Business Case for Investment in Low Voltage Network Monitoring

Prepared for the Electricity Networks Association

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Executive summary

This business case has been commissioned by the Electricity Networks Association (ENA). The purpose is to make the general case for investment in monitoring the low voltage network. It follows the 'Better Business Case' approach with the analysis being structured around four cases.

Strategic case – making the case for change

The LV network refers to the assets of electricity distribution businesses (EDBs) that carry power from distribution transformers to the electricity meters of industrial, commercial and residential customers. EDBs are responsible for maintaining and managing LV networks to ensure that power supply is reliable, and voltage and frequency meet supply quality standards. A set of presenting issues can be distilled into a problem definition with three parts.

Firstly, in the absence of systematic and real-time information from network monitoring, investment decisions to maintain or expand LV networks may suboptimal. For example, the investment of capital may be earlier than necessary or too late to prevent impaired performance. While this is a particular risk for EDBs with an expanding consumer base, all EDBs are exposed to changing consumption patterns as New Zealand's decarbonisation aspirations will mean increased electrification. Overall load growth of 70 per cent by 2050 has been forecast, arising from the conversion of transport and process heat to electricity (Transpower New Zealand Ltd, 2020, p. 23).

Secondly, the uptake of DER across LV networks, including high-load and injecting technologies, is largely unmonitored, and so the risk of consequent network disruptions is not presently well understood, nor are DER injections being actively managed.

Thirdly, investment in the remote monitoring of LV networks is inhibited as EDBs are not able to recover the cost of their investment under the regulated price path, other than, potentially and only partially, for trialling monitoring systems as an innovation.

As a result, there has been continued underinvestment in the monitoring of LV networks. The risks of poor outcomes from this underinvestment are increasing, namely:

- the suboptimal allocation of capital in LV network maintenance and expansion programmes
- unanticipated disruptions to LV networks from increased DER penetration (i.e. power outages or poor-quality power supply), and
- the uptake of DER technologies potentially being restricted by EDBs, counter to consumer preferences, as a blunt but necessary risk management strategy for their LV network; or else expensive upgrades in the LV network that is charged to consumers.

Economic case – identifying the preferred way forward

Four options for system-level investment in LV monitoring were constructed using the dimensions of scale (deployment of monitoring units) and functionality (technological capability). The preferred option identified is **small scale, high spec** – deployment of monitoring devices at small scale (i.e. on 1 per cent of transformers on the LV network) and with relatively high functionality, in terms of the scope and frequency of the data collection and diagnostic capability.

The cost-benefit analysis of the preferred option, referred to as the **trial scenario**, found a net benefit ranging from $52 million to $90 million over 10 years with a benefit-cost ratio ranging from 1.6 to 2.7, depending on the source of cost data used. The **expansion scenario** (i.e. deployment on 10 per cent of transformers) has a net benefit ranging from $174 million to $263 million with a benefit-cost ratio ranging from 1.6 to 2.2.

These results suggest that the deployment of monitoring technology on LV networks is likely to deliver a net benefit, at a system level, under the trial scenario and the expansion scenario. Under the assumption that the expansion scenario would follow a trial scenario, then the ability to incorporate lessons and to target transformer and circuit types would increase the certainty of a net benefit being obtained. The prospects of scale efficiencies through collaborative procurement and management of monitoring units could materially reduce the costs, thereby increasing the net benefit to the system and to individual EDBs.

The results of a complete deployment scenario (i.e. deployment on 100 per cent of transformers) suggest that a roll-out of monitoring units to every transformer may be uneconomic. However, this scenario has the highest uncertainty, as a full roll-out has not been implemented anywhere to date.

There are several points to be kept in mind with respect to these conclusions.

- Firstly, the cost-benefit analysis is from a societal perspective. This means that not all of the economic benefits accrue to EDBs. Consumers will benefit from using DER, but EDBs will not receive a quantifiable reward for increasing the capacity of the LV network to host DER.
- Secondly, the costs estimated here may be higher than will be the case over the next couple of years; the trend has been that unit costs are decreasing, and this trend is expected to continue.
- Thirdly, the benefits could be higher than estimated here; one reason is that in the absence of widespread monitoring, the scale and types of issues to be uncovered in LV networks are simply not known at this point.
- Finally, there is the issue of affordability; the costs (one-off and annual), even in the trial scenario, are likely to be seen as material at the level of individual EDBs, particularly in the absence of certainty that any costs can be recovered.

Financial Case – detailed costs and possible funding sources

With respect to modelling the one-off and ongoing costs, the approach has been to identify and analyse publicly available information on the cost of deploying monitoring technology on LV networks in other countries, notably in the United Kingdom and Australia. This information is supplemented with the costs obtained from two trials in New Zealand.

There is evidence of significant unit cost savings being obtained from deployment on a larger scale. In addition, as with many technologies, the overall costs are reducing, even as capabilities increase. Data management and modelling costs also appear to be falling, possibly due to the rise of integrated cloud-based solutions. Accordingly, the most recent monitoring projects have much lower costs than those from five or more years ago.

With respect to funding sources, in the short term, under DPP3, which applies to 31 March 2025, EDBs would have to incur the full cost of deploying monitoring technologies. There is the potential for up to half of this cost to be recovered later via the innovation fund. The Commerce Commission introduced this mechanism in DPP3 with the intention of creating incentives for innovation. A recoverable cost has been created for innovative projects, allowing for up to 50 per cent of the cost to be passed directly through in prices, separately from the price path limit.

To qualify, EDBs would need to commission a report from an independent specialist, ex ante, that the planned expenditure in LV network monitoring involves the application of new technology to deliver the electricity distribution service at a lower cost and/or at a higher level of quality. The recoverable amount is also limited to the higher of 0.1 per cent of forecast allowable revenue (excluding pass-through and recoverable costs) or $150,000.

In the medium term, i.e. following the third DPP which applies to 31 March 2025, the full recovery of the cost of investing in the monitoring of LV network will only be possible if the Commerce Commission permits the inclusion of these costs in the regulated price path. This would require submission of robust evidence, in the lead up to DPP4, that there is a case for a step change in operating expenses to account for the monitoring costs of the LV network.

Management Case – arrangements to ensure successful delivery

The decision to invest in LV monitoring is likely to occur at the level of each EDB. EDBs that discover actionable evidence from LV monitoring and look to transition the monitoring from innovation to business as usual will need to reflect the evidence and impact LV monitoring has on asset management. This will need to show a direct link between measured LV data, analysis, modelling, and extrapolation to better decision-making in their network.

Consideration needs to be given to coordinating investment and operational efforts across EDBs. This is likely to bring financial and knowledge sharing benefits, particularly among smaller businesses. This is because there are some potential savings through economies of scale, and also because the sharing of data and information and bigger asset samples are also beneficial.

Much of the initial value of LV monitoring is achieved through leveraging a smaller sample of LV feeders across the whole network. Overseas experience suggests a set of representative feeders (in the order of 10) can be applied across the whole network with most of the benefit of direct monitoring. By clubbing together, EDBs could better develop a statistically representative sample of LV feeders that can be extrapolated over a greater number of assets.

Later in the LV monitoring development, economies of scale may encourage common back-end systems, communication networks and eventual real-time monitoring across EDB groups[1]. Even more beneficial may be the common development of advanced analytical techniques, such as artificial intelligence, which again can be leveraged across a larger asset base.

[1] Real-time monitoring would also require more LV monitoring deployment.

Introduction

This section outlines the purpose of this business case and the approach used to develop the analysis.

Purpose of this business case

This business case has been commissioned by the Electricity Networks Association (ENA). The purpose is to make the general case for investment in monitoring the low voltage (LV) network.

Approach taken

The business case has been prepared by Sapere Research Group (Sapere), with input and feedback from an industry working group, facilitated by the ENA, at key stages of development. It has also been informed by the preparation of a Primer and Guideline document, also prepared by Sapere for the ENA, which provides information on LV monitoring internationally and guidance on the selection and use of LV monitoring technology (Reeve & Barton, October 2020).

The approach has been to use the 'Better Business Case' approach, which is the Treasury-mandated standard for business cases across the state sector. The format is a single-stage business case, which has been judged as being appropriate for the general case for investment being made.

Document structure

This business case follows the 'Better Business Case' approach; it utilises the following four cases.

1. Strategic Case – making the case for change.
2. Economic Case – options analysis to identify the preferred way forward, including a cost benefit analysis to determine net benefit.
3. Financial – detailed costings and possible funding sources.
4. Management – arrangements to ensure successful delivery.

The assumption is that a Commercial Case, which outlines a procurement strategy, is not necessary at this stage.

