Suburb of the Future Stage 1: LV Network Lab

INTSA Application

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1. Introduction & Context

Vector is New Zealand's largest electricity distribution business (EDB), servicing approximately 630,000 customers in the Auckland region. The company receives electricity from Transpower at 14 grid exit points and distributes power throughout its network via sub-transmission and high-voltage systems, which connect to around 23,000 distribution transformers supplying low voltage networks.

The low voltage (LV) system primarily employs a radial configuration with limited redundancy. It serves as the connection point for residential and most commercial customers, with each distribution transformer typically supporting up to 75 customers. In areas of higher urban density, individual transformers often supply more than 100 residential installation control points (ICPs).

Traditionally, LV networks have operated and grown without the need for real-time monitoring, visibility or control due to consistent customer usage patterns and unidirectional power flows, thus keeping operational costs manageable. However, the increasing uptake of distributed energy resources (DER) presents new challenges to these assumptions by introducing greater variability in loading and the possibility of bi-directional power flows, necessitating a revised approach to network management.

Although DER adoption rates remain unpredictable, their uptake is accelerating, making active monitoring and enhanced network visibility increasingly essential for effective LV network management and planning. The "Suburb of the Future: LV Network Lab" represents Stage 1 of Vector's response to these challenges and is the focus of this INTSA application.

Real-time monitoring and control will enable improved management of the LV network by:

- Tracking fluctuations in local energy demand linked to DER adoption and variable customer behaviour; and
- Managing the variability and clustering associated with DER usage to maintain stable and efficient network operations.

Vector seeks INTSA funding to establish an LV Network Lab, serving as a pilot site for real-time monitoring, control, and advanced functionality within LV networks. This lab will provide a practical testbed to identify optimal design and technology solutions for monitoring and controlling LV networks in the context of rising DER concentrations.

The initiative aims to generate insights that can inform scalable models for broader deployment as DER penetration increases. Key features of the LV Network Lab include:

- Installation of network monitoring devices at strategically selected points across both LV and interconnected high voltage (HV) circuits;
- Implementation of advanced smart network controls, such as LV circuit breakers and the potential integration of localized battery energy storage systems (BESS) to optimize LV network performance; and
- Deployment of next-generation metering infrastructure capable of delivering real-time network operating data (NOD).

Moreover, the growth in DER contributes to an expanding pool of flexible loads that can be coordinated to deliver benefits for both the network and consumers. The safe orchestration of these loads—managed through Retailers—is complex and requires direct observation in real-world settings to ensure safe scaling. Stage 2 of this project will address DER orchestration in detail and will form the basis of a future INTSA application (Suburb of the Future Stage 2: DER Orchestration).

2. Project Specific Information: Suburb of the Future Stage 1: LV Network Lab

2.1 Project Details

Project Title	**Suburb of the Future Stage 1: LV Network Lab**		
Project Start	March 2026	**INTSA Funding Sought**	$4,295,800
Project End	June 2027	**Vector Contact**	[redacted]

2.2 Purpose

The LV Network Lab testbed is designed to evaluate the installation and integration required for comprehensive real-time monitoring and control within a selected area of the LV network. Vector will assess how each component of the testbed contributes to LV monitoring and control capabilities, with the goal of creating a scalable plan for proactive LV asset management in the future.

Alongside the testbed, we plan to examine the feasibility of using LoRaWAN as a cost-effective, secure, and suitable communications standard for deploying network sensors at scale. LoRaWAN technology could enable greater automation of field devices, offering a potentially more affordable alternative to cellular M2M (machine-to-machine) solutions and better signal penetration in challenging environments.

The insights gained from the LV Network Lab will guide EDB investment decisions by enhancing real-time monitoring and supporting timely, appropriate responses when DER clustering starts to affect LV system performance.

