	268,191	281,885
20	Non-network assets	17,603	18,706	14,015	16,727	19,092	20,311	20,647	17,348	15,610	14,404	14,145
21	**Expenditure on assets**	233,177	241,177	239,796	235,855	259,096	273,549	268,424	259,418	266,542	282,595	296,030
22												
23	*plus* Cost of financing	3,955	4,497	4,459	4,237	4,756	5,180	4,935	4,719	5,027	5,501	5,876
24	*less* Value of capital contributions	67,489	64,585	65,138	65,117	65,598	64,529	64,564	65,978	65,081	65,810	67,442
25	*plus* Value of vested assets											
26												
27	**Capital expenditure forecast**	169,643	181,089	179,117	174,975	198,254	214,200	208,795	198,159	206,488	222,286	234,464
28												
29	Value of commissioned assets	169,604	181,452	179,966	175,810	198,608	220,651	209,349	207,109	195,541	228,218	233,340
30		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
32		**$000 (in constant prices)**										
33	Consumer connection	67,721	64,009	63,448	61,186	59,711	56,832	55,234	54,993	52,402	51,508	51,498
34	System growth	26,665	45,386	41,031	32,781	39,669	48,161	39,269	34,172	41,317	49,371	55,098
35	Asset replacement and renewal	93,398	84,004	91,120	90,508	99,178	99,980	101,107	96,815	94,625	96,289	96,058
36	Asset relocations	22,350	18,915	16,953	17,021	17,008	16,868	16,720	16,749	16,770	16,770	16,770
37	Reliability, safety and environment:											
38	Quality of supply	4,239	1,115	-	-	-	-	-	-	-	-	-
39	Legislative and regulatory	81	364	-	-	-	-	-	-	-	-	-
40	Other reliability, safety and environment	1,120	3,273	2,391	2,046	1,951	2,094	1,452	1,055	999	999	999
41	**Total reliability, safety and environment**	5,440	4,752	2,391	2,046	1,951	2,094	1,452	1,055	999	999	999
42	**Expenditure on network assets**	215,574	217,066	214,943	203,542	217,517	223,935	213,782	203,784	206,113	214,937	220,423
43	Non-network assets	17,603	18,252	13,342	15,537	17,303	17,961	17,814	14,604	12,822	11,544	11,061
44	**Expenditure on assets**	233,177	235,318	228,285	219,079	234,820	241,896	231,596	218,388	218,935	226,481	231,484
45												
46	**Subcomponents of expenditure on assets (where known)**											
47	Energy efficiency and demand side management, reduction of energy losses											
48	Overhead to underground conversion	6,191	6,269	4,792	4,792	4,792	4,792	4,792	4,792	4,792	4,792	4,792
49	Research and development	2,102	2,854	-	-	-	-	-	-	-	-	-

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 to 31 March 2028**

SCHEDULE 11a: REPORT ON FORECAST CAPITAL EXPENDITURE

This schedule requires a breakdown of forecast expenditure on assets for the current disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms. Also required is a forecast of the value of commissioned assets (i.e., the value of RAB additions)

EDBs must provide explanatory comment on the difference between constant price and nominal dollar forecasts of expenditure on assets in Schedule 14a (Mandatory Explanatory Notes).

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sch ref

		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5	CY+6	CY+7	CY+8	CY+9	CY+10
58												
59	**Difference between nominal and constant price forecasts**	**'$000**										
60	Consumer connection	-	1,594	3,199	4,685	6,173	7,437	8,783	10,332	11,395	12,762	14,360
61	System growth	-	1,130	2,069	2,510	4,101	6,302	6,244	6,420	8,984	12,232	15,363
62	Asset replacement and renewal	-	2,092	4,594	6,931	10,253	13,083	16,078	18,189	20,576	23,857	26,784
63	Asset relocations	-	471	855	1,303	1,758	2,207	2,659	3,147	3,647	4,155	4,676
64	Reliability, safety and environment:											
65	Quality of supply	-	28	-	-	-	-	-	-	-	-	-
66	Legislative and regulatory	-	9	-	-	-	-	-	-	-	-	-
67	Other reliability, safety and environment	-	81	121	157	202	274	231	198	217	248	279
68	**Total reliability, safety and environment**	-	118	121	157	202	274	231	198	217	248	279
69	**Expenditure on network assets**	-	5,405	10,838	15,586	22,487	29,303	33,995	38,286	44,819	53,254	61,462
70	Non-network assets	-	454	673	1,190	1,789	2,350	2,833	2,744	2,788	2,860	3,084
71	**Expenditure on assets**	-	5,859	11,511	16,776	24,276	31,653	36,828	41,030	47,607	56,114	64,546
72												

73		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
74	**11a(ii): Consumer Connection**						
75	*Consumer types defined by EDB**	**$000 (in constant prices)**					
76	Service Connection	12,729	17,282	16,316	17,416	17,691	17,691
	Customer Substations	9,952	9,338	8,943	8,474	7,918	7,718
77	Business subdivisions	1,854	2,120	1,855	1,598	1,268	1,180
78	Residential Subdivisions	27,639	30,973	31,097	28,505	27,641	25,050
	Capacity Changes	14,410	3,469	4,625	4,625	4,625	4,625
79	Street Lighting	1,093	827	612	568	568	568
	Relocations	-	-	-	-	-	-
80	Easements	44	-	-	-	-	-
81	**include additional rows if needed*						
82	**Consumer connection expenditure**	67,721	64,009	63,448	61,186	59,711	56,832
83	*less* Capital contributions funding consumer connection	55,202	53,372	52,768	51,197	50,172	47,875
84	**Consumer connection less capital contributions**	12,519	10,637	10,680	9,989	9,539	8,957
85	**11a(iii): System Growth**						
86	Subtransmission	1,302	2,118	668	2,161	3,256	4,954
87	Zone substations	10,196	19,698	21,608	11,469	16,156	25,166
88	Distribution and LV lines	-	-	708	944	944	944
89	Distribution and LV cables	9,386	17,232	15,829	16,320	17,426	15,210
90	Distribution substations and transformers	-	2,406	2,218	1,887	1,887	1,887
91	Distribution switchgear	490	29	-	-	-	-
92	Other network assets	5,291	3,903	-	-	-	-
93	**System growth expenditure**	26,665	45,386	41,031	32,781	39,669	48,161
94	*less* Capital contributions funding system growth						
95	**System growth less capital contributions**	26,665	45,386	41,031	32,781	39,669	48,161

Company Name: **Vector Electricity**

AMP Planning Period: **1 April 2018 to 31 March 2028**

SCHEDULE 11a: REPORT ON FORECAST CAPITAL EXPENDITURE

This schedule requires a breakdown of forecast expenditure on assets for the current disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms. Also required is a forecast of the value of commissioned assets (i.e., the value of RAB additions)

EDBs must provide explanatory comment on the difference between constant price and nominal dollar forecasts of expenditure on assets in Schedule 14a (Mandatory Explanatory Notes).

This information is not part of audited disclosure information.

sch ref		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
103							
104							
105	**11a(iv): Asset Replacement and Renewal**	**$000 (in constant prices)**					
106	Subtransmission	240	9,827	17,430	7,061	1,461	4,809
107	Zone substations	27,142	22,051	17,425	22,428	32,593	22,905
108	Distribution and LV lines	32,924	21,572	22,634	26,921	29,362	34,163
109	Distribution and LV cables	5,156	4,585	4,854	4,949	5,019	5,137
110	Distribution substations and transformers	13,064	8,701	8,775	9,065	9,173	9,600
111	Distribution switchgear	11,419	13,378	15,378	16,548	18,386	19,964
112	Other network assets	3,453	3,890	4,624	3,536	3,184	3,402
113	**Asset replacement and renewal expenditure**	93,398	84,004	91,120	90,508	99,178	99,980
114	*less* Capital contributions funding asset replacement and renewal						
115	**Asset replacement and renewal less capital contributions**	93,398	84,004	91,120	90,508	99,178	99,980
116	**11a(v):Asset Relocations**						
117	*Project or programme**						
118	Overground to underground conversions	6,191	6,269	4,792	4,792	4,792	4,792
119							
120							
121							
123	**include additional rows if needed*						
124	All other asset relocations projects or programmes	16,159	12,646	12,161	12,229	12,216	12,076
125	**Asset relocations expenditure**	22,350	18,915	16,953	17,021	17,008	16,868
126	*less* Capital contributions funding asset relocations	12,287	9,644	9,243	9,289	9,280	9,187
127	**Asset relocations less capital contributions**	10,063	9,271	7,710	7,732	7,728	7,681
128							
129	**11a(vi):Quality of Supply**						
130	*Project or programme**						
131							
132							
133							
134							
135							
136	**include additional rows if needed*						
137	All other quality of supply projects or programmes	4,239	1,115	-	-	-	-
138	**Quality of supply expenditure**	4,239	1,115	-	-	-	-
139	*less* Capital contributions funding quality of supply						
140	**Quality of supply less capital contributions**	4,239	1,115	-	-	-	-
141							
142	**11a(vii): Legislative and Regulatory**						
143	*Project or programme**						
144							
145							
146							
147							
148							
149	**include additional rows if needed*						
150	All other legislative and regulatory projects or programmes	81	364	-	-	-	-
151	**Legislative and regulatory expenditure**	81	364	-	-	-	-
152	*less* Capital contributions funding legislative and regulatory						
153	**Legislative and regulatory less capital contributions**	81	364	-	-	-	-

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 to 31 March 2028**

SCHEDULE 11a: REPORT ON FORECAST CAPITAL EXPENDITURE

This schedule requires a breakdown of forecast expenditure on assets for the current disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms. Also required is a forecast of the value of commissioned assets (i.e., the value of RAB additions)

EDBs must provide explanatory comment on the difference between constant price and nominal dollar forecasts of expenditure on assets in Schedule 14a (Mandatory Explanatory Notes).