1. The Strategic Case – the case for change

The Strategic Case makes the case for investment in monitoring the LV network. It outlines the drivers of this proposal and identifies the investment objectives to guide the options assessment. It also identifies the expected benefits and risks.

1.1 Strategic context

The LV network refers to the assets of electricity distribution businesses (EDBs) that carry power from distribution transformers to the electricity meters of industrial, commercial and residential customers. EDBs are responsible for maintaining and managing LV networks to ensure that power supply is reliable, and that voltage and frequency meet supply quality standards. LV networks in New Zealand are operated at 230 volts (single-phase) and 400 volts (three-phase) plus or minus 6 per cent, at the frequency of 50 hertz. LV networks are more likely to be located underground in urban areas and overhead in rural areas. Distribution transformers can be pole or ground-mounted.

An absence of systematic monitoring of the LV network

While EDBs have visibility over high and medium-voltage networks, they typically do not have the same level of visibility into their LV networks. The application of remote monitoring technologies to LV networks in New Zealand is limited to trials in a small number of EDBs (see text box). Historically, the relatively high reliability of LV networks compared with the potential cost of physically inspecting a considerable number of LV circuits has meant that visibility has not been a high priority. However, where expectations of network reliability are increasing, alongside the complicating addition of Distributed Energy Resources (DER), then the benefits of increased visibility mount. Alongside this, the cost of monitoring is falling as the technology evolves and is implemented at scale elsewhere.

Current state of LV monitoring in New Zealand

- A survey conducted by the ENA in 2019 revealed that 11 EDBs had LV monitoring trials underway or were intending to begin a trial in the near future.
- Trials have focused on transformers, rather than at other points on the network.
- EDBs with access to smart metering data have some monitoring capability at customer installations and can use this data to infer information about the nearest upstream transformer.

Furthermore, LV networks have features that mean they require close asset management attention.

- LV networks transport electricity to almost all electricity customers.
- LV networks consist of a significant portion of total distribution network assets.
- The physical proximity of LV networks to customers and the public means that asset management is an important part of safety systems.
- LV networks are needing to adapt to integrate a variety of high load consumer technologies, and host increased DER penetration, which can cause a variety of issues.

Performance risks are emerging with the uptake of new technologies

There are growing risks with respect to the performance of LV networks. The advent and spread of new technologies is adding complexity. DER can be high load in nature (e.g. electric vehicles, heat pumps) or injecting in nature (e.g. solar, batteries). EDBs are needing to understand how LV networks should be progressively adapted to integrate a variety of high load consumer technologies and to host increased DER penetration. These new technologies bring performance risks for LV networks that can result in network outages or persistent poor-quality power supply (see text box below). The absence of LV monitoring means that there is little or no visibility of these risks.

Even in the absence of DER uptake, the monitoring of LV networks would offer innate benefits, albeit smaller in scale. Those benefits would relate to: optimising the sizing of transformers and circuits to the number of consumers; diagnosing faults earlier than otherwise, and more targeted management of LV networks that have been conservatively managed to a level of reliability due to a lack of visibility (i.e. a higher level of caution on high density circuits in absence of visibility).

The uptake of new technologies and the potential disruption of LV networks

The integration of Renewable Energy Sources (RES) can cause an imbalance between the production and utilisation of electrical energy. This affects the operation and control of power system because the power flow becomes bidirectional which influences stability and voltage quality (Katyara, Shah, Chowdhary, Akhtar, & Lashari, 2018).

Monitoring the real operating conditions of the LV networks in terms of power flows, phase unbalances, voltage levels and other power quality indicators becomes essential to efficiently operate LV networks (Barbato, et al., 2018).

Potential impacts in a New Zealand context

Watson et al. (2016) reviewed literature on photovoltaic (PV) impacts on distribution networks that had investigated voltage issues, losses, unbalance, overcurrent, harmonics, and neutral displacement. Then, by simulating the entire LV network in New Zealand, the study found that some minor overvoltage problems can be expected in the future, particularly in urban areas.

- PV systems connected to the LV distribution network may cause overvoltage, particularly when high solar radiation coincides with times of low loading, as well as the overloading of conductors and transformers.
- Urban networks were found to have the least capacity to host PV. Nevertheless, each LV network is different, with wide variance as to how much a specific network can cope with.

Although the study found that the overvoltage, in most cases, would not be much higher than the statutory limit, New Zealand already operates close to its statutory voltage limit to allow for voltage drop across the network. Accordingly, network managers need to work on specific rather than average risk. This unknown variance is where LV monitoring can help to avoid unanticipated performance issues and, potentially, safety issues, given that consumer equipment is only required to operate correctly within statutory voltage.

Other countries are investing in monitoring to manage these risks

There are numerous examples of distribution businesses in other countries investing in the remote monitoring their LV network. This investment typically involves a degree of catch up, in response to performance issues resulting from the higher penetration of DER. This has occurred in territories that have subsidised the uptake of solar energy and encountered performance issues (e.g. California, New York, the United Kingdom, Germany and Spain).

Various strategies and technical specifications are being explored and adopted, based on the outcomes of trials of different monitoring equipment and data management systems. Approaches vary, with most EDBs initially using off-the-shelf systems offered by a range of commercial providers. There are also several projects developing customised solutions to drive down the per-unit monitoring device costs. It can be expected that these costs will continue to reduce as the scale of uptake increases.

New Zealand is therefore in a position to learn from overseas territories that have implemented LV network monitoring, as part of a strategy to "get ahead of the curve". This means New Zealand can take a considered approach to monitoring before DER penetration becomes a network problem. However, it is plausible that large scale take-up of DER could occur by the mid-2020s.

Cost recovery for LV monitoring is excluded from the regulated price

An inability to financially recoup the cost of investment in the context of a regulated price has constrained many EDBs from investing in LV monitoring technologies. The Commerce Commission sets a default price-quality path (DPP) for EDBs, which is intended to influence business behaviour by setting the maximum average price or total allowable revenue that the businesses can charge. The Commission also sets standards for the quality of services to ensure that businesses do not have incentives to reduce quality to maximise profits under their price-quality path.[2]

The third DPP (DPP3) for EDBs was set in November 2019 and applies for the period 1 April 2020 to 31 March 2025. In their submissions, the ENA and some EDBs argued for a step change in operating expenses for LV network monitoring costs. The Commission decided that the step change criteria were not satisfied, citing a lack of evidence:

- that the cost was significant
- to robustly verify the cost
- that the cost was applicable to most distributors.

The Commission stated that if changes in regulations require LV monitoring (or the acquisition of smart meter data), then the DPP could be re-opened in those circumstances (Commerce Commission, 2020). The Commission also noted that if the methods or technologies are innovative, the expenditure "is likely" to qualify as part of the innovation allowance recoverable cost. That option may allow for some partial cost recovery, on the basis of trialling innovation (see Financial Case for the criteria for recoverable costs of innovation).

[2] https://comcom.govt.nz/regulated-industries/electricity-lines/electricity-lines-price-quality-paths/electricity-lines-default-price-quality-path

1.2 A presenting problem with three elements

Figure 1 presents a distillation of the presenting issues into a problem definition with three parts. Firstly, in the absence of systematic and real time information from network monitoring, investment decisions to maintain or expand LV networks may suboptimal, for example, the investment of capital may be earlier than necessary or too late to prevent impaired performance. While this is a particular risk for EDBs with an expanding consumer base, all EDBs are exposed to changing consumption patterns as New Zealand's decarbonisation aspirations will mean increased electrification. Overall load growth of 70 per cent by 2050 has been forecast, arising from the conversion of transport and process heat to electricity (Transpower New Zealand Ltd, 2020, p. 23).

Secondly, the uptake of DER across LV networks, including high load and injecting technologies, is largely unmonitored and so the risk of consequent network disruptions is not presently well understood, nor are DER injections being actively managed.

Thirdly, investment in the remote monitoring of LV networks is inhibited as EDBs are not able to recover the cost of their investment under the regulated price path, other than, potentially and only partially, for trialling monitoring systems as an innovation.

As a result, there has been continued underinvestment in the monitoring of LV networks. The risks of poor outcomes from this underinvestment are increasing, namely:

- the suboptimal allocation of capital in LV network maintenance and expansion programmes
- unanticipated disruptions to LV networks from increased DER penetration (i.e. power outages or poor-quality power supply), and
- the uptake of DER technologies potentially being restricted by EDBs, counter to consumer preferences, as a blunt but necessary risk management strategy for their LV network; or else expensive upgrades in the LV network that is charged to consumers.

Figure 1: Drivers of the investment proposal – distillation of presenting problems

In the absence of systematic and real time information from monitoring, LV network maintenance and expansion decisions may suboptimal (i.e. investing earlier than needed or too late to prevent impaired performance).