2.3 Project Scope

2.3.1 Work Package 1: LV Visibility and Capability

The LV Network Lab will entail the implementation of a high-resolution monitoring architecture extending from the HV Zone Substation (ZS) to the Installation Control Points (ICP), encompassing both HV and LV networks. To accomplish this objective, Vector proposes to design and commission the following:

- **Asset performance monitoring sensors** deployed at strategic locations across the HV feeder and LV network—including poles, distribution transformers, LV open points, and kerbside pillars—to collect high-resolution data such as voltage, current, phase angle, and temperature.
- **Asset health monitoring sensors** involve the installation of condition monitoring devices on HV and LV infrastructure to provide continuous measurements of pole tilt, conductor clearance, and associated asset health indicators.
- **Next generation digital meters** within the lab footprint to provide real-time network operating data (NODs).
- **Enhanced LV circuit breakers** to enable real-time and remote network operation, facilitating proactive management of customer loading scenarios that may pose risks to network assets.

Implementing these components will enable real-time monitoring of power flows and asset conditions from the zone substation (ZS) through to the ICP, as shown in the diagram below.

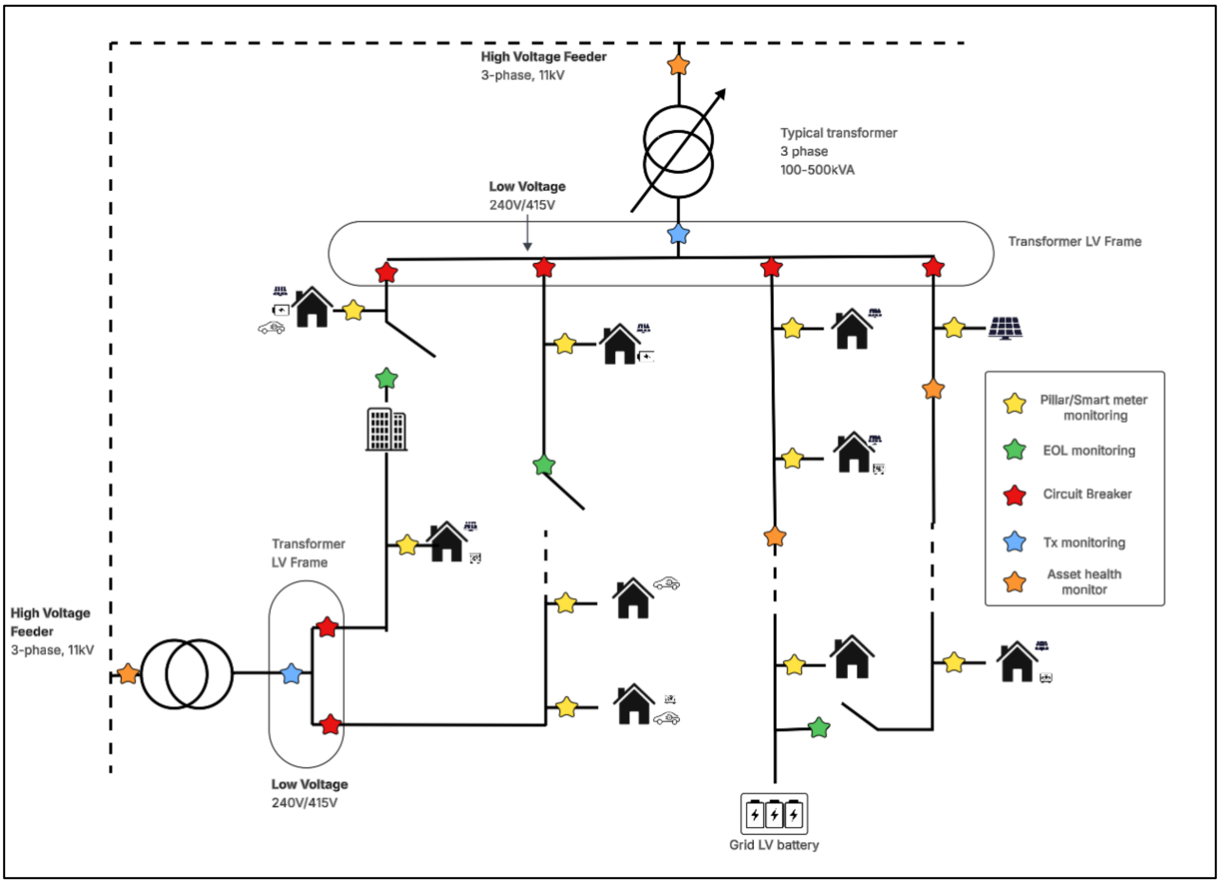


Figure 1 - Indicative diagram of LV Network Testbed Equipment Installations

2.3.2 Work Package 2: LoRaWAN

We have based our application on LoRaWAN to provide costing estimates and timelines since an initial review of published information supports that LoRaWAN is a leading contender worldwide to unlock the use of low power sensors for visibility and monitoring by utilities.