This information is not part of audited disclosure information.

sch ref		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
161							
162							
163	**11a(viii): Other Reliability, Safety and Environment**						
164	*Project or programme**	**$000 (in constant prices)**					
165							
166							
167							
168							
169							
170	**include additional rows if needed*						
171	All other reliability, safety and environment projects or programmes	1,120	3,273	2,391	2,046	1,951	2,094
172	**Other reliability, safety and environment expenditure**	1,120	3,273	2,391	2,046	1,951	2,094
173	*less* Capital contributions funding other reliability, safety and environment						
174	**Other reliability, safety and environment less capital contributions**	1,120	3,273	2,391	2,046	1,951	2,094
175							
176							
177							
178	**11a(ix): Non-Network Assets**						
179	**Routine expenditure**						
180	*Project or programme**						
181							
182							
183							
184							
185							
186	**include additional rows if needed*						
187	All other routine expenditure projects or programmes	10,415	11,160	8,158	9,500	10,580	10,982
188	**Routine expenditure**	10,415	11,160	8,158	9,500	10,580	10,982
189	**Atypical expenditure**						
190	*Project or programme**						
191							
192							
193							
194							
195							
196	**include additional rows if needed*						
197	All other atypical projects or programmes	7,188	7,092	5,184	6,037	6,723	6,979
198	**Atypical expenditure**	7,188	7,092	5,184	6,037	6,723	6,979
199							
200	**Non-network assets expenditure**	17,603	18,252	13,342	15,537	17,303	17,961

Appendix 7 Forecast Operational Expenditure (Schedule 11b)

Company Name: Vector Electricity
AMP Planning Period: 1 April 2018- 31 March 2028

SCHEDULE 11b: REPORT ON FORECAST OPERATIONAL EXPENDITURE

This schedule requires a breakdown of forecast operational expenditure for the disclosure year and a 10 year planning period. The forecasts should be consistent with the supporting information set out in the AMP. The forecast is to be expressed in both constant price and nominal dollar terms.
EDBs must provide explanatory comment on the difference between constant price and nominal dollar operational expenditure forecasts in Schedule 14a (Mandatory Explanatory Notes).
This information is not part of audited disclosure information.

sch ref												
7		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
8	for year ended	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**	**31 Mar 24**	**31 Mar 25**	**31 Mar 26**	**31 Mar 27**	**31 Mar 28**
9	**Operational Expenditure Forecast**	**$000 (in nominal dollars)**										
10	Service interruptions and emergencies	9,648	12,242	13,363	14,214	14,858	15,403	15,942	16,499	17,077	17,675	18,294
11	Vegetation management	6,996	6,170	6,741	6,293	6,255	6,441	6,621	6,807	6,997	7,193	7,395
12	Routine and corrective maintenance and inspection	13,960	15,507	16,255	17,090	17,823	18,516	19,205	19,917	20,656	21,421	22,221
13	Asset replacement and renewal	13,202	14,935	15,862	19,906	21,787	22,529	23,258	24,011	22,880	21,984	21,347
14	**Network Opex**	43,806	48,854	52,221	57,503	60,723	62,889	65,026	67,234	67,610	68,273	69,257
15	System operations and network support	36,829	37,729	39,278	39,449	40,516	41,782	43,037	44,340	45,676	47,052	48,450
16	Business support	35,332	41,212	42,622	43,975	45,305	46,650	47,956	49,299	50,680	52,099	53,557
17	**Non-network opex**	72,161	78,941	81,900	83,424	85,821	88,432	90,993	93,639	96,356	99,151	102,007
18	**Operational expenditure**	115,967	127,795	134,121	140,927	146,544	151,321	156,019	160,873	163,966	167,424	171,264
19		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
20	for year ended	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**	**31 Mar 24**	**31 Mar 25**	**31 Mar 26**	**31 Mar 27**	**31 Mar 28**
21		**$000 (in constant prices)**										
22	Service interruptions and emergencies	9,648	11,825	12,489	12,876	13,064	13,152	13,242	13,332	13,423	13,514	13,607
23	Vegetation management	6,996	5,959	6,300	5,700	5,500	5,500	5,500	5,500	5,500	5,500	5,500
24	Routine and corrective maintenance and inspection	13,960	14,978	15,191	15,481	15,670	15,811	15,952	16,093	16,236	16,378	16,527
25	Asset replacement and renewal	13,202	14,426	14,824	18,031	19,156	19,237	19,319	19,401	17,984	16,809	15,877
26	**Network Opex**	43,806	47,188	48,804	52,088	53,390	53,700	54,013	54,326	53,143	52,201	51,511
27	System operations and network support	36,829	36,442	36,708	35,734	35,623	35,678	35,748	35,827	35,901	35,976	36,035
28	Business support	35,332	39,807	39,834	39,834	39,834	39,834	39,834	39,834	39,834	39,834	39,834
29	**Non-network opex**	72,161	76,249	76,542	75,568	75,457	75,512	75,582	75,661	75,735	75,810	75,869
30	**Operational expenditure**	115,967	123,437	125,346	127,656	128,847	129,212	129,595	129,987	128,878	128,011	127,380
31	**Subcomponents of operational expenditure (where known)**											
32	Energy efficiency and demand side management, reduction of											
33	energy losses											
34	Direct billing*											
35	Research and Development	-	-	-	-	-	-	-	-	-	-	-
36	Insurance	2,668	2,762	2,854	2,945	3,034	3,124	3,212	3,301	3,394	3,489	3,587
37	** Direct billing expenditure by suppliers that direct bill the majority of their consumers*											
38												
39		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*	*CY+6*	*CY+7*	*CY+8*	*CY+9*	*CY+10*
40												
41	**Difference between nominal and real forecasts**	**$000**										
42	Service interruptions and emergencies	-	417	874	1,338	1,794	2,251	2,700	3,167	3,654	4,161	4,687
43	Vegetation management	-	211	441	593	755	941	1,121	1,307	1,497	1,693	1,895
44	Routine and corrective maintenance and inspection	-	529	1,064	1,609	2,153	2,705	3,253	3,824	4,420	5,043	5,694
45	Asset replacement and renewal	-	509	1,038	1,875	2,631	3,292	3,939	4,610	4,896	5,175	5,470
46	**Network Opex**	-	1,666	3,417	5,415	7,333	9,189	11,013	12,908	14,467	16,072	17,746
47	System operations and network support	-	1,287	2,570	3,715	4,893	6,104	7,289	8,513	9,775	11,076	12,415
48	Business support	-	1,405	2,788	4,141	5,471	6,816	8,122	9,465	10,846	12,265	13,723
49	**Non-network opex**	-	2,692	5,358	7,856	10,364	12,920	15,411	17,978	20,621	23,341	26,138
50	**Operational expenditure**	-	4,358	8,775	13,271	17,697	22,109	26,424	30,886	35,088	39,413	43,884

Appendix 8 Asset Condition (Schedule 12a)

Company Name **Vector Electricity**
AMP Planning Period **1 April 2018 – 31 March 2028**

SCHEDULE 12a: REPORT ON ASSET CONDITION

This schedule requires a breakdown of asset condition by asset class as at the start of the forecast year. The data accuracy assessment relates to the percentage values disclosed in the asset condition columns. Also required is a forecast of the percentage of units to be replaced in the next 5 years. All information should be consistent with the information provided in the AMP and the expenditure on assets forecast in Schedule 11a. All units relating to cable and line assets, that are expressed in km, refer to circuit lengths.

sch ref											
7					**Asset condition at start of planning period (percentage of units by grade)**						
8											
	Voltage	**Asset category**	**Asset class**	**Units**	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**	**Grade unknown**	**Data accuracy (1–4)**	**% of asset forecast to be replaced in next 5 years**
9											
10	All	Overhead Line	Concrete poles / steel structure	No.	0.00%	0.05%	63.29%	36.66%		4	6.11%
11	All	Overhead Line	Wood poles	No.	0.01%	1.67%	92.43%	5.89%		4	9.65%
12	All	Overhead Line	Other pole types	No.	-	-	-	100.00%		4	-
13	HV	Subtransmission Line	Subtransmission OH up to 66kV conductor	km	0.12%	-	91.50%	8.38%		3	0.12%
14	HV	Subtransmission Line	Subtransmission OH 110kV+ conductor	km	-	-	72.31%	27.69%		3	-
15	HV	Subtransmission Cable	Subtransmission UG up to 66kV (XLPE)	km	0.38%	0.16%	23.05%	76.40%		2	0.55%
16	HV	Subtransmission Cable	Subtransmission UG up to 66kV (Oil pressurised)	km	-	-	95.98%	4.02%		2	-
17	HV	Subtransmission Cable	Subtransmission UG up to 66kV (Gas pressurised)	km	-	-	100.00%	-		2	-
18	HV	Subtransmission Cable	Subtransmission UG up to 66kV (PILC)	km	-	38.45%	58.51%	3.03%		2	62.60%
19	HV	Subtransmission Cable	Subtransmission UG 110kV+ (XLPE)	km	-	-	27.96%	72.04%		2	-
20	HV	Subtransmission Cable	Subtransmission UG 110kV+ (Oil pressurised)	km	-	-	93.87%	6.13%		2	-
21	HV	Subtransmission Cable	Subtransmission UG 110kV+ (Gas Pressurised)	km			-			N/A	
22	HV	Subtransmission Cable	Subtransmission UG 110kV+ (PILC)	km			-			N/A	
23	HV	Subtransmission Cable	Subtransmission submarine cable	km	-	-	100.00%	-		2	-
24	HV	Zone substation Buildings	Zone substations up to 66kV	No.	1.01%	-	98.99%	-		4	3.03%
25	HV	Zone substation Buildings	Zone substations 110kV+	No.	-	-	100.00%	-		4	-
26	HV	Zone substation switchgear	22/33kV CB (Indoor)	No.	-	-	29.06%	70.94%		4	14.53%
27	HV	Zone substation switchgear	22/33kV CB (Outdoor)	No.	-	8.92%	64.97%	26.11%		4	22.78%
28	HV	Zone substation switchgear	33kV Switch (Ground Mounted)	No.			-			N/A	
29	HV	Zone substation switchgear	33kV Switch (Pole Mounted)	No.	-	-	100.00%	-		4	-
30	HV	Zone substation switchgear	33kV RMU	No.	-	-	100.00%	-		4	-
31	HV	Zone substation switchgear	50/66/110kV CB (Indoor)	No.	-	-	45.00%	55.00%		4	-
32	HV	Zone substation switchgear	50/66/110kV CB (Outdoor)	No.	-	-	100.00%	-		4	-
33	HV	Zone substation switchgear	3.3/6.6/11/22kV CB (ground mounted)	No.	-	11.66%	46.79%	41.55%		4	27.75%
34	HV	Zone substation switchgear	3.3/6.6/11/22kV CB (pole mounted)	No.			-			N/A	
35											