The unmonitored uptake of DER across LV networks, including high load and injecting technologies, is creating a growing risk of network disruptions (outages, poor quality supply).

Investment in LV network monitoring is inhibited as EDBs are not able to recover the cost under the regulated price path, other than, potentially and only partially, for trialling innovation.

Source: Sapere

1.3 Investment objectives

An investment objective is the outcome sought from the proposed investment, based on the gap between the current state and the current and future business needs. Three investments objectives have been identified for investment in LV networks.

1. To enable electricity distribution businesses to make better asset management decisions with respect to the LV network in the context of changing demand patterns.
2. To enable consumer preferences for the uptake of distributed energy resources as part of decarbonisation, while maintaining current reliability.
3. To make the case for network monitoring costs being included in the regulated price path so that EDBs can invest in monitoring on a business-as-usual basis.

Table 1 summarises how these objectives are grounded in a gap analysis between the current state and the current and future business needs.

Table 1: Investment Objectives, summary of the existing arrangements and business needs

Objective 1: To enable electricity distribution businesses to make better investment decisions with respect to the LV network in the context of changing demand patterns.	
Existing arrangements	There is little or no monitoring of LV networks and so investment decisions to maintain or expand may suboptimal, i.e. earlier than necessary or too late to prevent impaired performance. This is a risk for EDBs with an expanding consumer base, while all EDBs are exposed to changing consumption patterns, as New Zealand's decarbonisation aspirations will mean a material increase in electrification and in the demand for electricity.
Business needs	To obtain information about current network performance to optimise investment decisions about asset maintenance and network expansion. That is, capital is efficiently allocated to where it is needed most, geographically and temporally, on the basis of robust evidence.
Objective 2: To enable consumer preferences for the uptake of distributed energy resources as part of decarbonisation, while maintaining current reliability.	
Existing arrangements	The lack of monitoring means that consumer preferences for the use of DER across LV networks, including high load and injecting technologies, are largely unknown. The consequent risks of network disruptions, such as outages or poor quality supply, are not well understood nor DER injections actively managed. This risk will increase with the uptake of DER by consumers, the speed of which is unknown. In response, EDBs may be forced to restrict the use of DER to manage unforeseeable performance and safety problems for the network; or else expensive upgrades in the LV network that is on-charged to consumers.
Business needs	EDBs need to be prepared by having sufficient network monitoring in place, before DER-related performance issues occur. The resulting information needs to inform investment decisions so that: (a) network disruptions from

	increased DER penetration can be avoided; (b) consumer preferences for DER can be realised rather than constrained by the network; and (c) that the information is available so that DER injections can be coordinated.

Objective 3: To make the case for network monitoring costs being included in the regulated price path so that EDBs can invest in monitoring on a business-as usual basis.

Existing arrangements	The regulatory regime has constrained EDBs from investing in monitoring technologies. Investment in LV network monitoring is inhibited as EDBs are not able to recover that cost under the regulated price path, other than, potentially and only partially, for the trialling of innovation. This situation is contributing to the uptake of DER across LV networks being unmonitored, so that the risk of consequent network disruptions is neither well understood nor being actively managed.
Business needs	The investment in network monitoring should make the case for the costs being recoverable through inclusion in the regulated price. That is, providing evidence that the monitoring of LV networks in New Zealand is an essential part of business as usual, particularly with the increased uptake of DER, with key benefits being improved use of capital and better services for customers (i.e. improving network reliability and a reducing in safety risks). In line with criteria identified by the Commerce Commission, that evidence needs to show that the costs are both material and verifiable as well as being widespread across the LV network. Uncertainty over the rate of growth in DER will remain; but EDBs will be better placed to monitor and to plan for that growth than would otherwise be the case.

1.4 Expected benefits from investment

Investment in LV monitoring can be expected to provide more, and better quality, information about the LV network, including a topology of the LV network assets (including substations), identification of existing performance issues, and picture of the current take up of DER. That information would allow for the diagnosis of issues as they emerge and would also inform decisions about where and when to replace or expand a network. In turn, EDBs would make better use of capital, improve performance by reducing outages, reduce risks to safety and to allow consumer preferences for the use of DER to be realised. Consumers directly benefit from improved network performance and from their preferences for the use of DER to be realised rather than constrained. These benefits can be categorised as follows.

1. **Improved network performance** – customer service is improved, with fewer outages than otherwise resulting in a more stable supply, as for example, measured using SAIDI and SAIFI metrics for outages.[3] The amount of lost load from outages would also be reduced. There may

[3] System Average Interruption Duration Index and System Average Interruption Frequency Index – these are not currently measured for the LV network but could be with LV monitoring

also be an assumption from customers that EDBs already have remote monitoring visibility of their networks at all voltage levels, and so deployment would fulfil those expectations.

2. **Better data to measure outages** – monitoring LV networks would provide more comprehensive and real time data on the frequency and duration of network outages.
3. **More efficient allocation of resources** – arising from better information about the topology of the network, performance and risks. Investment in LV networks could be prioritised to where it is most needed, and replacement or expansion decisions may be deferred or brought forward. There is the potential for long-run costs to be lower than otherwise, particularly given investment needs in response to electrification arising from decarbonisation.
4. **Reduced risks to safety** – monitoring brings the ability to identify hazards. LV monitoring enables a shift to a safety-by-design approach, meaning EDBs can proactively detect deteriorating and broken neutral connections. Experience in Victoria has shown that near real-time LV monitoring has the capability to substantially lower safety risks to customers by detecting and alarming for neutral integrity failures before they cause customer shocks (Mohammadi & Mehraeen, 2017) (Energy Queensland, 2019).
5. **Consumer preferences realised** – the uptake of DER on the LV network can be realised in line with consumer preferences for use, rather than being restricted by EDBs as a way to manage unforeseeable performance and safety problems for the network; an alternative may for expensive upgrades to the LV network that end up being on-charged to consumers.

Figure 2: Summary of main benefits expected

Improved network performance	• Fewer outages means better customer service • Improved customer confidence • Fewer outages means reductions in lost load
Better data to measure outages	• Comprehensive and real time data on the frequency and duration of outages
More efficient resource allocation	• Building up a model of LV topology and issues • Invesment may be deferred or brought forward • Long-run costs may be lower than otherwise
Reduced risks to safety	• Proactive identification of potential hazards (e.g. detect deteriorating or broken neutral connections)
Consumer preferences realised	• The uptake of DER on the LV network can be realised in line with consumer preferences for use

Source: Sapere

1.5 Risks of investing in low voltage monitoring

A decision to invest in monitoring technologies for the LV network monitoring is not without risk. The following risks have been identified.

1. **Over-investment** – the scale of investment in LV monitoring devices does not prove to be warranted by the issues uncovered.
2. **Loss of flexibility** – the risk of making the wrong choice of monitoring technology in a rapidly changing environment so that options to change or scale up are closed off.
3. **Unable to recover costs** – EDBs are unable to recover the cost of investment into monitoring technology in the medium term (i.e. 5+ years), which would inhibit further investment.
4. **Unknown issues are uncovered** – problems which then need a diagnosis and response.

Table 2 assesses the likelihood and consequence of these risks and suggests a mitigation approach.

Table 2: Assessment of risks and possible mitigation approaches

Risk	Likelihood assessment	Consequence assessment	Comment and risk management
1. **Over-investment – investment in LV monitoring devices does not prove to be warranted by the issues uncovered.**	Low	Low	Obtaining baseline knowledge about the current state of the LV network would be valuable in itself, as would knowing that there is not significant take up of DER. A small-scale deployment can be leveraged to the wider network (i.e. rotated; or sampling to inform extrapolation).
2. **Loss of flexibility – an initial investment closes off options to change or scale up monitoring technology as more information becomes known.**	Low	Low	The trend is towards SaaS and cloud storage. A graduated approach with initial investment into an open software platform operating on off-the-shelf commodity hardware.
3. **Unable to recover costs – the inability to recover costs in the medium term (i.e. 5+ years) prevents a shift from innovation to business as usual operations.**	Medium	High	This would inhibit deployment of monitoring technologies. This risk can be mitigated by preparing a compelling business case for LV monitoring as part of EDB core business.
4. **Unknown issues uncovered – problems which then need to be diagnosed and responded to.**	Medium	Low	A benefit as unknown issues would need to be addressed eventually. A way of mitigating the risk would be to include diagnostic capability in the LV monitoring equipment.

Source: Sapere assessment

2. The Economic Case – options assessment

The Economic Case considers the options for investment into LV monitoring at a system level and identifies a preferred way forward on the basis of fulfilling the investment objectives and critical success factors. The potential costs and benefits are also identified and estimated.