A more in depth market scan of IoT communications standards will be done at the outset of the project to evaluate alternatives like Low Power Wide Area Network (LPWAN) and Narrow Band IoT (NB-IOT) technologies to test the validity of our initial view on LoRaWAN.

This will be a first-time trial of LoRaWAN for Vector and an opportunity to discover if this technology presents a viable alternative for cellular technology for in field asset communications. The ultra-low power usage of LoRaWAN has the potential to significantly decrease the maintenance for field devices and reduce communication costs.

We are proposing to validate the use of this technology across a variety of asset monitoring tools including asset health indicators for network assets such as line clearance monitoring, pole tilting and partial discharge on cable terminations across both the HV and LV networks.

Specifically, the project will review the reliability of LoRaWAN measuring parameters such as on time receipt of information, information exchanges, cyber security and performance across different environmental conditions to consider its effectiveness as an alternative for cellular connectivity. A reliability assessment of LoRaWAN will also complement other factors such as coverage and competitiveness.

2.3.3 Work Package 3: Data Management

The project will establish an end-to-end data management capability designed to support low-latency analytics across the LV Network Lab. This includes secure ingestion of high-frequency data from field devices, LV monitoring sensors and next-generation meters into Vector's Data Platform (MDP) and associated operational data environments. Data pipelines will be designed to support near real-time processing, validation, enrichment and time-synchronisation of network operating data (NODs) to enable rapid analytics, event detection and operational use cases.

The scope also includes enhancements to smart meter data processing to prioritise timeliness over batch latency where required, integration of monitoring data with operational technology (OT) and analytics platforms, and updates to asset records and GIS to ensure data is accurately contextualised against physical network assets.

Appropriate data governance, quality controls, security and access management will be implemented to ensure the data is reliable, scalable and fit for future LV monitoring, control and automation use cases.

2.3.4 Work Package 4: Project Management and Learning Dissemination

The project is governed by Vector's INTSA specific Governance, which includes executive level oversight. Project Management and PMO activities will be administered by internal resource, who are allocated to the project for its duration. These team members will also be responsible for coordinating the sharing of project learnings, and interactions with other EDBs and industry groups to facilitate this. This will include hosting sharing webinars, attending and presenting at relevant industry events and ad-hoc sessions with other EDB's operational teams. There will also be delivery project management resource from our Capital Programme team allocated to the project to oversee the physical Installation programme of the monitoring devices.

2.4 [redacted confidential information]

2.5 Project Delivery Milestones

The below table 1, provides a view to the deliverables for the LV Network Lab.

Table 1: Delivery programme split into Work Packages (WP)

Title	Milestones/Deliverables
WP1: LV Visibility and Capability	• Design architecture investigation and assessment of suitable assets for monitoring capability • Procurement, Installation and configuration and in-field commissioning of equipment • Configuration of operational technology control systems • Design, test and configure LV circuit breakers
WP2: LoRaWAN Assessment	• Completion of a market scan of LPWAN technologies to confirm the selection of LoRaWAN. • Determine LoRaWAN network reliability for network loading and asset condition monitoring and evaluate its suitability for supporting LV monitoring and control.
WP3: Data Management	• LV network survey and detailed GIS updating of assets in the project precinct • Upgrading of metering within footprint • Establish data ingestion pipelines and integration of data into OT and IT environments
WP4: Project Management and Industry Knowledge sharing	• Knowledge dissemination on the commissioning experience, community engagement and insights the architecture offers for future LV deployments and the use of new sensor technology into network designs • Knowledge sharing on LV technology integration into network OT systems • Knowledge dissemination of the benefits of NODs data and algorithms to support its future use

2.6 Forecast costs

Below is a high-level estimate of the resourcing required for the above work packages to deliver to the milestones above. Vector notes the ability to undertake a real-world commissioning of extensively monitored LV system is an intensive exercise with the design and asset deployment occupying a significant proportion of costs.