36					Asset condition at start of planning period (percentage of units by grade)						
37	Voltage	Asset category	Asset class	Units	Grade 1	Grade 2	Grade 3	Grade 4	Grade unknown	Data accuracy (1–4)	% of asset forecast to be replaced in next 5 years
38											
39	HV	Zone Substation Transformer	Zone Substation Transformers	No.	-	3.24%	72.22%	24.54%		4	8.33%
40	HV	Distribution Line	Distribution OH Open Wire Conductor	km	-	0.09%	93.81%	6.11%		3	2.80%
41	HV	Distribution Line	Distribution OH Aerial Cable Conductor	km			-			N/A	
42	HV	Distribution Line	SWER conductor	km			-			N/A	
43	HV	Distribution Cable	Distribution UG XLPE or PVC	km	0.53%	0.08%	13.42%	85.97%		2	1.03%
44	HV	Distribution Cable	Distribution UG PILC	km	0.31%	1.35%	68.70%	29.64%		2	1.66%
45	HV	Distribution Cable	Distribution Submarine Cable	km	-	-	100.00%	-		2	-
46	HV	Distribution switchgear	3.3/6.6/11/22kV CB (pole mounted) - reclosers and sectionalisers	No.	-	-	81.75%	18.25%		4	11.36%
47	HV	Distribution switchgear	3.3/6.6/11/22kV CB (Indoor)	No.	-	-	48.78%	51.22%		4	-
48	HV	Distribution switchgear	3.3/6.6/11/22kV Switches and fuses (pole mounted)	No.	2.44%	1.80%	68.28%	27.48%		4	9.13%
49	HV	Distribution switchgear	3.3/6.6/11/22kV Switch (ground mounted) - except RMU	No.	0.53%	0.29%	93.16%	6.02%		3	8.02%
50	HV	Distribution switchgear	3.3/6.6/11/22kV RMU	No.	1.56%	1.40%	69.88%	27.16%		3	3.93%
51	HV	Distribution Transformer	Pole Mounted Transformer	No.	1.77%	0.89%	74.23%	23.10%		3	8.13%
52	HV	Distribution Transformer	Ground Mounted Transformer	No.	5.19%	1.66%	59.00%	34.15%		3	6.97%
53	HV	Distribution Transformer	Voltage regulators	No.	-	-	8.33%	91.67%		4	-
54	HV	Distribution Substations	Ground Mounted Substation Housing	No.	3.93%	1.70%	85.88%	8.48%		4	4.37%
55	LV	LV Line	LV OH Conductor	km	-	-	94.44%	5.56%		3	0.23%
56	LV	LV Cable	LV UG Cable	km	0.50%	1.89%	60.90%	36.71%		2	2.39%
57	LV	LV Streetlighting	LV OH/UG Streetlight circuit	km			-		100.00%	1	0.08%
58	LV	Connections	OH/UG consumer service connections	No.			-		100.00%	1	-
59	All	Protection	Protection relays (electromechanical, solid state and numeric)	No.	-	2.21%	82.76%	15.04%		3	2.21%
60	All	SCADA and communications	SCADA and communications equipment operating as a single system	Lot	-	6.11%	60.13%	33.76%		4	6.15%
61	All	Capacitor Banks	Capacitors including controls	No.	-	-	94.51%	5.49%		3	-
62	All	Load Control	Centralised plant	Lot	-	-	100.00%	-		4	-
63	All	Load Control	Relays	No.			-			N/A	
64	All	Civils	Cable Tunnels	km	-	-	8.62%	91.38%		4	-

Appendix 9 Forecast Capacity (Schedule 12b)

Company Name: **Vector Electricity**

AMP Planning Period: **1 April 2018 – 31 March 2028**

SCHEDULE 12b: REPORT ON FORECAST CAPACITY

This schedule requires a breakdown of current and forecast capacity and utilisation for each zone substation and current distribution transformer capacity. The data provided should be consistent with the information provided in the AMP. Information provided in this table should relate to the operation of the network in its normal steady state configuration.

sch ref

7 **12b(i): System Growth - Zone Substations**

sch ref	*Existing Zone Substations*	Current Peak Load (MVA)	Installed Firm Capacity (MVA)	Security of Supply Classification (type)	Transfer Capacity (MVA)	Utilisation of Installed Firm Capacity %	Installed Firm Capacity +5 years (MVA)	Utilisation of Installed Firm Capacity + 5yrs %	Installed Firm Capacity Constraint +5 years (cause)	Explanation
8										
9	Atkinson Road	18.6	21.4	N-1	14.1	87%	21	96%	No constraint within +5 years	Meets Vector security criteria
10	Auckland Airport	16.2	25	N-1	10	65%	25	91%	Other	Meets customers security criteria
11	Avondale	30	24	N-1 switched	21.8	125%	24	121%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
12	Bairds	25.5	24	N-1 switched	21.8	106%	24	118%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
13	Balmain	8.2	0	N-1 switched	11.3	-	-	-	No constraint within +5 years	Meets Vector security criteria
14	Balmoral	13	24	N-1	14	54%	24	60%	No constraint within +5 years	Meets Vector security criteria
15	Belmont	17.8	14	N-1 switched	9.5	127%	14	103%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
16	Birkdale	22.5	24	N-1	8.7	94%	24	98%	No constraint within +5 years	Meets Vector security criteria
17	Brickworks	10.4	0	N	10	-	18	88%	No constraint within +5 years	Constraint relieved by the installation of the second transformer
18	Browns Bay	16.9	10	N-1 switched	23.5	169%	24	76%	No constraint within +5 years	Constraint relieved by transformer capacity upgrade
19	Bush Road	27.7	22.6	N-1 switched	9.9	123%	23	122%	No constraint within +5 years	Meets Vector security criteria after 11kV reinforcement project
20	Carbine	14.4	21.5	N-1	10.7	67%	22	68%	No constraint within +5 years	Meets Vector security criteria
21	Chevalier	19.6	24	N-1	16.8	82%	24	78%	No constraint within +5 years	Meets Vector security criteria
22	Clendon	21.5	24	N-1	18.5	90%	24	107%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
23	Clevedon	3	0	N	2.9	-	-	-	No constraint within +5 years	Meets Vector security criteria
24	Coatesville	9.9	0	N-1 switched	10.4	-	12	110%	No constraint within +5 years	Constraint relieved by the installation of the second transformer
25	Drive	25.8	24	N-1 switched	23.1	108%	24	101%	No constraint within +5 years	Transfer load to Newmarket substation
26	East Coast Road	15.8	0	N	12.7	-	-	-	No constraint within +5 years	Meets Vector security criteria after 11kV reinforcement project
27	East Tamaki	14.3	24	N-1	7.4	60%	24	96%	No constraint within +5 years	Meets Vector security criteria
28	Flatbush	11.4	24	N-1	9.1	48%	24	86%	No constraint within +5 years	Meets Vector security criteria
29	Forrest Hill	17.2	20	N-1	14	86%	20	84%	No constraint within +5 years	Meets Vector security criteria
30	Freemans Bay	18	21.6	N-1	16.2	83%	22	98%	No constraint within +5 years	Transfer load to CBD 22kV distribution network
31	Glen Innes	12.4	13.4	N-1	27.5	93%	24	59%	No constraint within +5 years	Constraint relieved by transformer and subtransmission circuit replacements
32	Greenhithe	11.2	0	N	10.6	-	-	-	No constraint within +5 years	Constraint relieved by Hobsonville Point zone substation
33	Greenmount	39	48	N-1	34.8	81%	48	92%	No constraint within +5 years	Meets Vector security criteria
34	Gulf Harbour	7.8	0	N-1 switched	9.3	-	-	-	No constraint within +5 years	Meets Vector security criteria after 11kV reinforcement project
35	Hans	23.5	23.8	N-1	14.6	99%	24	108%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
36	Hauraki	8.4	0	N-1 switched	10.1	-	-	-	No constraint within +5 years	Meets Vector security criteria
37	Helensville	14.2	9	N-1 switched	6.5	158%	18	86%	No constraint within +5 years	Constraint relieved by transformer capacity upgrade
38	Henderson Valley	18.7	15.2	N-1 switched	20.2	123%	15	126%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
39	Highbrook	8.9	23.4	N-1	0	38%	23	60%	No constraint within +5 years	Meets Vector security criteria
40	Highbury	13.5	0	N	12.9	-	24	58%	No constraint within +5 years	Constraint relieved by the installation of the second transformer
41	Hillcrest	25	23.8	N-1 switched	13.9	105%	24	102%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
42	Hillsborough	15.6	23.6	N-1	15.4	66%	24	78%	No constraint within +5 years	Meets Vector security criteria
43	Hobson 110/11kV	12.8	25	N-1	10.8	51%	25	64%	No constraint within +5 years	Meets Vector security criteria
44	Hobson 22/11kV	18.5	18	N-1 switched	9.7	103%	18	84%	No constraint within +5 years	Transfer load to CBD 22kV distribution network
45	Hobson 22kV	45	40	N-1 switched	31.7	113%	80	90%	No constraint within +5 years	Capacity to increase by installation of Hobson - Quay 110kV circuit