2.1 Critical success factors

Critical success factors are the attributes essential to success of the investment. The following factors have been identified as essential for investment into monitoring technologies for LV networks.

1. **Flexibility** – the option maintains some optionality to change or scale up technology as more information becomes known. As experience with monitoring is limited in the New Zealand context, monitoring regimes will need to evolve as better information becomes available.
2. **Affordability** – the cost of the investment in monitoring solutions for LV networks needs to be affordable at the level of individual EDBs. The issues of likely costs, funding and affordability are outlined in the Financial Case.
3. **Cooperation** – the option allows for EBDs to cooperate in implementing LV monitoring and in the collation of a widespread evidence base on the benefits to the business and to consumers. This will be essential to inform future investment and to make the case for the costs being included in the regulated price path. The issue is outlined in the Management Case.

These critical success factors are used, along with the investment objectives, to assess a short list of potential options and to identify a preferred option or way forward.

2.2 Functionality of monitoring solutions

For any monitoring solution, there are three technological components that need consideration.

- **Monitoring** – how the low voltage network is monitored. This includes scale, such as the number of monitoring devices deployed (and how they might be leveraged through rotation) and the scope of the data collected and how frequently it is collected.
- **Data management** – how the monitoring data is received, stored and processed. Communication is also an important element too; all of the monitoring technology can interface with existing communications systems.
- **Analytics** – how the monitoring data is used to inform decision making.

Figure 3 illustrates these components by level of functionality. A lower level of functionality is likely to come at a lower cost but has drawbacks in the scope of data that is captured and the inability to automatically diagnose all issues that are identified. These drawbacks may be significant, given the lack of information about the history, loads and performance issues of LV networks. Conversely, a higher level of functionality comes with a higher cost. However, highly sophisticated solutions that are customised in nature may more complex than necessary in terms of data management; an "off-the-shelf" complete package with cloud-based storage may be more suitable.

Figure 3: Components of monitoring by level of functionality

	Less sophisticated		More sophisticated
Analytics	• Manual analysis on ad hoc basis	• Regular analysis • LV network models • Some advanced analytics	• Advanced analytics • Accurate LV topology • Predictive AI
Data management	• Device feeds • Manual data aggregation	• Database for storage • Data processing overlay	• Database built to be integrated with devices • Faster processing
Monitoring	• Devices rotated • Few in number • Limited scope of data, collected periodically • Lagged data flow	• Devices permanent • Higher numbers • Faster data flow • More data collected more frequently	• Devices permanent • Higher numbers • Wide scope of data, allowing for diagnosis • Real time data flow

Source: Sapere

2.3 Short list options assessment

Four options for system-level investment in LV monitoring are constructed using the dimensions of **scale** (small versus large scale deployment of monitoring units) and **functionality** (low versus high specification technology). These are generic options that may be plausible for some EDBs, while recognising they may not be optimal for all EDBs, given differences in the attributes and scale of their networks and their starting points (i.e. some EDBs have trialled monitoring on their LV network).

1. **Small scale, low spec** – deployment of monitoring devices at small scale (i.e. approximately 1 per cent of transformers on the LV network) and with relatively low functionality (in terms of the scope and frequency of the data collection and diagnostic capability).
2. **Small scale, high spec** – deployment of monitoring devices at small scale (as above) with relatively high functionality (in terms of the scope and frequency of the data collection and diagnostic capability).
3. **Large scale, low spec** – deployment of monitoring devices at larger scale (i.e. approximately 10 per cent of transformers on the LV network) and with relatively low functionality (in terms of the scope and frequency of the data collection and diagnostic capability).
4. **Large scale, high spec** – deployment of monitoring devices at larger scale (as above) and with relatively high functionality (in terms of the scope and frequency of the data collection and diagnostic capability).

These options are assessed against the investment objectives and the critical success factors to identify a preferred option to carry forward for economic analysis, in the form of a cost benefit analysis. Table 3 summarises the options assessment.

Option 2 (**small scale, high spec**) is carried forward, as it is most likely to capture the right data at the right time (so that performance and safety issues can be identified), to be affordable, and to provide demonstrable benefits to the business and its customers. Options 1, 3 and 4 are not carried forward on the basis of being likely to fail to meet one or more of the investment objectives and critical success factors

Table 3: Options assessment

	Option 1 (Small scale, low spec)	**Option 2 (Small scale, high spec)**	**Option 3 (Large scale, low spec)**	**Option 4 (Large scale, high spec)**
Investment objective 1: To enable electricity distribution businesses to make better investment decisions with respect to the LV network in the context of changing demand patterns.	**Meets** Functionality is sufficient to identify most issues.	**Meets +** Functionality is sufficient to identify and diagnose all issues.	**Meet** Functionality is sufficient to identify most issues.	**Meets+** Functionality is sufficient to identify and diagnose all issues.
Investment objective 2: To enable consumer preferences for the uptake of distributed energy resources as part of decarbonisation, while maintaining current reliability.	**Does not meet** Functionality insufficient to respond to high DER uptake	**Meets** Functionality is sufficient to manage high DER uptake	**Does not meet** Functionality insufficient to respond to high DER uptake	**Meets** Functionality insufficient to respond to high DER uptake
Investment objective 3: To make the case for network monitoring costs being included in the regulated price path so that EDBs can invest in monitoring on a business-as usual basis.	**Uncertain** Depends on management	**Uncertain** Depends on management	**Uncertain** Depends on management	**Uncertain** Depends on management
Critical success factor 1: Maintains flexibility to adapt, so that lessons can be factored in over time.	**Meets** Small scale maximised flexibility	**Meets** Small scale maximised flexibility	**Does not meet** Less likely, for larger scale investment	**Does not meet** Less likely, for larger scale investment
Critical success factor 2: Affordable for EBDs in absence of ability to recover costs.	**Meets** More likely to be affordable in the short term	**Meets** More likely to be affordable in the short term	**Does not meet** Affordability is uncertain	**Does not meet** Affordability is uncertain
Critical success factor 3: Enables cooperation to collate evidence of widespread benefits.	**Uncertain** Depends on management	**Uncertain** Depends on management	**Uncertain** Depends on management	**Uncertain** Depends on management
Result	**Not carried forward**	**Carry forward**	**Not carried forward** Possible long-term outcome	**Not carried forward** Possible long-term outcome

Source: Sapere analysis

2.4 Economic assessment

This section presents the results of a cost benefit analysis of the deployment of LV monitoring technology at a system level. The purpose is to determine whether the deployment of monitoring technology on LV networks would offer a credible net benefit at a system level. A small-scale trial scenario is considered, and for comparative purposes, expansion and complete deployment scenarios. In each scenario, the costs and benefits are considered over a timeframe of ten years, with the results being presented on a net present value basis (using discount rate of 6 per cent).

The cost estimates are derived from a detailed cost model, outlined in the Financial Case. The exercise shows the scale of potential costs at the level of the system and individual EDBs. With respect to the benefits, the approach has been to start with the benefits identified in the Strategic Case and then to consider evidence and experience internationally. The concepts are applied to a New Zealand setting using available relevant data, while making conservative assumptions about what would be achieved.

Three deployment scenarios are modelled

Three system-level scenarios have been developed for analysis. The scenarios graduate from a trial to an expansion to the complete deployment of monitoring technology on LV networks.

- **Trial scenario** – under which monitoring units are deployed on 1 per cent of transformers on the LV network of each EDB. The assumption is one unit per transformer, with the rationale being that the data obtained from one feeder on that transformer would provide a representative view of the state of all of the feeders connected to that transformer.
- **Expansion scenario** – in which monitoring units are deployed on 10 per cent of transformers on the LV network of each EDB. The rationale is that, building on the data and knowledge obtained from the trial, a targeted approach to expanding deployment would focus on the transformers that would be most likely to benefit from monitoring.
- **Complete scenario** – monitoring units are deployed on 100 per cent of transformers. This scenario has been developed for comparative purposes, to show what the maximum cost could be, at the level of the system and for individual EDBs. Such a roll out would only be considered after extensive experience with the monitoring technology and data obtained under the expansion scenario or if widespread coordination of DER injection was required.

Estimating the costs

The cost estimates are based on the deployment assumption (i.e. 1, 10 or 100 per cent) and the number of transformers at each EDB. The costs comprise a one-off cost per unit and an annual cost per unit. Under a **standard cost** assumption, each EDB is assumed to procure individually, with larger EDBs (those assumed to purchase >1,000 units) gaining a lower price than smaller EDBs due to scale economies. Under a **pooled cost** assumption, all EDBs are assumed to collaborate to maximise scale efficiencies in the procurement and management of the monitoring units. This means that the system would procure at the lowest price (i.e. conservatively, the unit price modelled for the >1,000 volume).