We also consider the LV Network Lab as our signature INTSA project for DPP4 and its ambition involves taking a project from concept to commissioning which is a key contributing factor for the cost levels presented below.

Vector has assessed each Work Package separately in regard to the cost recovery request, which is further detailed in Section 3 that covers Eligibility.

Internal resourcing has been estimated using our standard rates. For WP1, we treated this as a standard capital project with a duration of 15 months and applied the standard resourcing and rates to support this. This includes a capital project manager for the duration, planning and asset engineers allocated at 0.3 for the duration. WP3 will be conducted with internal resourcing, and similarly followed our standard estimating methodology, this cost is covered in the Data Management line item. WP4 covers overall programme management at 0.2FTE for the duration of the project. There are no internal costs allocated to WP2 as the relevant resources are already accounted for in other work packages.

The amount Vector have applied for in terms of cost recovery is explained in the Eligibility Section.

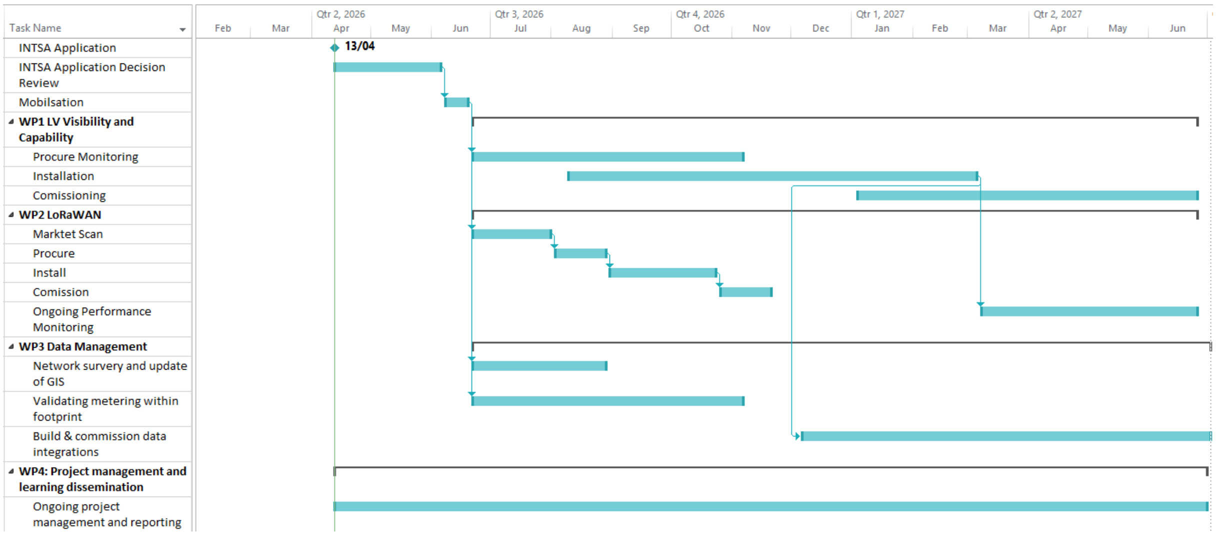
Work Package	Description	Cost	Cost recovery	INTSA Request
WP1: LV Visibility and Capability	LV Visibility – network design, supply and Installation of monitoring equipment both phase, voltage asset performance monitoring and asset health monitoring devices and low voltage LV circuit breakers	$2,340,000	100%	$2,340,000
	Internal resources: engineering, capital project management, planning	$1,060,000	100%	$1,060,000
WP2: LoRaWAN	Communications Backhaul – cost for access to LoRaWAN network	$50,000	75%	$37,500
	Communications/	$10,000	75%	11,125

	monitoring market scan			
WP3: Data Validation	Network Survey to validate physical assets	$100,000	75%	$75,000
	Digital integration including architecture and security	$100,000	75%	$75,000
	Data management	$500,000	75%	$375,000
	Procurement of Smart Meter Data & Prioritisation of Meter Replacement	$300,000	75%	$225,000
WP4: Project Management and Information Dissemination	Internal resource; Programme/PMO Management	$100,800	100%	$100,800
Total Forecast Cost		$4,560,800		
Total INTSA Request				$4,295,800

2.7 Indicative Timeline

Following an Installation period throughout the 26/27 summer, the testbed will be established by mid-2027. Beyond this point other pilots and demonstrations will be possible within the testbed, such as the DER Orchestration trial which is discussed in Section 3.