	Existing Zone Substations	Current Peak Load (MVA)	Installed Firm Capacity (MVA)	Security of Supply Classification (type)	Transfer Capacity (MVA)	Utilisation of Installed Firm Capacity %	Installed Firm Capacity +5 years (MVA)	Utilisation of Installed Firm Capacity + 5yrs %	Installed Firm Capacity Constraint +5 years (cause)	Explanation
46	Hobsonville	22.2	15.2	N-1 switched	11.9	146%	15	99%	No constraint within +5 years	Constraint relieved by the installation of Hobsonville Point zone substation
47	Howick	39.1	48	N-1	12.1	81%	48	89%	No constraint within +5 years	Meets Vector security criteria
48	James Street	19.8	15.2	N-1 switched	19.5	130%	15	141%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
49	Keeling Road	12	0	N-1 switched	15	-	-		No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
50	Kingsland	23.9	24	N-1	23.2	100%	24	117%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
51	Laingholm	8.6	9	N-1	7	96%	9	96%	No constraint within +5 years	Meets Vector security criteria
52	Lichfield	17.6	20	N-1	0	88%	20	88%	No constraint within +5 years	Meets Vector security criteria
53	Liverpool	37.1	48	N-1	24.3	77%	48	87%	No constraint within +5 years	Meets Vector security criteria
54	Liverpool 22kV	100.2	100	N-1 switched	63.7	100%	150	78%	No constraint within +5 years	Capacity to increase by upgrading transformer T3
55	Mangere Central	31.8	24	N-1 switched	16.5	133%	48	85%	No constraint within +5 years	Constraint relieved by the installation of the third transformer
56	Mangere East	26.5	24	N-1 switched	23.5	110%	24	128%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
57	Mangere West	22.2	30	N-1	3.3	74%	30	119%	No constraint within +5 years	Constraint relieved by load transfer to Managere Central substation
58	Manly	18.7	14	N-1 switched	20.3	134%	14	147%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
59	Manukau	30.3	48	N-1	27.4	63%	48	71%	No constraint within +5 years	Meets Vector security criteria
60	Manurewa	50.9	48	N-1 switched	26.1	106%	48	112%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
61	Maraetai	9.9	18	N-1	4.6	55%	18	65%	No constraint within +5 years	Meets Vector security criteria
62	McKinnon	20.2	23.8	N-1	15.6	85%	24	110%	No constraint within +5 years	Meets Vector security criteria after 11kV reinforcement project
63	Mcleod Road	10.2	0	N	8.5	-	-	-	No constraint within +5 years	Constraint resolved by 11kV reinforcement
64	McNab	44.1	48	N-1	35.7	92%	48	97%	No constraint within +5 years	Meets Vector security criteria
65	Milford	8.4	0	N-1 switched	9.4	-	-	-	No constraint within +5 years	Meets Vector security criteria
66	Mt Albert	6.7	0	N-1 switched	12	-	-	-	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
67	Mt Wellington	19	24	N-1	13.6	79%	24	91%	No constraint within +5 years	Meets Vector security criteria
68	New Lynn	14.1	14	N-1 switched	12.3	101%	14	93%	No constraint within +5 years	Transfer load to Brickworks substation
69	Newmarket	34.2	48	N-1	33.3	71%	96	85%	No constraint within +5 years	Additioanl capacity to be installed in Newmarket substation
70	Newton	20	18.9	N-1 switched	34.7	106%	19	102%	No constraint within +5 years	Transfer load to CBD 22kV distribution network
71	Ngataringa Bay	7.5	0	N-1 switched	8.8	-	-	-	No constraint within +5 years	Meets Vector security criteria after 11kV reinforcement project
72	Northcote	6.4	0	N-1 switched	9.1	-	-	-	No constraint within +5 years	Meets Vector security criteria
73	Onehunga	15	14.7	N-1 switched	30	102%	24	74%	No constraint within +5 years	Planned subtransmission circuit replacement project
74	Orakei	21	21.6	N-1	14.7	97%	22	107%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
75	Oratia	5.2	0	N-1 switched	11	-	-	-	No constraint within +5 years	Meets Vector security criteria
76	Orewa	17.2	15.2	N-1 switched	5	113%	24	84%	No constraint within +5 years	Constraint relieved by 11kV switchgear replacement
77	Otara	28	31.2	N-1	29.3	90%	31	102%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
78	Pacific Steel	20	42	N-1	0	48%	42	48%	No constraint within +5 years	Meets Vector security criteria
79	Pakuranga	23.7	24	N-1	14.5	99%	24	106%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
80	Papakura	27.8	23.4	N-1 switched	16	119%	23	115%	No constraint within +5 years	Constraint relieved by load transfer to Takanini substation
81	Parnell	10	14.4	N-1	17.3	69%	18	72%	No constraint within +5 years	Scheduled transformer replacement project
82	Ponsonby	15.4	14.4	N-1 switched	15.2	107%	18	86%	No constraint within +5 years	Constraint relieved by subtransmission circuit replacement
83	Quay	23.4	24	N-1	21.8	98%	48	66%	No constraint within +5 years	Capacity to increase by installation of additional transformer
84	Quay 22kV	41.5	60	N-1	34.5	69%	60	95%	No constraint within +5 years	Meets Vector security criteria
85	Ranui	11.5	0	N-1 switched	23	-	-	-	No constraint within +5 years	Meets Vector security criteria
86	Red Beach	10.6	22.8	N-1	13.4	46%	23	52%	No constraint within +5 years	Meets Vector security criteria
87	Remuera	28.7	24	N-1 switched	26	120%	24	105%	No constraint within +5 years	Transfer load to Newmarket substation
88	Riverhead	12	9	N-1 switched	6.8	133%	9	116%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup, assisted by Waimauku 33+11kV cable project
89	Rockfield	20.2	24	N-1	23.9	84%	24	91%	No constraint within +5 years	Meets Vector security criteria
90	Rosebank	23	24	N-1	21.7	96%	24	101%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
91	Rosedale	13.4	0	N	11.3	-	24	73%	No constraint within +5 years	Constraint relieved by the installation of the second transformer
92	Sabulite Road	21.8	14	N-1 switched	20.4	156%	24	92%	No constraint within +5 years	Constraint relieved by transformer capacity upgrade
93	Sandringham	21	24	N-1	21.3	88%	24	104%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
94	Simpson Road	6.6	0	N	5.5	-	-		No constraint within +5 years	Meets Vector security criteria
95	Snells Beach	6.4	0	N-1 switched	8.6	-	-		No constraint within +5 years	Constraint relieved by the installation of the BESS

	Existing Zone Substations	Current Peak Load (MVA)	Installed Firm Capacity (MVA)	Security of Supply Classification (type)	Transfer Capacity (MVA)	Utilisation of Installed Firm Capacity %	Installed Firm Capacity +5 years (MVA)	Utilisation of Installed Firm Capacity + 5yrs %	Installed Firm Capacity Constraint +5 years (cause)	Explanation
96	South Howick	28.9	24	N-1 switched	23	120%	24	112%	No constraint within +5 years	Constraint relieved by load transfer to Greenmount substation
97	Spur Road	10.9	0	N-1 switched	11.4	-	24	67%	No constraint within +5 years	Constraint relieved by the installation of the second transformer
98	St Heliers	20.8	21	N-1	19.5	99%	21	108%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
99	St Johns	17.5	24	N-1	32.9	73%	24	83%	No constraint within +5 years	Meets Vector security criteria
100	Sunset Road	15.9	14	N-1 switched	16.2	114%	14	123%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
101	Swanson	10.6	0	N	8.5	-	-		No constraint within +5 years	Meets Vector security criteria with 11kV cascade switching
102	Sylvia Park	18	24	N-1	11.7	75%	24	88%	No constraint within +5 years	Meets Vector security criteria
103	Takanini	15.9	18	N-1	23.4	88%	24	118%	No constraint within +5 years	Constraint relieved by transformer capacity upgrade
104	Takapuna	10.7	0	N	8.7	-	24	52%	No constraint within +5 years	Constraint relieved by the installation of the second transformer
105	Te Atatu	21.3	14	N-1 switched	12.7	152%	24	104%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
106	Te Papapa	20.1	22.5	N-1	11.4	89%	23	91%	No constraint within +5 years	Meets Vector security criteria
107	Torbay	7.6	0	N	6.6	-	-		No constraint within +5 years	Constraint relieved by a new 11kV cable
108	Triangle Road	16.5	12	N-1 switched	12.6	138%	18	75%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
109	Victoria	21	22.4	N-1	18.6	94%	22	94%	No constraint within +5 years	Transfer load to CBD 22kV distribution network
110	Waiake	9.4	0	N-1 switched	12.8	-	-		No constraint within +5 years	Meets Vector security criteria
111	Waiheke	11.5	15	N-1	2	77%	15	87%	No constraint within +5 years	Meets Vector security criteria
112	Waikaukau	7.4	0	N-1 switched	8.4	-	-		No constraint within +5 years	Meets Vector security criteria
113	Waimauku	9.6	0	N-1 switched	11	-	11	110%	No constraint within +5 years	Constraint relieved by the Waimauku 33+11kV cable project
114	Wairau Road	18.6	16	N-1 switched	29.8	116%	16	134%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
115	Warkworth	19	18	N-1 switched	1.7	106%	18	94%	No constraint within +5 years	Constraint relieved by the BESS at Snells Beach and Warkworth South, and by Omaha zone substation
116	Wellsford	8.1	9	N-1	1.4	90%	9	103%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
117	Westfield	23	24	N-1	22.3		24	98%	No constraint within +5 years	Meets Vector security criteria
118	Westgate	0	24	N-1	0		24	66%	No constraint within +5 years	Meets Vector security criteria
119	White Swan	26	32.2	N-1	22	81%	32	102%	No constraint within +5 years	Meets Vector security criteria
120	Wiri	42.8	42.5	N-1 switched	21.2	101%	43	114%	No constraint within +5 years	Meets Vector security criteria due to sufficient 11kV backup
121	Woodford	9.6	0	N-1 switched	17.4	-	-		No constraint within +5 years	Meets Vector security criteria

122 [1] *Extend forecast capacity table as necessary to disclose all capacity by each zone substation*

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Appendix 10 Forecast Network Demand (Schedule 12c)

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 – 31 March 2028**

SCHEDULE 12C: REPORT ON FORECAST NETWORK DEMAND

This schedule requires a forecast of new connections (by consumer type), peak demand and energy volumes for the disclosure year and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumptions used in developing the expenditure forecasts in Schedule 11a and Schedule 11b and the capacity and utilisation forecasts in Schedule 12b.

sch ref							
7	**12c(i): Consumer Connections**						
8	*Number of ICPs connected in year by consumer type*				**Number of connections**		
9		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
10	for year ended	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
11	*Consumer types defined by EDB**						
12	Residential & Small Medium Enterprise (SME)	10,530	11,067	11,604	12,141	11,862	11,862
13	Industrial & Commercial	206	176	146	116	88	88
14							
15							
16							
17	**Connections total**	10,736	11,243	11,750	12,257	11,950	11,950
18	**include additional rows if needed*						
19	**Distributed generation**						
20	Number of connections	1,000	1,000	1,000	1,000	1,000	1,000
21	Capacity of distributed generation installed in year (MVA)	3	3	3	3	3	3
22	**12c(ii) System Demand**						
23		*Current Year CY*	*CY+1*	*CY+2*	*CY+3*	*CY+4*	*CY+5*
24	**Maximum coincident system demand (MW)** for year ended	**31 Mar 18**	**31 Mar 19**	**31 Mar 20**	**31 Mar 21**	**31 Mar 22**	**31 Mar 23**
25	GXP demand	1,754	1,798	1,842	1,887	1,931	1,984
26	*plus* Distributed generation output at HV and above	14	14	14	14	14	14
27	**Maximum coincident system demand**	1,768	1,812	1,856	1,901	1,945	1,998
28	*less* Net transfers to (from) other EDBs at HV and above	-	-	-	-	-	-
29	**Demand on system for supply to consumers' connection points**	1,768	1,812	1,856	1,901	1,945	1,998
30	**Electricity volumes carried (GWh)**						
31	Electricity supplied from GXPs	8,571	8,609	8,626	8,636	8,627	8,607
32	*less* Electricity exports to GXPs						
33	*plus* Electricity supplied from distributed generation	106	106	106	106	106	106
34	*less* Net electricity supplied to (from) other EDBs						
35	**Electricity entering system for supply to ICPs**	8,677	8,715	8,732	8,742	8,733	8,713
36	*less* Total energy delivered to ICPs	8,366	8,387	8,408	8,417	8,409	8,389
37	**Losses**	311	328	324	325	324	324
38							
39	**Load factor**	56%	55%	54%	52%	51%	50%
40	**Loss ratio**	3.6%	3.8%	3.7%	3.7%	3.7%	3.7%