Table 4 presents cost estimates at different deployment rates, using data from international (Int) and New Zealand (NZ) sources.

Table 4: Estimated monitoring costs over ten years by deployment scenario and source

$ million (NPV) EDB	Trial scenario (1%) Int	Trial scenario (1%) NZ	Expansion scenario (10%) Int	Expansion scenario (10%) NZ	Complete scenario (100%) Int	Complete scenario (100%) NZ
Alpine Energy	3.9	2.1	12.3	7.9	54.2	50.6
Aurora Energy	4.7	2.5	14.6	9.4	64.3	60.1
Buller Electricity	0.5	0.3	4.9	2.2	16.4	10.6
Centralines	1.5	0.8	4.8	3.1	21.2	19.9
Counties Power	2.7	1.4	8.3	5.3	36.6	34.2
EA Networks	4.8	2.5	15.0	9.6	65.8	61.4
Eastland Network	2.4	1.3	7.4	4.8	32.6	30.4
Electra	1.7	0.9	5.3	3.4	23.2	21.7
Electricity Invercargill	0.3	0.2	2.7	1.2	9.0	5.8
Horizon Energy	2.2	1.2	6.9	4.4	30.1	28.1
MainPower NZ	5.5	2.9	17.1	11.0	75.0	70.0
Marlborough Lines	2.6	1.4	8.3	5.3	36.3	34.0
Nelson Electricity	0.1	0.1	1.3	0.6	4.2	2.7
Network Tasman	3.0	1.6	9.4	6.0	41.2	38.5
Network Waitaki	1.9	1.0	6.0	3.9	26.4	24.6
Northpower	4.5	2.0	15.0	9.5	66.8	62.4
Orion NZ	2.8	2.2	10.6	9.9	106.1	99.1
OtagoNet	2.9	1.5	9.0	5.8	39.4	36.8
Powerco	8.7	6.8	32.4	30.3	324.1	302.8
Scanpower	1.0	0.5	3.0	1.9	13.2	12.3
The Lines Company	3.6	1.9	11.3	7.3	49.7	46.4
The Power Company	2.7	2.1	10.1	9.5	101.5	94.8
Top Energy	3.9	2.1	12.3	7.9	54.2	50.6
Unison Networks	6.6	3.5	20.5	13.1	89.9	84.0
Vector Lines	5.3	4.2	19.9	18.6	199.1	186.0
Waipa Networks	2.3	1.2	7.3	4.7	32.1	30.0
WEL Networks	4.1	2.2	12.7	8.2	56.0	52.3
Wellington Electricity	2.9	1.5	9.0	5.8	39.5	36.9
Westpower	1.7	0.9	5.2	3.3	22.7	21.2
Total cost (standard)	**90.9**	**52.8**	**302.6**	**213.8**	**1,730.7**	**1,608.3**
Total cost (pooled)	**45.9**	**36.1**	**171.4**	**160.1**	**1,714.2**	**1,601.4**
Savings from	45.0	16.7	131.2	53.7	16.5	6.9

Note: values are $ million, on a Net Present Value (NPV) basis over 10 years at a 6% discount rate

Source: Sapere analysis

Estimating the benefits

Four categories of benefit have been assessed: the value of lost load avoided; asset replacement and renewal savings; system growth saving; DER optimisation benefits increase with projected uptake. The potential safety benefits were considered for inclusion. While monitoring of the LV network is likely to bring about safety benefits, it is difficult to estimate these from available data. Ongoing trials are expected to provide new information about the safety benefits that are achievable.

Value of lost load avoided

LV monitoring is expected to reduce the value of lost load. The assumption is that monitoring could reduce 'cause unknown' outages by 50 per cent, and 'defective equipment' and 'vegetation' outages by 10 per cent. The logic of a reduction factor of 50 per cent for 'cause unknown' is that being able to identify causes will mean faults are resolved more quickly and result in repairs that prevent recurrence.

The benefit is estimated using a value of $20,000 per MWh and reported SAIDI levels in 2019 (a proxy, as SAIDI figures do not cover the LV network). The benefit is allocated evenly across EDBs based on the number of transformers. The assumption is that 10 per cent of the potential benefit is achieved in the trial scenario (1 per cent of transformers), rising to 100 per cent in the expansion scenario.

Asset replacement and renewal savings

The rationale is that, with information about the topology of the network, performance and risks, investment will be prioritised to where it is most needed, and replacement or expansion decisions may be deferred or brought forward. There is the potential for long-run costs to be lower than otherwise.

To estimate the potential scale of this benefit, data on capital expenditure has been extracted from reported EDB Asset Management Plans for 2019. In the trial scenario, the approach is to conservatively assume 1 per cent saving per annum on asset replacement and renewal. With further deployment of monitoring equipment, this is increased to 10 per cent per annum.

System growth savings

In the absence of LV monitoring, assumptions need to be made about the required capacity of the network to supply consumer premises. These assumptions relate to the consumption at premises, the occasional peak needs (for which the network must be sized), the reactive power (a non-productive use of capacity that is created by some loads), the load diversity (how likely it is for loads to peak at the same time), and how well the loading on transformers and circuits is balanced across the three phases (unbalanced loads mean that capacity must be sized for the largest phase loading).

In the absence of measured data, network engineers must make prudent estimates of the demand requirements of consumers. Generally, the cost of outages on consumers and the cost of in-service failures is much higher than the cost of some extra capacity. Therefore, prudent estimates deliberately over-estimate capacity by a sensible safety margin. With monitoring transformers in place, circuits can be sized more closely with less of a safety margin.

The approach here is to translate the savings identified in SP Energy Networks (2015), of 39 kVA per transformer, to the New Zealand context. This was done by pro-rating the saving per transformer based on the average size of SP Energy Networks' distribution transformers compared to all of New Zealand's EDB's transformers. This produced a saving of 9.5 kVA per transformer or a total of 1.8 million kVA and saving of 8 per cent on 2019 forecast expenditure of $153 million. This translates to $12 million per year. This amount is spread evenly across the EDBs based on the number of transformers; all this benefit is assumed to be potentially achievable even with monitoring of just 1 per cent of transformers on a rotating monitoring basis.

Consumption patterns tend to be static over medium term timeframes and findings can be extrapolated to other circuits. This assumption holds, providing there are not significant dynamic loads such as from DER, and especially large heat pumps and/or EV battery chargers.

Optimisation benefits increase with projected uptake of DER

DER, either as significant loads, such as heat pumps or EV chargers, or generation such as PV solar and discharging batteries, is likely to bring significant volatility to consumption patterns on LV networks. At low levels of take up, the impact of large individual DER will still lead to more dynamic changes in consumption patterns than the current LV network is designed for. At higher levels of take up, the DER will increasingly need to be coordinated, in which case dynamic monitoring of LV networks will be essential. The more dynamic the monitoring needs, the more LV monitoring equipment will need to be deployed.

Current forecasts predict thousands of MWs of DER being deployed over the next five to 15 years in response to the decarbonisation of transport and process heat, and with DER becoming increasingly competitive over that period (Transpower New Zealand Ltd, 2020, p. 33), (Reeve, Comendant, & Stevenson, 2020, p. Exec Summ 19).

The approach here is to draw on work looking at DER incentives, information and coordination to estimate $1.8 million of potential benefits in year 1, rising to $14 million in year 5 and $83 million in year 10. This estimated benefit is spread evenly across EDBs, based on the number of transformers. It is assumed that 10 per cent of benefits are realised in trial scenario, 20 per cent in the expansion scenario, and 50 per cent in the complete scenario with monitoring on all LV transformers.

Summary of estimated benefits and assumptions

Figure 4 summarises the estimation results for each of these categories of benefit, for each of the three deployment scenarios.