Indicative timeline of the different Work Packages and how these interact is provided below. This is subject to change during detailed planning.



2.8 Customer engagement

Vector is proposing a thorough community engagement programme for the project given the commissioning experience will be novel for Vector and its customers. Given the LV Network Lab will be the location for several different network trials Vector is very interested in maintaining our social licence with this community by informing them of this trial and future learnings we are intending to undertake in their area.

We are keen to understand the impact the proposed architecture will mean in terms of customer support and feedback from the commissioning experience.

2.9 Project Benefits

The LV Network Lab project gives Vector a proactive opportunity to investigate the emerging challenge of complex LV management. It will inform the future requirements and design of LV monitoring and control as DER uptake accelerates and begins to have a material impact on network performance.

Over the long-term, the findings of this project will support the evolution of LV networks to protect network assets and support customer adoption and use of DER technology.

Pursuing a full-scale trial with a wide variety of technologies working together, rather than testing these on a case-by-case basis, gives the richest view of real-world interoperability so that Vector can determine which combinations of technology provide the most effective architecture for proactive LV monitoring and control.

We recognise network technologies and customer DER technologies will change over time which will also inform the future LV network architecture. However, we see these technological developments complementing our real-world testing of a visibility network architecture rather than a reason to avoid this type of inquiry.

Benefit	Description
Financial	• More efficient asset management strategies from an informed view of LV monitoring deployment • Cost savings as LoRaWAN enabled sensors offer a lower cost monitoring option
Non-Financial	• Improved customer experience for DER customers and non-DER customers • Better reliability of network elements • Better asset management strategies

2.10 Uncertainty of innovation benefits within DPP4

The need for real-time LV monitoring is closely tied to the challenges that distributed energy resources (DER) will create as customer adoption becomes more widespread. The main uncertainty lies in determining when DER adoption rates and concentrations will reliably predict future issues for customers at the distribution transformer level. These adoption rates depend on evolving economics and capabilities of DER systems, which influence customer decisions to purchase and install them. Currently, with the present pace of DER uptake, we do not anticipate any clustering of DER on LV systems during the DPP4 period that would require changes to our LV planning strategy.

On the other hand, we expect a reliable, low-cost communication standard such as LoRaWAN to demonstrate tangible benefits within the DPP4 timeframe. If the technology proves dependable for network applications, Vector sees the potential to deploy additional remote communication assets based on the learnings from this project. Nonetheless, we must weigh its reliability against considerations such as coverage, cost compared to machine-to-machine (M2M) solutions, and integration with our automation program.

2.11 Reliability benefit under DPP4 SAIDI / SAIFI

The project is forecasted to have no material impact on Vector's unplanned or planned SAIDI or SAIFI.

Given the limited real-time information for the timing and extent of LV outages and the lower customer counts impacted per event, Part 4 quality requirements have not extended to LV outages. Therefore, the LV Network Lab will not have direct reliability benefits or detriment as defined within the DPP. Vector is not anticipating any material change to our SAIDI and SAIFI statistics from the commissioning of the LV Network Lab.

We do see the LV Network Lab itself providing a material improvement in the monitoring of LV unplanned outages within the precinct once it is commissioned.

2.12 Collaboration

The LV Network Lab initiative is not a collaborative learning project with other EDBs, since Vector is proposing to target an LV network within our network footprint.

2.12.1 Learning Dissemination

Although the project will not seek funding from the Collaborative Allowance, we are committed to sharing as much of the learnings of this project with other EDBs and the industry more broadly. We are committed to publishing information for the project at regular intervals and are proposing to present papers to the Electricity Engineers Association (EEA), host free public webinars and present our findings at suitable industry forums.

2.12.2 Project Partners

We have collaborated with multiple suppliers to identify suitable and cost-effective equipment capable of delivering comprehensive network visibility and protection across the low voltage network at the transformer, line, and customer levels.