Appendix 11 Forecast Interruptions and Duration (Schedule 12d)

Company Name	Vector Electricity
AMP Planning Period	1 April 2018 – 31 March 2028
Network / Sub-network Name	Vector Limited

SCHEDULE 12d: REPORT FORECAST INTERRUPTIONS AND DURATION

This schedule requires a forecast of SAIFI and SAIDI for disclosure and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumed impact of planned and unplanned SAIFI and SAIDI on the expenditures forecast provided in Schedule 11a and Schedule 11b.

sch ref		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
9	for year ended	31 Mar 18	31 Mar 19	31 Mar 20	31 Mar 21	31 Mar 22	31 Mar 23
10	**SAIDI**						
11	Class B (planned interruptions on the network)	9.6	9.6	9.6	9.6	9.6	9.6
12	Class C (unplanned interruptions on the network)	86.4	86.4	86.4	86.4	86.4	86.4
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.06	0.06	0.06	0.06	0.06	0.06
15	Class C (unplanned interruptions on the network)	1.23	1.23	1.23	1.23	1.23	1.23

Company Name	Vector Electricity
AMP Planning Period	1 April 2018 – 31 March 2028
Network / Sub-network Name	Southern Network

SCHEDULE 12d: REPORT FORECAST INTERRUPTIONS AND DURATION

This schedule requires a forecast of SAIFI and SAIDI for disclosure and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumed impact of planned and unplanned SAIFI and SAIDI on the expenditures forecast provided in Schedule 11a and Schedule 11b.

sch ref		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
9	for year ended	31 Mar 18	31 Mar 19	31 Mar 20	31 Mar 21	31 Mar 22	31 Mar 23
10	**SAIDI**						
11	Class B (planned interruptions on the network)	2.7	2.7	2.7	2.7	2.7	2.7
12	Class C (unplanned interruptions on the network)	34.9	34.9	34.9	34.9	34.9	34.9
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.02	0.02	0.02	0.02	0.02	0.02
15	Class C (unplanned interruptions on the network)	0.51	0.51	0.51	0.51	0.51	0.51

Company Name	Vector Electricity
AMP Planning Period	1 April 2018 – 31 March 2028
Network / Sub-network Name	Northern Network

SCHEDULE 12d: REPORT FORECAST INTERRUPTIONS AND DURATION

This schedule requires a forecast of SAIFI and SAIDI for disclosure and a 5 year planning period. The forecasts should be consistent with the supporting information set out in the AMP as well as the assumed impact of planned and unplanned SAIFI and SAIDI on the expenditures forecast provided in Schedule 11a and Schedule 11b.

sch ref		Current Year CY	CY+1	CY+2	CY+3	CY+4	CY+5
9	for year ended	31 Mar 18	31 Mar 19	31 Mar 20	31 Mar 21	31 Mar 22	31 Mar 23
10	**SAIDI**						
11	Class B (planned interruptions on the network)	6.9	6.9	6.9	6.9	6.9	6.9
12	Class C (unplanned interruptions on the network)	51.5	51.5	51.5	51.5	51.5	51.5
13	**SAIFI**						
14	Class B (planned interruptions on the network)	0.04	0.04	0.04	0.04	0.04	0.04
15	Class C (unplanned interruptions on the network)	0.73	0.73	0.73	0.73	0.73	0.73

Appendix 12 Asset Management Maturity (Schedule 13)

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 – 31 March 2028**
Asset Management Standard Applied	

SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY

This schedule requires information on the EDB'S self-assessment of the maturity of its asset management practices .

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
3	Asset management policy	To what extent has an asset management policy been documented, authorised and communicated?	3	Vector's Asset Management Policy (latest version published August 2017 has been authorised by our Chief Network Officer). The document has been circulated to key stakeholders and is readily available for staff to access. The document is part of the controlled document management system and reviewed periodically.		Widely used AM practice standards require an organisation to document, authorise and communicate its asset management policy (eg, as required in PAS 55 para 4.2 i). A key pre-requisite of any robust policy is that the organisation's top management must be seen to endorse and fully support it. Also vital to the effective implementation of the policy, is to tell the appropriate people of its content and their obligations under it. Where an organisation outsources some of its asset-related activities, then these people and their organisations must equally be made aware of the policy's content. Also, there may be other stakeholders, such as regulatory authorities and shareholders who should be made aware of it.	Top management. The management team that has overall responsibility for asset management.	The organisation's asset management policy, its organisational strategic plan, documents indicating how the asset management policy was based upon the needs of the organisation and evidence of communication.
10	Asset management strategy	What has the organisation done to ensure that its asset management strategy is consistent with other appropriate organisational policies and strategies, and the needs of stakeholders?	2	Good asset management is practiced implicitly based on the policies and strategies which are approved by Vector's Board. The Board also approves the asset management plans and associated budget. However, there is room to improve.		In setting an organisation's asset management strategy, it is important that it is consistent with any other policies and strategies that the organisation has and has taken into account the requirements of relevant stakeholders. This question examines to what extent the asset management strategy is consistent with other organisational policies and strategies (eg, as required by PAS 55 para 4.3.1 b) and has taken account of stakeholder requirements as required by PAS 55 para 4.3.1 c). Generally, this will take into account the same polices, strategies and stakeholder requirements as covered in drafting the asset management policy but at a greater level of detail.	Top management. The organisation's strategic planning team. The management team that has overall responsibility for asset management.	The organisation's asset management strategy document and other related organisational policies and strategies. Other than the organisation's strategic plan, these could include those relating to health and safety, environmental, etc. Results of stakeholder consultation.
11	Asset management strategy	In what way does the organisation's asset management strategy take account of the lifecycle of the assets, asset types and asset systems over which the organisation has stewardship?	3	Specific and more detailed asset management strategies are being developed for all assets. Lifecycle cost and service implications are adequately considered in maintenance and replacement decisions. This is an ongoing program of work with the opportunity to improve and integrate the results of Vector's Condition Based Asset Risk Management (CBARM) models.		Good asset stewardship is the hallmark of an organisation compliant with widely used AM standards. A key component of this is the need to take account of the lifecycle of the assets, asset types and asset systems. (For example, this requirement is recognised in 4.3.1 d) of PAS 55). This question explores what an organisation has done to take lifecycle into account in its asset management strategy.	Top management. People in the organisation with expert knowledge of the assets, asset types, asset systems and their associated life-cycles. The management team that has overall responsibility for asset management. Those responsible for developing and adopting methods and processes used in asset management	The organisation's documented asset management strategy and supporting working documents.
26	Asset management plan(s)	How does the organisation establish and document its asset management plan(s) across the life cycle activities of its assets and asset systems?	2	High level strategies and plans are contained in the Asset Management Plan (AMP). Life cycle activities are documented in the form of standards (maintenance, inspection, testing). Asset condition data, the collection process and specific asset strategies are being improved.		The asset management strategy need to be translated into practical plan(s) so that all parties know how the objectives will be achieved. The development of plan(s) will need to identify the specific tasks and activities required to optimize costs, risks and performance of the assets and/or asset system(s), when they are to be carried out and the resources required.	The management team with overall responsibility for the asset management system. Operations, maintenance and engineering managers.	The organisation's asset management plan(s).

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 – 31 March 2028**
Asset Management Standard Applied	

SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
27	Asset management plan(s)	How has the organisation communicated its plan(s) to all relevant parties to a level of detail appropriate to the receiver's role in their delivery?	3	The AMP is communicated to all stakeholders including employees and Field Service Providers (FSPs). The organisation, end to end process, Vector's Delegated Financial Authorities (DFA) and works programmes are all set up to deliver the works effectively. The AMP is also published on the Vector web site.		Plans will be ineffective unless they are communicated to all those, including contracted suppliers and those who undertake enabling function(s). The plan(s) need to be communicated in a way that is relevant to those who need to use them.	The management team with overall responsibility for the asset management system. Delivery functions and suppliers.	Distribution lists for plan(s). Documents derived from plan(s) which detail the receivers role in plan delivery. Evidence of communication.
29	Asset management plan(s)	How are designated responsibilities for delivery of asset plan actions documented?	3	The AMP outlines the key roles responsible for the delivery for the AMP. Vector's delegated authorities framework and policy, and position descriptions for each role define the roles and authorities further.		The implementation of asset management plan(s) relies on (1) actions being clearly identified, (2) an owner allocated and (3) that owner having sufficient delegated responsibility and authority to carry out the work required. It also requires alignment of actions across the organisation. This question explores how well the plan(s) set out responsibility for delivery of asset plan actions.	The management team with overall responsibility for the asset management system. Operations, maintenance and engineering managers. If appropriate, the performance management team.	The organisation's asset management plan(s). Documentation defining roles and responsibilities of individuals and organisational departments.
31	Asset management plan(s)	What has the organisation done to ensure that appropriate arrangements are made available for the efficient and cost effective implementation of the plan(s)? (Note this is about resources and enabling support)	2	Vector has a process to optimise proposed projects to improve cost effective delivery. Vector is also working on an integrated works plan to improve resource utilisation as there is a resourcing shortfall (skill and numbers) in some areas (internal and external).		It is essential that the plan(s) are realistic and can be implemented, which requires appropriate resources to be available and enabling mechanisms in place. This question explores how well this is achieved. The plan(s) not only need to consider the resources directly required and timescales, but also the enabling activities, including for example, training requirements, supply chain capability and procurement timescales.	The management team with overall responsibility for the asset management system. Operations, maintenance and engineering managers. If appropriate, the performance management team. If appropriate, the performance management team. Where appropriate the procurement team and service providers working on the organisation's asset-related activities.	The organisation's asset management plan(s). Documented processes and procedures for the delivery of the asset management plan.
33	Contingency planning	What plan(s) and procedure(s) does the organisation have for identifying and responding to incidents and emergency situations and ensuring continuity of critical asset management activities?	3	Contingency plans are in place for business continuity, supply restoration, response to natural disasters, health, safety and environmental events. Supplies to critical areas are duplicated and mobile connection units are available for emergency supplies. Regular reviews of business continuity plans ensure they are current. Incident management processes and Corporate HSE policies ensure that incident and emergency situations are appropriately managed and reported both internally and to external regulators if required.		Widely used AM practice standards require that an organisation has plan(s) to identify and respond to emergency situations. Emergency plan(s) should outline the actions to be taken to respond to specified emergency situations and ensure continuity of critical asset management activities including the communication to, and involvement of, external agencies. This question assesses if, and how well, these plan(s) triggered, implemented and resolved in the event of an incident. The plan(s) should be appropriate to the level of risk as determined by the organisation's risk assessment methodology. It is also a requirement that relevant personnel are competent and trained.	The manager with responsibility for developing emergency plan(s). The organisation's risk assessment team. People with designated duties within the plan(s) and procedure(s) for dealing with incidents and emergency situations.	The organisation's plan(s) and procedure(s) for dealing with emergencies. The organisation's risk assessments and risk registers.