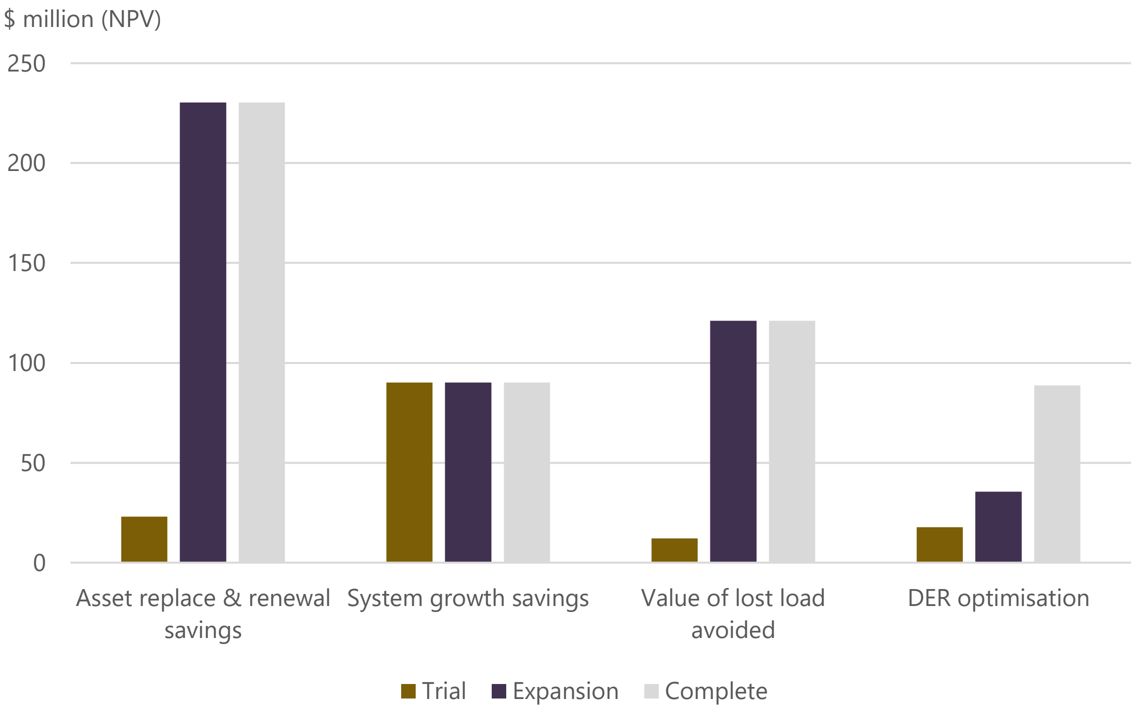
In the **trial scenario**, system growth savings are estimated to be the largest category of benefit ($90 million or 63 per cent of total benefits), followed by asset replacement and renewal savings ($23 million or 16 per cent), DER optimisation ($18 million or 12 per cent) and the value of lost load avoided ($12 million or 8 per cent).

In the **expansion scenario**, asset replacement and renewal savings are assumed to increase proportionately with the increased deployment of monitoring units and are estimated as the largest category of benefit ($230 million or 48 per cent of total benefits). Similarly, the value of lost load avoided ($121 million or 25 per cent) is also assumed to increase proportionately with the increased deployment. System growth savings remain unchanged ($90 million, now accounting for 16 per cent). The benefits from DER optimisation are assumed to double in size ($36 million or 7 per cent).

In the **complete scenario**, the estimated benefits in three categories of benefit are assumed to remain unchanged from the expansion scenario: asset replacement and renewal savings, system growth savings, and the value of lost load avoided. The rationale is that the pattern of normal demand changes relatively slowly and less dynamic monitoring (i.e. less monitoring on average) can generally achieve most of the benefits. Findings from monitoring can also be extrapolated to the rest of the LV network. This is a conservative assumption.

Conversely, the benefits from DER optimisation are estimated to increase in this scenario ($89 million or 17 per cent). This is because, at the levels of DER that is forecasted with decarbonisation, changes in consumption patterns become more dynamic and require more LV monitoring to manage and coordinate the LV network.

Figure 4: Estimated benefits over ten years by benefit category and deployment scenario



Source: Sapere analysis

Results – trialling and expansion scenarios offer net benefit

The results of this cost benefit analysis are reported in Table 5. All monetary figures are on a net present value basis. The **trial scenario** has a net benefit ranging from $52 to $90 million and a benefit-cost ratio ranging from 1.6 to 2.7, depending on the source of cost data. The **expansion scenario** has a higher net benefit, ranging from $174 to $263 million with a benefit-cost ratio ranging from 1.6 to 2.2. In each scenario, the cost data from New Zealand (specifically, the annual costs) is lower than that from international sources and so gives rise to the higher value in the ranges reported.

These results are improved under the pooled cost assumption, in which EDBs are assumed to collaborate to maximise scale efficiencies in the procurement and management of the monitoring units. The resulting lower costs mean that the net benefit range improves to $97-106 million in the trial scenario and to $306-317 million in the expansion scenario. The benefit-cost ratio range improves to 3.1-4.0 in the trial scenario and to 2.8-3.0 in the expansion scenario.

In the **complete scenario**, the benefits do not outweigh the costs in the ten-year timeframe examined here. Under the standard cost assumption, the net benefit is over -$1 billion for both sets of costs and the benefit-cost ratio is 0.3. This means that the benefits equate to 30 per cent of the costs, on a net present value basis. The pooled cost assumption does not materially improve this result because, owing to the large scale roll-out in each EDB, most are assumed to already obtain scale economies individually in this scenario.

Table 5: Summary of cost benefit analysis, by scenario

Scenario component	Trial scenario (1%) Int	Trial scenario (1%) NZ	Expansion scenario (10%) Int	Expansion scenario (10%) NZ	Complete scenario (100%) Int	Complete scenario (100%) NZ
Standard cost assumption						
Costs ($m NPV)	91	53	303	214	1,731	1,608
Benefits ($m NPV)	143	143	477	477	530	530
Net benefit ($m NPV)	52	90	174	263	-1,201	-1,078
Benefit-cost ratio	1.6	2.7	1.6	2.2	0.3	0.3
Pooled (low) cost assumption						
Costs ($m NPV)	46	36	171	160	1,714	1,601
Benefits ($m NPV)	143	143	477	477	530	530
Net benefit ($m NPV)	97	106	306	317	-1,184	-1,071
Benefit-cost ratio	3.1	4.0	2.8	3.0	0.3	0.3

Notes: costs and benefits modelled over 10 years using a discount rate of 6%

Source: Sapere

2.5 Conclusions

The following conclusions can be drawn from the results of the cost benefit analysis.

- The deployment of monitoring technology on LV networks is likely to deliver a net benefit, at a system level, under the trial scenario (deployment on 1 per cent of transformers) and under the expansion scenario (10 per cent of transformers). Under the assumption that the expansion scenario would follow a trial scenario, then the ability to incorporate lessons and to target transformer and circuit types would increase the certainty of a net benefit being obtained.
- The prospects of scale efficiencies through collaborative procurement and management of monitoring units could materially reduce the costs, thereby increasing the net benefit to the system and to individual EDBs.
- The results of the complete deployment scenario suggest that a full roll out of monitoring units to every transformer may be uneconomic. However, this is the scenario with the highest uncertainty; partly because a full roll-out has not been implemented anywhere to date. It is possible that there would be wider benefits that are not factored into this analysis, especially if widespread DER injection needs to be coordinated.

There are several points to be kept in mind, with respect to these conclusions. Firstly, the cost benefit analysis is from a societal perspective. This means that not all of the economic benefits accrue directly to EDBs; consumers using DER will benefit from that use, but EDBs will receive no quantifiable reward for increasing the capacity of the LV network to host DER. In fact, the price/quality regulated price regime assumes that, subject to investment being linked to the maintenance of quality, consumers benefit from increased regulated asset base. Neither the LV network nor the regulatory framework were built in anticipation of consumers being able to self-supply energy, capacity, and power quality in significant volume.

Secondly, the costs estimated here may be higher than will be the case over the next couple of years; the trend has been that unit costs are decreasing and this trend is expected to continue.

Thirdly, the benefits could be higher than estimated here; one reason is that in the absence of widespread monitoring, the scale and types of issues to be uncovered in LV networks are simply not known at this point.

Finally, there is the issue of affordability; the costs (one-off and annual), even in the trial scenario, are likely to be seen as material at the level of individual EDB, particularly in the absence of certainty that any costs can be recovered. The options for funding these costs are considered in the Financial Case.

3. The Financial Case – costings and funding

The Financial Case outlines the details behind the costings. It also considers the funding implications.

3.1 Approach to estimating costs

The approach has been to identify and analyse publicly available information on the cost of deploying monitoring technology on LV networks in other countries, notably, in the United Kingdom and Australia. This information is supplemented with the costs obtained from two trials in New Zealand.

Cost per unit is expected to continue to reduce in the near term

There is evidence of significant unit cost savings being obtained from deployment on a larger scale. In addition, as with many technologies, the overall costs are reducing, even as capabilities increase. Data management and modelling costs also appear to be falling, possibly due to the rise of integrated cloud-based solutions. Accordingly, the most recent monitoring projects have much lower costs than those from five or more years ago. There are also several international research projects, involving industry and academia, that are aiming to further reduce unit costs to enable widespread adoption.

The following generalisations can be drawn from available information on the cost of applying monitoring technologies to LV networks.