A primary objective of this engagement was to select suppliers who could demonstrate the deployment of their solutions using scalable, low-cost communication networks as viable alternatives to those currently employed by Vector and the industry. Given that this approach represents new territory for the industry, and that these communication networks are presently limited to existing geographical coverage areas, it was essential to engage suppliers willing to invest in expanding their networks to ensure adequate coverage within the designated section of the Vector network for this project.

2.13 Eligibility

Criterion 1 – Related to the supply of electricity	The electricity distribution services (EDS) refer to all electricity lines services (ELS) other than those delivered by Transpower – as prescribed by section 52C of the *Commerce Act* (the Act). The Act reference to "line" considers all elements used to support the conveyance of electricity – including all supporting structures to the point of supply. The point of supply demarcation is generally recognised as the fuse for the customer service lead. In the 2016 Input Methodologies Review – the Commission explicitly considered the issue of ELS and noted the definition of "line" only relates to the nature of the line service and does not exclude other assets that are used to support the lines service. In this regard, the Commission has recognised the "use" of an asset is important as to whether it should be considered part of the ELS or not. Vector's proposal for the LV Network Lab provides additional monitoring and control capability for the lines service at the LV network to help with real-time monitoring of assets for a select group of customers. LV network assets are the "last mile" of conveyance to the customers and have performed effectively with limited need for real-time visibility. We note this INTSA application does include funding to support upgrading of the customer metering fleet to next generation meters within the LV Network Lab. Our request in this regard is consistent with the definition of ELS as the funding would be utilised as incentive payments to prioritise the rollout of metering within our trial footprint, should this be necessary. It is not ringfenced to cover the meters.
Criterion 2 – Promotes the Part 4 Purpose	The Part 4 Purpose is set out in s52A. The purpose of the LV Network Lab will be to test the effort to deliver full network visibility across LV systems connected to a single HV feeder. The LV Network Lab promotes the long term benefit of consumers as these investigations are intended to support a key frontier for EDBs – the uplifting the

	real-time visibility and reliability of the last mile of their networks to the end-user. We believe this INTSA project meets all four limbs of the Part 4 purpose as: 1. the primary driver for the investigations is to *innovate* with the delivery of the "last mile" of the network to the customer as their needs evolve and their use of DER technology increases 2. the delivery of the project will *uncover efficiencies* that can be leveraged for broad scale network rollout or in the instance of LoRaWAN communications a greater adoption of remote monitoring or controlled devices based on the alternative mode of communications 3. Vector is determined to make the right investments at the right time for our customers – and this investigation is about discovering how LV visibility should be efficiently managed as take up of DER challenges existing LV design assumptions. 4. In the absence of INTSA – Vector would not undertake this investigation as this type of investment is not proposed by our Asset Management Plan and is not counted for in the capital programme included for DPP4. We see a need for the Commission to work with industry on a shared approach for progressively and economically upgrading LV systems that meets the Part 4 purpose as this presents the next frontier for networks.
Criterion 3a – Unlikely to otherwise result in any financial benefits	The Commission's guidance for eligibility criterion is whether the INTSA project offers financial benefits to the EDB in the next five disclosure years. The Commission's guidance here recognises the challenges of how financial benefits are captured as part of the price setting process for EDBs. The LV Network Lab will not provide Vector with any anticipated direct or indirect financial benefit. Vector is not adopting a charging model for the LV Network Lab. Rather, the investment is research and development focused. The research is about getting firsthand experience about the asset information and effort needed to obtain effective near real-time LV asset visibility and the optimal network architecture. In absence of the INTSA allowance, this project is not included within Vector's capital programme. The works relating to the Installation of physical assets in the LV Network Lab does not substitute or complement other Vector work programmes. Therefore, it poses no benefit for the financial incentives within the DPP or outside of the DPP and we have requested 100% funding for these elements of scope (Work Package 1 and 4). For scope relating the establishment of LoRaWAN and data management (Work Package 2 and 3), there are likely to be benefits within a 5 year period as this work can be operationalised immediately, and so the funding request is 75%.
Criterion 3b – Sufficiently Uncertain Benefits	The LV Network Lab is a research focused project to discover the right assets and architecture to monitor the LV network in real-time in anticipation of greater customer take-up of DERs. The benefits of the project are to provide a real-worked Installation of LV monitoring. Vector is conscious there is significant uncertainty as to the rate of customer adoption of DER and when this will begin to occur at concentrations granular enough to affect performance of LV networks. We are also aware that LV

	monitoring technology is largely untested in real-world applications, and so it's advantages are not well understood or quantified. Due to these two key uncertainties, the benefits of conducting this project are also uncertain, and cannot be reliably quantified such that we would pursue this project using our normal investment approach. We recognise the investigation into LoRaWAN could confirm the reliability benefits of the technology within the DPP. However, once the technology is confirmed we see the use cases for the technology will be determined on a case-by-case basis, as opposed to an overall efficiency benefit based on a mix of coverage, monitoring application and wireless conversion programme.