Company Name	**Vector Electricity**
AMP Planning Period	**1 April 2018 – 31 March 2028**
Asset Management Standard Applied	

SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
37	Structure, authority and responsibilities	What has the organisation done to appoint member(s) of its management team to be responsible for ensuring that the organisation's assets deliver the requirements of the asset management strategy, objectives and plan(s)?	3	As defined in Section 3.3. of the AMP, the CNO has overall responsibility for Vector's Network Asset Management. The Heads of Asset Management, Engineering, Customer Excellence and Networks Programme Delivery teams all report to the CNO and are tasked with delivering various parts of the asset management policy and plan. External Field Services Providers have a good understanding of their roles in the delivery of asset management strategy, objectives and plans.		In order to ensure that the organisation's assets and asset systems deliver the requirements of the asset management policy, strategy and objectives responsibilities need to be allocated to appropriate people who have the necessary authority to fulfil their responsibilities. (This question, relates to the organisation's assets eg, para b), s 4.4.1 of PAS 55, making it therefore distinct from the requirement contained in para a), s 4.4.1 of PAS 55).	Top management. People with management responsibility for the delivery of asset management policy, strategy, objectives and plan(s). People working on asset-related activities.	Evidence that managers with responsibility for the delivery of asset management policy, strategy, objectives and plan(s) have been appointed and have assumed their responsibilities. Evidence may include the organisation's documents relating to its asset management system, organisational charts, job descriptions of post-holders, annual targets/objectives and personal development plan(s) of post-holders as appropriate.
40	Structure, authority and responsibilities	What evidence can the organisation's top management provide to demonstrate that sufficient resources are available for asset management?	2	Vector utilises external contractors and consultants to supplement internal resources to deliver on its AMP. The successful delivery of the current year development and integrity works programme, and the compilation of new sets of standards demonstrates good management of available resources. With the strong growth in Auckland and potential resource constraints, Vector will continue to focus on resource management initiatives.		Optimal asset management requires top management to ensure sufficient resources are available. In this context the term 'resources' includes manpower, materials, funding and service provider support.	Top management. The management team that has overall responsibility for asset management. Risk management team. The organisation's managers involved in day-to-day supervision of asset-related activities, such as frontline managers, engineers, foremen and chargehands as appropriate.	Evidence demonstrating that asset management plan(s) and/or the process(es) for asset management plan implementation consider the provision of adequate resources in both the short and long term. Resources include funding, materials, equipment, services provided by third parties and personnel (internal and service providers) with appropriate skills competencies and knowledge.
42	Structure, authority and responsibilities	To what degree does the organisation's top management communicate the importance of meeting its asset management requirements?	3	Service Levels and KPI's are set and monitored across the organisation through readily accessible dashboards. In addition, monthly reporting, quarterly team updates and strong engagement with programme delivery and service providers ensure that there is a strong focus on the delivery of asset management requirements.		Widely used AM practice standards require an organisation to communicate the importance of meeting its asset management requirements such that personnel fully understand, take ownership of, and are fully engaged in the delivery of the asset management requirements (eg, PAS 55 s 4.4.1 g).	Top management. The management team that has overall responsibility for asset management. People involved in the delivery of the asset management requirements.	Evidence of such activities as road shows, written bulletins, workshops, team talks and management walk-abouts would assist an organisation to demonstrate it is meeting this requirement of PAS 55.
45	Outsourcing of asset management activities	Where the organisation has outsourced some of its asset management activities, how has it ensured that appropriate controls are in place to ensure the compliant delivery of its organisational strategic plan, and its asset management policy and strategy?	2	Maintenance, design and planning standards have been developed which together, with the controls established in the commercial contracts with the service providers, ensure that the KPI's established are being monitored and deficiencies addressed. Maintenance information is collected and stored in SAP-PM. The requirements and performance expectations are communicated through well-established communications mechanisms. In addition, delivery and performance of some elements are verified by third party. Overall, there is still room for improvement.		Where an organisation chooses to outsource some of its asset management activities, the organisation must ensure that these outsourced process(es) are under appropriate control to ensure that all the requirements of widely used AM standards (eg, PAS 55) are in place, and the asset management policy, strategy objectives and plan(s) are delivered. This includes ensuring capabilities and resources across a time span aligned to life cycle management. The organisation must put arrangements in place to control the outsourced activities, whether it be to external providers or to other in-house departments. This question explores what the organisation does in this regard.	Top management. The management team that has overall responsibility for asset management. The manager(s) responsible for the monitoring and management of the outsourced activities. People involved with the procurement of outsourced activities. The people within the organisations that are performing the outsourced activities. The people impacted by the outsourced activity.	The organisation's arrangements that detail the compliance required of the outsourced activities. For example, this this could form part of a contract or service level agreement between the organisation and the suppliers of its outsourced activities. Evidence that the organisation has demonstrated to itself that it has assurance of compliance of outsourced activities.

Company Name	Vector Electricity
AMP Planning Period	1 April 2018 – 31 March 2028
Asset Management Standard Applied	

SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
48	Training, awareness and competence	How does the organisation develop plan(s) for the human resources required to undertake asset management activities - including the development and delivery of asset management strategy, process(es), objectives and plan(s)?	2	An HR strategy is in place to align competencies and human resources with Vector's AMP and strategy, but there is still opportunity to improve. A graduate program is in place and some asset management training is completed.		There is a need for an organisation to demonstrate that it has considered what resources are required to develop and implement its asset management system. There is also a need for the organisation to demonstrate that it has assessed what development plan(s) are required to provide its human resources with the skills and competencies to develop and implement its asset management systems. The timescales over which the plan(s) are relevant should be commensurate with the planning horizons within the asset management strategy considers e.g. if the asset management strategy considers 5, 10 and 15 year time scales then the human resources development plan(s) should align with these. Resources include both 'in house' and external resources who undertake asset management activities.	Senior management responsible for agreement of plan(s). Managers responsible for developing asset management strategy and plan(s). Managers with responsibility for development and recruitment of staff (including HR functions). Staff responsible for training. Procurement officers. Contracted service providers.	Evidence of analysis of future work load plan(s) in terms of human resources. Document(s) containing analysis of the organisation's own direct resources and contractors resource capability over suitable timescales. Evidence, such as minutes of meetings, that suitable management forums are monitoring human resource development plan(s). Training plan(s), personal development plan(s), contract and service level agreements.
49	Training, awareness and competence	How does the organisation identify competency requirements and then plan, provide and record the training necessary to achieve the competencies?	2	The competency requirements and associated training requirements (e.g. Worker Type Competency (WTC) are well established for safety critical activities across both FSP's and Vector. Individuals when recruited have their competency assessed against the job skill requirements. Training needs are identified and agreed. Training achieved is recorded in Vector's learning management system. However, there is room for improvement through ongoing talent development plans and ongoing skills development in asset management.		Widely used AM standards require that organisations to undertake a systematic identification of the asset management awareness and competencies required at each level and function within the organisation. Once identified the training required to provide the necessary competencies should be planned for delivery in a timely and systematic way. Any training provided must be recorded and maintained in a suitable format. Where an organisation has contracted service providers in place then it should have a means to demonstrate that this requirement is being met for their employees. (eg, PAS 55 refers to frameworks suitable for identifying competency requirements).	Senior management responsible for agreement of plan(s). Managers responsible for developing asset management strategy and plan(s). Managers with responsibility for development and recruitment of staff (including HR functions). Staff responsible for training. Procurement officers. Contracted service providers.	Evidence of an established and applied competency requirements assessment process and plan(s) in place to deliver the required training. Evidence that the training programme is part of a wider, co-ordinated asset management activities training and competency programme. Evidence that training activities are recorded and that records are readily available (for both direct and contracted service provider staff) e.g. via organisation wide information system or local records database.
50	Training, awareness and competence	How does the organization ensure that persons under its direct control undertaking asset management related activities have an appropriate level of competence in terms of education, training or experience?	3	The competency requirements and associated training requirements are well established for safety critical activities across both FSP's and Vector. These are assessed regularly and the currency monitored. As mentioned above, there is still room for improvement.		A critical success factor for the effective development and implementation of an asset management system is the competence of persons undertaking these activities. organisations should have effective means in place for ensuring the competence of employees to carry out their designated asset management function(s). Where an organisation has contracted service providers undertaking elements of its asset management system then the organisation shall assure itself that the outsourced service provider also has suitable arrangements in place to manage the competencies of its employees. The organisation should ensure that the individual and corporate competencies it requires are in place and actively monitor, develop and maintain an appropriate balance of these competencies.	Managers, supervisors, persons responsible for developing training programmes. Staff responsible for procurement and service agreements. HR staff and those responsible for recruitment.	Evidence of a competency assessment framework that aligns with established frameworks such as the asset management Competencies Requirements Framework (Version 2.0); National Occupational Standards for Management and Leadership; UK Standard for Professional Engineering Competence, Engineering Council, 2005.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
53	Communication, participation and consultation	How does the organisation ensure that pertinent asset management information is effectively communicated to and from employees and other stakeholders, including contracted service providers?	3	Readily accessible two-way communication channels are in place for staff and other stakeholders in the form of dashboards, reporting, standards, meetings and additional information on Vector's web site. In addition, the FSPs have direct access to a suite of controlled technical standards and pertinent systems, such as GIS and SAP. The effectiveness of these are reviewed and monitored regularly.		Widely used AM practice standards require that pertinent asset management information is effectively communicated to and from employees and other stakeholders including contracted service providers. Pertinent information refers to information required in order to effectively and efficiently comply with and deliver asset management strategy, plan(s) and objectives. This will include for example the communication of the asset management policy, asset performance information, and planning information as appropriate to contractors.	Top management and senior management representative(s), employee's representative(s), employee's trade union representative(s); contracted service provider management and employee representative(s); representative(s) from the organisation's Health, Safety and Environmental team. Key stakeholder representative(s).	Asset management policy statement prominently displayed on notice boards, intranet and internet; use of organisation's website for displaying asset performance data; evidence of formal briefings to employees, stakeholders and contracted service providers; evidence of inclusion of asset management issues in team meetings and contracted service provider contract meetings; newsletters, etc.
59	Asset Management System documentation	What documentation has the organisation established to describe the main elements of its asset management system and interactions between them?	3	The AMP is approved by the Board and widely communicated to internal and external stakeholders, including FSPs. In addition, a comprehensive set of design, maintenance and operating standards have been established.		Widely used AM practice standards require an organisation maintain up to date documentation that ensures that its asset management systems (ie, the systems the organisation has in place to meet the standards) can be understood, communicated and operated. (eg, s 4.5 of PAS 55 requires the maintenance of up to date documentation of the asset management system requirements specified throughout s 4 of PAS 55).	The management team that has overall responsibility for asset management. Managers engaged in asset management activities.	The documented information describing the main elements of the asset management system (process(es)) and their interaction.
62	Information management	What has the organisation done to determine what its asset management information system(s) should contain in order to support its asset management system?	3	Asset Management Systems have been developed but are evolving further. This includes further collection and analysis of data and improving the utilisation of SAP for asset lifecycle information. A data analytics team has been established to deliver consistent and relevant information needed for quality decision-making.		Effective asset management requires appropriate information to be available. Widely used AM standards therefore require the organisation to identify the asset management information it requires in order to support its asset management system. Some of the information required may be held by suppliers. The maintenance and development of asset management information systems is a poorly understood specialist activity that is akin to IT management but different from IT management. This group of questions provides some indications as to whether the capability is available and applied. Note: To be effective, an asset information management system requires the mobilisation of technology, people and process(es) that create, secure, make available and destroy the information required to support the asset management system.	The organisation's strategic planning team. The management team that has overall responsibility for asset management. Information management team. Operations, maintenance and engineering managers	Details of the process the organisation has employed to determine what its asset information system should contain in order to support its asset management system. Evidence that this has been effectively implemented.
63	Information management	How does the organisation maintain its asset management information system(s) and ensure that the data held within it (them) is of the requisite quality and accuracy and is consistent?	2	Controls have been developed to govern the data quality in Vector's asset management systems. Cross-checking across systems (e.g. GIS and PowerFactory modelling) However, there are still gaps in the data and more work is needed to improve this in time.		The response to the questions is progressive. A higher scale cannot be awarded without achieving the requirements of the lower scale. This question explores how the organisation ensures that information management meets widely used AM practice requirements (eg, s 4.4.6 (a), (c) and (d) of PAS 55).	The management team that has overall responsibility for asset management. Users of the organisational information systems.	The asset management information system, together with the policies, procedure(s), improvement initiatives and audits regarding information controls.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
64	Information management	How has the organisation's ensured its asset management information system is relevant to its needs?	2	Business requirements such as condition data and updated maintenance standards have driven the need for a wide range of new asset data. Improved processes and data standards are being implemented to improve the integrity and quality of the data.		Widely used AM standards need not be prescriptive about the form of the asset management information system, but simply require that the asset management information system is appropriate to the organisations needs, can be effectively used and can supply information which is consistent and of the requisite quality and accuracy.	The organisation's strategic planning team. The management team that has overall responsibility for asset management. Information management team. Users of the organisational information systems.	The documented process the organisation employs to ensure its asset management information system aligns with its asset management requirements. Minutes of information systems review meetings involving users.
69	Risk management process(es)	How has the organisation documented process(es) and/or procedure(s) for the identification and assessment of asset and asset management related risks throughout the asset life cycle?	3	Risk management processes are documented and managed proactively with the aid of supporting systems such as Active Risk Manager (ARM), Risk and Incident Management System (RIMS), Failure Mode and Effects Analysis (FMEA), HSE Management Systems and Bowtie Analysis. Both the FMEA and Safety Management Systems specifically work to identify risks through the asset lifecycle. These activities and systems are aligned through an established framework. Improvements in the identification of risk controls and assurance activities are ongoing.		Risk management is an important foundation for proactive asset management. Its overall purpose is to understand the cause, effect and likelihood of adverse events occurring, to optimally manage such risks to an acceptable level, and to provide an audit trail for the management of risks. Widely used standards require the organisation to have process(es) and/or procedure(s) in place that set out how the organisation identifies and assesses asset and asset management related risks. The risks have to be considered across the four phases of the asset lifecycle (eg, para 4.3.3 of PAS 55).	The top management team in conjunction with the organisation's senior risk management representatives. There may also be input from the organisation's Safety, Health and Environment team. Staff who carry out risk identification and assessment.	The organisation's risk management framework and/or evidence of specific process(es) and/ or procedure(s) that deal with risk control mechanisms. Evidence that the process(es) and/or procedure(s) are implemented across the business and maintained. Evidence of agendas and minutes from risk management meetings. Evidence of feedback in to process(es) and/or procedure(s) as a result of incident investigation(s). Risk registers and assessments.
79	Use and maintenance of asset risk information	How does the organisation ensure that the results of risk assessments provide input into the identification of adequate resources and training and competency needs?	3	Risk assessments are used to support high level asset management decisions associated with asset management strategies and plans, and the prioritisation and allocation of resources, budget and activities. These are well established in Vector's risk, incident and investigation processes. However, there is room for further improvements.		Widely used AM standards require that the output from risk assessments are considered and that adequate resource (including staff) and training is identified to match the requirements. It is a further requirement that the effects of the control measures are considered, as there may be implications in resources and training required to achieve other objectives.	Staff responsible for risk assessment and those responsible for developing and approving resource and training plan(s). There may also be input from the organisation's Safety, Health and Environment team.	The organisations risk management framework. The organisation's resourcing plan(s) and training and competency plan(s). The organisation should be able to demonstrate appropriate linkages between the content of resource plan(s) and training and competency plan(s) to the risk assessments and risk control measures that have been developed.
82	Legal and other requirements	What procedure does the organisation have to identify and provide access to its legal, regulatory, statutory and other asset management requirements, and how is requirements incorporated into the asset management system?	3	The business has a regulatory team that advises the business of its obligations. The business utilises "Comply With" software to assist with this. This includes HSE requirements. Regulatory changes are assessed and corresponding changes are made to business operating procedures and practices. A recent example of this is the introduction of the "Working De-energised Policy". In addition, Vectors asset management is also subject to external audit.		In order for an organisation to comply with its legal, regulatory, statutory and other asset management requirements, the organisation first needs to ensure that it knows what they are (eg, PAS 55 specifies this in s 4.4.8). It is necessary to have systematic and auditable mechanisms in place to identify new and changing requirements. Widely used AM standards also require that requirements are incorporated into the asset management system (e.g. procedure(s) and process(es))	Top management. The organisations regulatory team. The organisation's legal team or advisors. The management team with overall responsibility for the asset management system. The organisation's health and safety team or advisors. The organisation's policy making team.	The organisational processes and procedures for ensuring information of this type is identified, made accessible to those requiring the information and is incorporated into asset management strategy and objectives

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
88	Life Cycle Activities	How does the organisation establish implement and maintain process(es) for the implementation of its asset management plan(s) and control of activities across the creation, acquisition or enhancement of assets. This includes design, modification, procurement, construction and commissioning activities?	3	A suite of technical standards form the basis of Vector's control and management of its network assets. These are supported by the AMP, a maintenance plan and good project and operations management. The effective management of associated projects, budgets and high level work plans are monitored against the expectations established in the AMP.		Life cycle activities are about the implementation of asset management plan(s) i.e. they are the "doing" phase. They need to be done effectively and well in order for asset management to have any practical meaning. As a consequence, widely used standards (eg, PAS 55 s 4.5.1) require organisations to have in place appropriate process(es) and procedure(s) for the implementation of asset management plan(s) and control of lifecycle activities. This question explores those aspects relevant to asset creation.	Asset managers, design staff, construction staff and project managers from other impacted areas of the business, e.g. Procurement	Documented process(es) and procedure(s) which are relevant to demonstrating the effective management and control of life cycle activities during asset creation, acquisition, enhancement including design, modification, procurement, construction and commissioning.
91	Life Cycle Activities	How does the organisation ensure that process(es) and/or procedure(s) for the implementation of asset management plan(s) and control of activities during maintenance (and inspection) of assets are sufficient to ensure activities are carried out under specified conditions, are consistent with asset management strategy and control cost, risk and performance?	2	New maintenance standards are being deployed with more specific data requirements and defined data standards. Further improvements are being developed in the form of audits and better continuous improvement processes.		Having documented process(es) which ensure the asset management plan(s) are implemented in accordance with any specified conditions, in a manner consistent with the asset management policy, strategy and objectives and in such a way that cost, risk and asset system performance are appropriately controlled is critical. They are an essential part of turning intention into action (eg, as required by PAS 55 s 4.5.1).	Asset managers, operations managers, maintenance managers and project managers from other impacted areas of the business	Documented procedure for review. Documented procedure for audit of process delivery. Records of previous audits, improvement actions and documented confirmation that actions have been carried out.
95	Performance and condition monitoring	How does the organisation measure the performance and condition of its assets?	3	Service levels, asset condition and performance information is gathered and reviewed. Vector has also adopted a condition based risk management approach to its asset management together with dashboard KPI's and performance reporting. These are yet to be fully developed and implemented.		Widely used AM standards require that organisations establish implement and maintain procedure(s) to monitor and measure the performance and/or condition of assets and asset systems. They further set out requirements in some detail for reactive and proactive monitoring, and leading/lagging performance indicators together with the monitoring or results to provide input to corrective actions and continual improvement. There is an expectation that performance and condition monitoring will provide input to improving asset management strategy, objectives and plan(s).	A broad cross-section of the people involved in the organisation's asset-related activities from data input to decision-makers, i.e. an end-to end assessment. This should include contactors and other relevant third parties as appropriate.	Functional policy and/or strategy documents for performance or condition monitoring and measurement. The organisation's performance monitoring frameworks, balanced scorecards etc. Evidence of the reviews of any appropriate performance indicators and the action lists resulting from these reviews. Reports and trend analysis using performance and condition information. Evidence of the use of performance and condition information shaping improvements and supporting asset management strategy, objectives and plan(s).
99	Investigation of asset-related failures, incidents and nonconformities	How does the organisation ensure responsibility and the authority for the handling, investigation and mitigation of asset-related failures, incidents and emergency situations and non conformances is clear, unambiguous, understood and communicated?	3	Vector has an investigation process in place and clear responsibilities defined. This is managed in line with Vector's safety management system and is supported by our Risk and Incident Management and Active Risk Manager systems. Incidents are reported as defined by Vector's Incident Management Process. Major events are investigated systemically, risk assessed and appropriate mitigation plans are developed. Ownership of the actions are defined and followed up and reported on.		Widely used AM standards require that the organisation establishes implements and maintains process(es) for the handling and investigation of failures incidents and non-conformities for assets and sets down a number of expectations. Specifically this question examines the requirement to define clearly responsibilities and authorities for these activities, and communicate these unambiguously to relevant people including external stakeholders if appropriate.	The organisation's safety and environment management team. The team with overall responsibility for the management of the assets. People who have appointed roles within the asset-related investigation procedure, from those who carry out the investigations to senior management who review the recommendations. Operational controllers responsible for managing the asset base under fault conditions and maintaining services to consumers. Contractors and other third parties as appropriate.	Process(es) and procedure(s) for the handling, investigation and mitigation of asset-related failures, incidents and emergency situations and non conformances. Documentation of assigned responsibilities and authority to employees. Job Descriptions, Audit reports. Common communication systems i.e. all Job Descriptions on Internet etc.