- Early trials involving a small number of units (<100) reported costs in magnitude of $10,000 per monitoring location.
- More recent experience, involving the scaling up of trialling, has seen the costs reduce to the range of $2,000 to $5,000 per location. Two EDBs in New Zealand reported costs for monitoring devices ($4,500) that lie near the upper end of this range.
- Research projects have been funded with the goal of bringing down the cost of units and installation to the range of $200 to $500 per location.

Deriving cost estimates based on the scale of deployment

Two sets of cost estimates have been prepared, each differentiated by the scale of deployment. The first set is derived from the most recently reported examples from the United Kingdom and Australia, using detailed cost categories where available (converted to NZD). A second set of estimates adjusts the international costs to include recent cost information obtained from two trials in New Zealand.

Table 6 presents the cost estimates based on the information sourced from international examples. The results are presented for three deployment scenarios, in New Zealand dollars (nominal basis).

- **Small scale**, defined as less than 100 units, has a one-off per-unit cost of $5,100 and an annual per unit cost of $5,700.
- **Medium scale**, defined as between 100 and 1,000 units, one-off per-unit cost of $3,500 and an annual per unit cost of $1,700.
- **Large scale**, defined as more than 1,000 units, one-off per-unit cost of $2,400 and an annual per unit cost of $700.

These results are high level in nature and insensitive to differences in installation location and device specification. Network specifics will impact installation, communication, and maintenance and it is likely that EDBs can access more accurate cost estimates from discussions with equipment suppliers.

In the absence of costs per unit for some cost categories at large scale (e.g. data management, project management), it has been necessary to assume a level of cost for those items. The approach has been to assume a reduction costs in moving from medium to large scale deployment, based on the proportionate reduction observed in moving from small to medium scale deployment.

Table 6: Estimate of costs by scale of deployment (international data)

Cost components	Description	Small scale	Medium scale	Large scale
Scale	Number of units	<100	<1,000 & >100	>1,000
One-off costs				
Site surveys	Assess sites for installation and data transmission	$309	$209	$109
Monitoring equipment	Unit cost (assume 10-year life)	$4,244	$2,926	$1,995
Installation	Install cost per unit	$500	$394	$303
Total one-off cost		**$5,053**	**$3,529**	**$2,407**
Annual costs				
Maintenance	Assume 1% of unit cost	$42	$29	$20
Communication*	Transfer of data from unit to database	$786	$437	$243
Data hub*	Database infrastructure	$2,894	$450	$70
Data quality*	Data management	$275	$73	$19
Project management*	Modelling and administration	$1,674	$728	$317
Total annual cost (nominal costs, NZ dollars)		**$5,671**	**$1,717**	**$669**

Note: * estimates for large scale have been derived, in absence of actual data, from the percentage change from small to medium scale, being applied to medium to obtain an estimate for large scale

Sources: (Evoenergy, 2018; Energy Queensland, 2019; SP Energy Networks, 2015; SA Power Networks, 2019)

Table 7 presents the cost estimates based on the information obtained from New Zealand trials. The main differences from the international examples are as follows.

- The one-off costs are higher, both for the monitoring equipment and the installation cost per unit. While there are cost savings on a per-unit basis from increasing scale of deployment, these savings occur at a lower rate than those seen in the international examples. These higher costs are only partly offset by the finding that site surveys have not been required in the New Zealand examples.
- The annual costs associated with data management are much lower than the international examples. The New Zealand trials have involved a lower technical specification than the international examples, and so this may be a factor in the annual costs being lower.

Table 7: Estimate of costs by scale of deployment (New Zealand data)

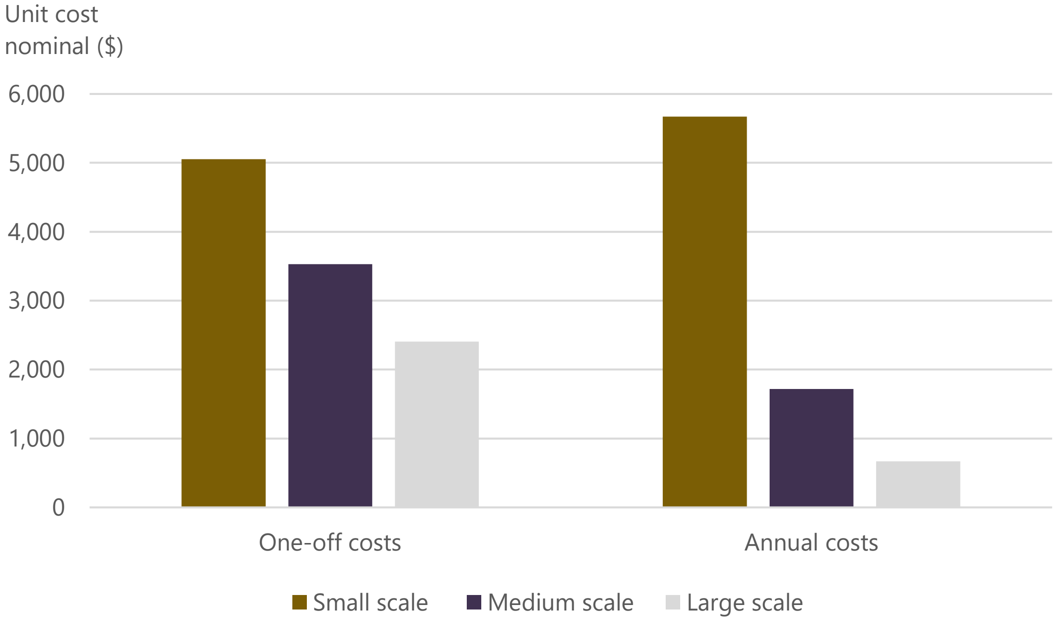
Cost components	Description	Small scale	Medium scale	Large scale
Scale	Number of units	<100	<1,000 & >100	>1,000
One-off costs				
Site surveys	Likely not required for most transformers	-	-	-
Monitoring equipment	Unit cost (assume 10-year life)	$4,500	$4,183	$3,844
Installation	Install cost per unit	$850	$650	$400
Total one-off cost		**$5,350**	**$4,833**	**$4,244**
Annual costs				
Maintenance	Assume 1% of unit cost, 10% for small scale deployment	450	42	38
Communication*	Transfer of data from unit to database	55	50	46
Data hub*	Database infrastructure	15	13	12
Data quality*	Data management	15	13	12
Project management*	Modelling and administration	1,674	728	317
Total annual cost (nominal costs, NZ dollars)		**$2,209**	**$846**	**$425**

Note: * estimates for data related costs are likely understated as these are based on trials with a lower technical specification and therefore involve lower volumes of data.

Sources: Sapere analysis of data provided from two trials In New Zealand, supplemented with data in Table 6

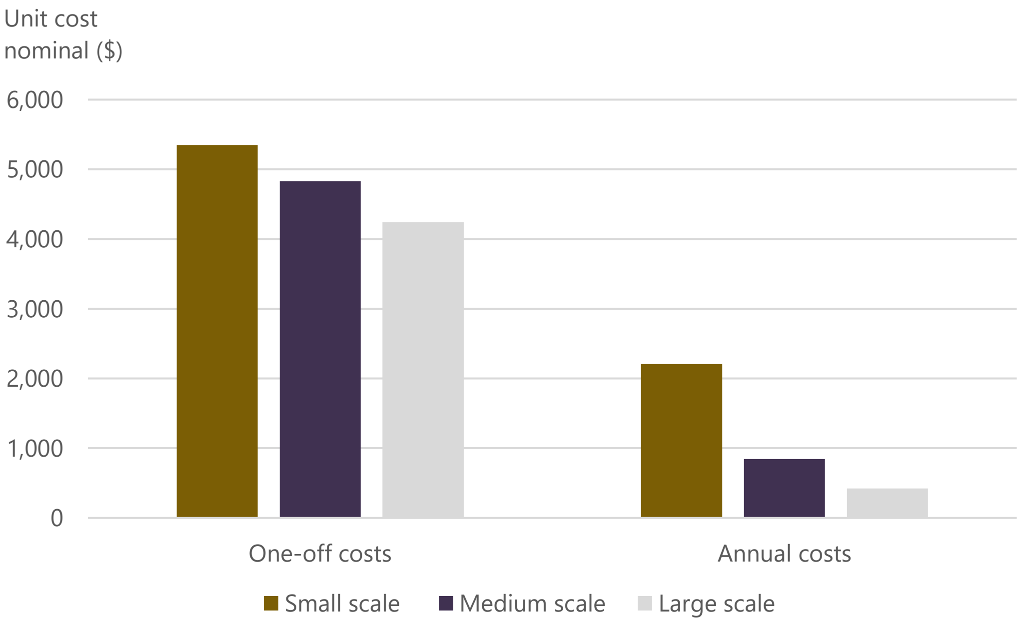
Figure 5 illustrates the per unit costs (one-off and annual) derived from the international examples, by scale of deployment. Figure 6 illustrates the equivalent results for the New Zealand cost data. In each case, the scale economies are apparent, particularly the reduction in total annual costs between small scale (100 units or less) and medium scale deployment (between 100 and 1,000 units).