2.14 Additional Information

2.14.1 Building on Prior Learning

The LV Network Lab builds on learning and capability that EDBs have developed on their High Voltage networks with real-time circuit visibility.

The Vector LV Network Lab will complement this capability by trialling network monitoring/control devices measuring assets along an LV circuit to give timely feedback on voltage and thermal constraints.

Current learning of LV networks are based on simulation models, direct device management and direct customer engagement. The installation of network monitoring tools and network capability is a first investigation of the effort required to get firsthand LV visibility. Previous trials of smart EV charging, time-of-use analysis and customer behaviour analysis have provided insights into load profiles and load shaping opportunities. This trial focuses directly on uplifting visibility on LV network elements and network protection controls.

In contrast to other investigations of LV capability – the LV Network Lab will put in place an architecture that can be reused over again for future endeavours to trial or test new approaches for LV customer and network management.

2.14.2 Replicable in NZ

The project problem statement, setup and learnings from the LV Network Lab can be replicated in other electricity networks. The testbed and the learnings for future LV monitoring design can be replicated by other EDBs and behavioural data will be comparable.

More importantly, the model allows EDBs and non-EDBs to further explore LV visibility and complementary investments to DER. The learnings from the LV Network Lab also provides a lead indicator model for other EDBs to understand the aggressive adoption rate of DER devices and when they start to affect LV network planning assumptions for load behaviour and diversity. Furthermore, the learnings around LoRaWAN will determine if this technology can offer a reliable and cost-efficient path for large-scale rollout across New Zealand.

3. Suburb of the Future Stage 2: DER Orchestration

A fully monitored and controlled LV network testbed opens the opportunity to safely conduct other real-world trials, and so this project is a preferred location (contingent on this project being approved) for Vector's proposed retailer DER orchestration pilot supported by EECA.

The DER orchestration pilot would investigate retailer led management of DER clusters as a means of supporting demand flexibility, encouraging load diversity and limiting the loading on LV assets to ensure LV network security. Vector has already received expressions of interest from retailers wishing to participate in this type of trial. In addition to the monitoring and control equipment proposed in this application, the DER orchestration pilot would require at least the following additional investments:

- Platforms capable of publishing key asset capacity information for publication
- Literature review of relevant projects from around the world
- Design of orchestration techniques which could include a combination of signals such as headroom, Dynamic Operating Envelopes (DOEs) and tariffs
- Design and delivery of architecture between Vector and retailers to support two-way communication to securely transmit signals and exchange data

3.1.1 Trial phasing

This trial is split into two distinct phases:

Phase 1 is concerned with data validation, establishing emergency stop processes, and ensuring that retailers and in turn their customers, respond to headroom signals consistently. This includes verifying metering consumption data against the real-world impact observed at monitoring points throughout the network. This stage is focussed on building confidence in the system response to simpler signals. It also includes comparing the effectiveness and benefits of safeguarding options like smart LV fuses to the alternative of providing emerging generation options like battery storage support.

Phase 2 is to test more sophisticated orchestration techniques, such as the use of DOEs, allocated headroom and more complex pricing. Vector will only progress to this stage if the orchestration requirements cannot be satisfied by the options explored in Stage 1.

4. Vector INTSA Financial Summary

Financial summary	**Collaborative Allowance**	**Vector Allowance**	**Value ($)**
DPP4 Decision	$7,100,00	$21,300,000	$28,400,000
Applications previously approved	$2,237,000	0	$2,237,000
Applications Pending Decision	0	0	0
This application	0	$ 4,295,800	$4,295,800

Remaining Allowance	$4,863,000	$17,004,200	$21,867,200