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SCHEDULE 13: REPORT ON ASSET MANAGEMENT MATURITY (cont)

Question No.	Function	Question	Score	Evidence—Summary	User Guidance	Why	Who	Record/documented Information
105	Audit	What has the organisation done to establish procedure(s) for the audit of its asset management system (process(es))?	2	Vector has an established audit procedure. External and internal audits, and reviews on asset management practices are carried out on a regular basis. Field work carried out by contractors is sample audited. However, further improvements in the internal audit process and end-to-end capture of audit actions is underway.		This question seeks to explore what the organisation has done to comply with the standard practice AM audit requirements (eg, the associated requirements of PAS 55 s 4.6.4 and its linkages to s 4.7).	The management team responsible for its asset management procedure(s). The team with overall responsibility for the management of the assets. Audit teams, together with key staff responsible for asset management. For example, Asset Management Director, Engineering Director. People with responsibility for carrying out risk assessments	The organisation's asset-related audit procedure(s). The organisation's methodology(s) by which it determined the scope and frequency of the audits and the criteria by which it identified the appropriate audit personnel. Audit schedules, reports etc. Evidence of the procedure(s) by which the audit results are presented, together with any subsequent communications. The risk assessment schedule or risk registers.
109	Corrective & Preventative action	How does the organisation instigate appropriate corrective and/or preventive actions to eliminate or prevent the causes of identified poor performance and non conformance?	2	Actions arising from audits, investigations, risks and legal compliance are captured in various registers. Formal investigation processes are in place for major events. Root cause analysis and condition and performance reviews are being completed when needed but there is room to improve.		Having investigated asset related failures, incidents and non-conformances, and taken action to mitigate their consequences, an organisation is required to implement preventative and corrective actions to address root causes. Incident and failure investigations are only useful if appropriate actions are taken as a result to assess changes to a businesses risk profile and ensure that appropriate arrangements are in place should a recurrence of the incident happen. Widely used AM standards also require that necessary changes arising from preventive or corrective action are made to the asset management system.	The management team responsible for its asset management procedure(s). The team with overall responsibility for the management of the assets. Audit and incident investigation teams. Staff responsible for planning and managing corrective and preventive actions.	Analysis records, meeting notes and minutes, modification records. Asset management plan(s), investigation reports, audit reports, improvement programmes and projects. Recorded changes to asset management procedure(s) and process(es). Condition and performance reviews. Maintenance reviews
113	Continual Improvement	How does the organisation achieve continual improvement in the optimal combination of costs, asset related risks and the performance and condition of assets and asset systems across the whole life cycle?	2	Continuous improvement processes exist for the ongoing improvements to Vector's technical standards. Internal action registers are also in place to capture improvements associated risks, audits and asset performance reviews. Optimisation improvements across risk, cost and performance will improve with improved data and SAP reporting, currently underway. In addition, further embedded risk thinking and assurance processes will drive continuous improvement in budgeting, strategic thinking and project optimisation.		Widely used AM standards have requirements to establish, implement and maintain process(es)/procedure(s) for identifying, assessing, prioritising and implementing actions to achieve continual improvement. Specifically there is a requirement to demonstrate continual improvement in optimisation of cost risk and performance/condition of assets across the life cycle. This question explores an organisation's capabilities in this area—looking for systematic improvement mechanisms rather that reviews and audit (which are separately examined).	The top management of the organisation. The manager/team responsible for managing the organisation's asset management system, including its continual improvement. Managers responsible for policy development and implementation.	Records showing systematic exploration of improvement. Evidence of new techniques being explored and implemented. Changes in procedure(s) and process(es) reflecting improved use of optimisation tools/techniques and available information. Evidence of working parties and research.
115	Continual Improvement	How does the organisation seek and acquire knowledge about new asset management related technology and practices, and evaluate their potential benefit to the organisation?	3	Vector participates in a number of national and international working groups to identify new asset management technologies and practices. A dedicated team is in place to review new technologies e.g. Lidar, grid batteries, solar, hot water load control and mPrest etc.		One important aspect of continual improvement is where an organisation looks beyond its existing boundaries and knowledge base to look at what 'new things are on the market'. These new things can include equipment, process(es), tools, etc. An organisation which does this (eg, by the PAS 55 s 4.6 standards) will be able to demonstrate that it continually seeks to expand its knowledge of all things affecting its asset management approach and capabilities. The organisation will be able to demonstrate that it identifies any such opportunities to improve, evaluates them for suitability to its own organisation and implements them as appropriate. This question explores an organisation's approach to this activity.	The top management of the organisation. The manager/team responsible for managing the organisation's asset management system, including its continual improvement. People who monitor the various items that require monitoring for 'change'. People that implement changes to the organisation's policy, strategy, etc. People within an organisation with responsibility for investigating, evaluating, recommending and implementing new tools and techniques, etc.	Research and development projects and records, benchmarking and participation knowledge exchange professional forums. Evidence of correspondence relating to knowledge acquisition. Examples of change implementation and evaluation of new tools, and techniques linked to asset management strategy and objectives.

Appendix 13 Mandatory Explanatory Notes on Forecast Information (Schedule 14a)

1. This Schedule requires EDBs to provide explanatory notes to reports prepared in accordance with clause 2.6.6.
2. This Schedule is mandatory - EDBs must provide the explanatory comment specified below, in accordance with clause 2.7.2. This information is not part of the audited disclosure information, and so is not subject to the assurance requirements specified in Section 2.8.

Commentary on difference between nominal and constant price capital expenditure forecasts (Schedule 11a)

3. In the box below, comment on the difference between nominal and constant price capital expenditure for the current disclosure year and 10 year planning period, as disclosed in Schedule 11a.

BOX 1: COMMENTARY ON DIFFERENCE BETWEEN NOMINAL AND CONSTANT PRICE CAPITAL EXPENDITURE FORECASTS

Vector has used a capital expenditure inflator based on the model used by the Commerce Commission in its DPP price reset on 1 April 2015. We have used an inflator which is a mix of Capital Goods Price Index (CGPI) and Labour Cost Index (LCI). The weighting between CGPI (51%) and LCI (49%) is based on Vector 2016/17 year cost structure, i.e. the capital goods component and labour cost component in our CAPEX.

The CGPI forecast is 2%, which is based on a 9-year average to September 2017. The LCI forecast is 2%, which is based on a 9 year New Zealand average to September 2017. We have then increased the LCI forecast by 1% to account for the higher labour cost observed in Auckland. Vector asked an expert economist to consider all available evidence to determine if there are any Auckland specific costs that warrant specific consideration when compared to the cost of operations in other parts of the country. The expert economist considered information such as the Household Economic Survey (HES) and found there to be cost pressures for operating in Auckland that were not as apparent in other parts of the county. To address this Auckland specific cost pressure the economist recommended applying a 1% premium on LCI to ensure it is accounted for. The expert economist also recommended having an LCI component for inflating constant price capital expenditures given the CGPI does not expressly account for capitalised labour.

The constant price capital expenditure forecast is inflated by the above mentioned index to convert to a nominal price capital expenditure forecasts..

Commentary on difference between nominal and constant price operational expenditure forecasts (Schedule 11b)

4. In the box below, comment on the difference between nominal and constant price operational expenditure for the current disclosure year and 10-year planning period, as disclosed in Schedule 11b.

BOX 2: COMMENTARY ON DIFFERENCE BETWEEN NOMINAL AND CONSTANT PRICE OPERATIONAL EXPENDITURE FORECASTS

Vector has used an operational expenditure inflator based on the model used by the Commerce Commission in its DPP price reset on 1 April 2015. We have used an inflator which is a mix of Producer Price Index (PPI) and Labour Cost Index (LCI). The weighting between PPI (40%) and LCI (60%) as per the Commission's model.

Vector has used the NZIER (New Zealand Institute of Economic Research) December 2017 PPI (Producer Price Index-outputs) forecast up to March 2021. Thereafter, we have assumed a long term inflation rate of 2.50%.

The LCI forecast is 2%, which is based on a 9 year New Zealand average to September 2017. We have then increased the LCI forecast by 1% to account for the higher labour cost observed in Auckland. As discussed above in Box 1, Capex, Vector commissioned an expert economist to consider whether there are Auckland specific cost drivers that warrant explicit consideration. The expert economist's review of evidence found there were Auckland specific cost drivers warranting a 1% premium on the LCI to address the costs of being an EDB in this region. The constant price operational expenditure forecast is inflated by the above mentioned index to convert to a nominal price operational expenditure forecasts.

Appendix 14 Certificate for Year Beginning Disclosures

Schedule 17 Certification for Year-beginning Disclosures

Clause 2.9.1

We, James Carmichael, and Michael Stiassny, being directors of Vector Limited certify that, having made all reasonable enquiry, to the best of our knowledge:

a) The following attached information of Vector Limited prepared for the purposes of clauses 2.6.1, 2.6.6 and 2.7.2 of the Electricity Distribution Information Disclosure Determination 2012 in all material respects complies with that determination.

b) The prospective financial or non-financial information included in the attached information has been measured on a basis consistent with regulatory requirements or recognised industry standards.

c) The forecasts in Schedules 11a, 11b, 12a, 12b, 12c,12d and 13 are based on objective and reasonable assumptions which both align with Vector Limited's corporate vision and strategy and are documented in retained records.

J Carmichael

Director

Director

01 MAY 2018

Date