Figure 5: One-off and annual costs by scale of deployment (international data)



Source: Sapere analysis

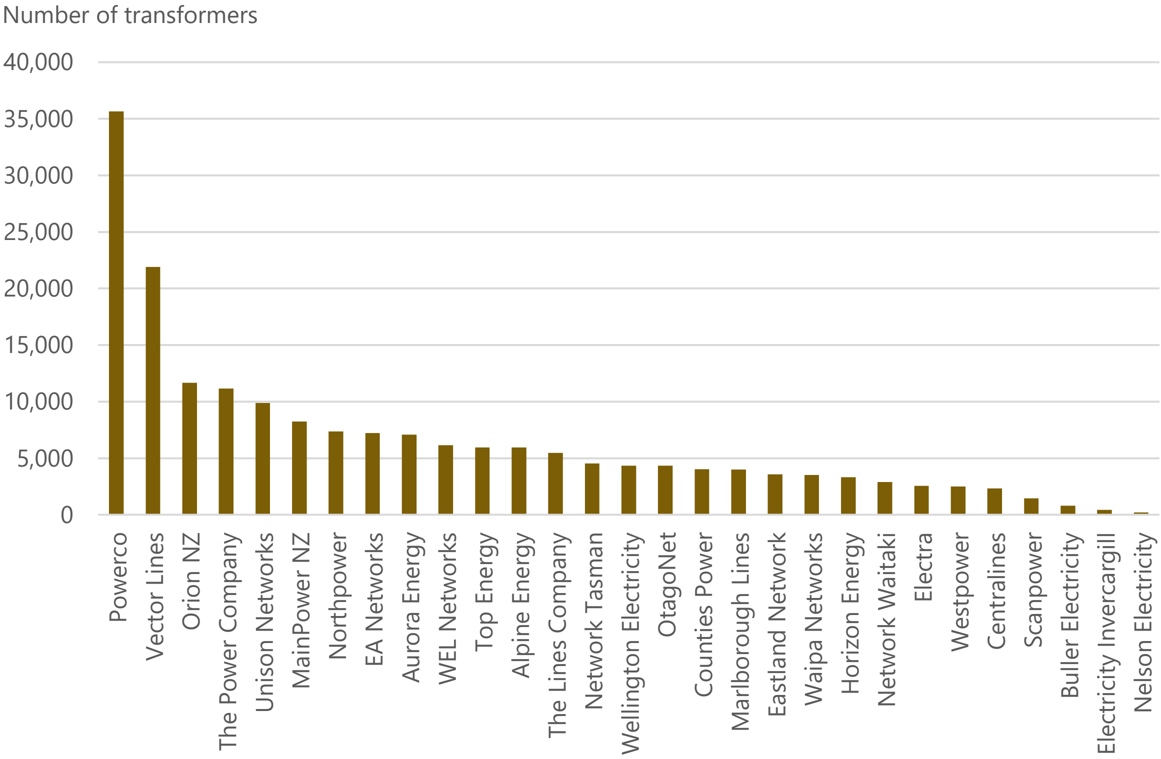
Figure 6: One-off and annual costs by scale of deployment (New Zealand data)



Source: Sapere analysis

The approach for the cost benefit analysis (see Economic Case) is to apply these detailed cost estimates to each EDB, according to the number of transformers at each EDB and the assumed scale of deployment (i.e. 1, 10 or 100 per cent). Figure 7 shows the number of transformers by EDB.

Figure 7: Number of transformers, by EDB



Source: Commerce Commission

3.2 Consideration of funding sources

This section considers the potential sources of funding in the short and medium term.

Short term – self-funding with partial recovery as innovation

In the short term, under DPP3, which applies to 31 March 2025, EDBs would have to incur the full cost of deploying monitoring technologies. There is the potential for up to half of this cost to be recovered later via the innovation fund. The Commerce Commission introduced this mechanism in DPP3 with the intention of creating incentives for innovation. A recoverable cost has been created for innovative projects, allowing for up to 50 per cent of the cost to be passed directly through in prices, separately from the price path limit.

To qualify, EDBs would need to commission a report from an independent specialist, ex ante, that the planned expenditure in LV network monitoring involves the application of new technology to deliver the electricity distribution service at a lower cost and/or at a higher level of quality. The Commission considers whether to approve the recoverable cost ex post; the recoverable amount is also limited to the higher of 0.1 per cent of forecast allowable revenue (excluding pass-through and recoverable costs) or $150,000. The text box below summarises the criteria for recovering costs through this route.

Innovation Fund – summary of criteria for recoverable cost

The criteria are that the recoverable cost:

1. is targeted for expenditure on innovative projects;
2. requires at least 50% contribution from the distributor;
3. is limited per distributor to the higher of 0.1% of forecast allowable revenue (excluding pass-through and recoverable costs) or $150,000 over DPP3;
4. requires a report from an independent engineer or other suitable specialist that the planned expenditure on the project meets the set of criteria for it to be considered an innovation project and potentially benefits customers, namely (in summary):
    - The specialist is independent of the distributor(s) and is registered as an engineer, or is a suitable specialist.
    - The planned expenditure is aimed at delivering the electricity distribution service at a lower cost and/or at a higher level of quality.
    - The planned expenditure is focused on the creation, development, or application of a new or improved technology, process, or approach in respect of the provision of electricity lines services.
    - The planned expenditure has a reasonable prospect of being scaled up within the distributor or to other distributors if it is successful, i.e. the benefits are of general application.

Source: Commerce Commission (2019)

Medium term – inclusion within regulated asset base

In the medium term, i.e. following the third DPP which applies to 31 March 2025, the full recovery of the cost of investing in the monitoring of LV network will only be possible if the Commerce Commission permits the inclusion of these costs in the regulated price path.

This would require submission of robust evidence, in the lead up to DPP4, that there is a case for a step change in operating expenses to account for the monitoring costs of the LV network. As noted earlier, the ENA and some EDBs, in their submissions for DPP3, had argued for a step change in operating expenses for LV network monitoring costs. The Commerce Commission decided that the step change criteria were not satisfied, citing a lack of evidence:

- that the cost was significant
- to robustly verify the cost
- that the cost was applicable to most distributors.

The accumulation of sufficient evidence to satisfy these criteria is considered in the Management Case.

4. The Management Case – implementation

The Management Case outlines the arrangements required to ensure the successful delivery of the preferred option.

4.1 Project planning

The decision to invest in LV monitoring is likely to occur at the level of each EDB. It needs to be recognised, in the decision to invest in LV monitoring, that the installation of monitoring is only one step. It is important to lay out a high-level plan for what will be done as a result of an LV monitoring project. An individual plan should include the following elements:

- How and when the data will be obtained
- How that data will be used to address network performance issues or inform network expansion planning
- How benefits of those actions and decisions will be identified and quantified (where possible)
- How an evidence base will be collated (i.e. impact in the form of benefits to the business and to consumers) to inform future cases for LV monitoring, including making the case for the associated costs being included in the regulated price path.

EDBs that discover actionable evidence from LV monitoring and look to transition the monitoring from innovation to business as usual will need to reflect on the evidence and impact LV monitoring has on asset management. This will need to show a direct link between measured LV data, analysis, modelling, and extrapolation to better decision-making in their network.

4.2 Benefits of cooperation

Consideration needs to be given to coordinating investment and operational efforts across EDBs. This cooperation is likely to bring financial and knowledge sharing benefits, particularly among smaller businesses. This is because there are some potential savings through economies of scale, and also because the sharing of data and information and bigger asset samples are also beneficial.

Much of the initial value of LV monitoring is achieved through leveraging a smaller sample of LV feeders across the whole network. Overseas experience suggests a set of representative feeders (in the order of 10) can be applied across the whole network with most of the benefit of direct monitoring. By clubbing together, EDBs could better develop a statistically representative sample of LV feeders that can be extrapolated over a greater number of assets.

Later in the LV monitoring development, economies of scale may encourage common back-end systems, communication networks and eventual real-time monitoring across EDB groups. Even more beneficial may be the common development of advanced analytical techniques, such as artificial intelligence, which again can be leveraged across a larger asset base.

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