Network communications: 3G shutdown

PAL BUS 6.06 - 3G shutdown - Jan2020 - Public

Regulatory proposal 2021–2026

Powercor

January 2020

Contents

Business	Powercor
Title	Network communications: 3G shutdown
Project ID	PAL BUS 6.06 - 3G shutdown - Jan2020 - Public
Category	Augmentation capital investment
Identified need	Maintain network reliability, efficiency, safety and compliance with regulatory obligations.
Recommended option	Option 2 - Upgrade 3G communication boxes and access points
Proposed start date	2021
Proposed commission date	2021
Supporting documents	1. PAL MOD 6.05 - 3G shutdown - Jan2020 - Public 2. PAL ATT006 - Telstra - 3G service closure - 2019 - Public 3. PAL ATT178 - ESC - Electricity distribution code - Jan2020 - Public

1 Overview

Telstra's 3G communications network will be retired over the 2021–2026 regulatory period to make way for 5G technology. When the 3G communications network is retired, we will lose our capability to remotely communicate with a number of devices used to operate, control and monitor the network, and collect metering data. This will impact our ability to operate the network efficiently, safely and maintain reliability.

We have considered three options to manage the 3G network retirement, which are:

1. do nothing and lose communications to end devices relying on the 3G network
2. upgrading communication control boxes and access points to maintain communications to end devices
3. develop a new technology using Advanced Meter Infrastructure (**AMI**) to communicate with end devices.

The net present values (**NPV**) over 10 years of the three options are presented below. We recommend adopting Option 2, which is to maintain communication with devices. This option has the highest net present value and the lowest unquantified risks.

Table 1 NPV of options ($000, 2019)

Option	NPV
1—do nothing	-196,747
2—upgrade 3G control boxes and access points	-14,885
3—develop a communication network using AMI	-16,107

Source: Powercor

The capital investment forecast for option 2 is outlined is outlined below.

Table 2 Recommended option: expenditure profile ($000, 2019)

Expenditure forecast	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capital investment	7,751	7,751	-	-	-	15,502

Source: Powercor

2 Background

2.1 Communication with devices

We have a number of devices on our network with which we remotely communicate. To communicate, we send a signal over Telstra's telecommunications network to either:

- a control box located near the device
- in the case of access points used to collect data from AMI meters, the access point itself (these do not have associated control boxes).

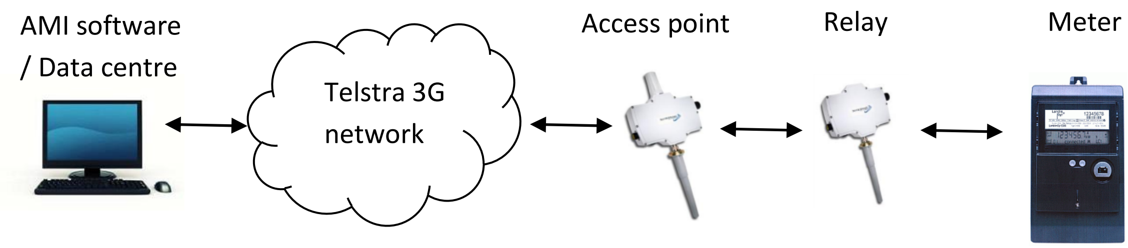
A number of the control boxes, and all of the access points installed on the network operate over the 3G telecommunications network. To instead operate over 4G or 5G networks, components in these control boxes (such as the modem and antenna) and access points would need to be upgraded given the different set of frequencies and transmission protocols needed.

The end devices we communicate with via control boxes perform important network functions such as:

- outage detection—used to detect the location of an outage, resulting in shorter outage times
- remote switching—used to switch electricity around the electricity network to minimise the effect of outages
- remote sensing—remotely monitor the condition/operation of assets and power quality such as voltage
- regulatory compliance—varies the operation mode of assets to ensure regulatory compliance.

Similarly, we have access points that are required to collect information from AMI meters installed at customers' premises. The access point provides 'long haul' communications back to our data centre where the AMI software is housed. The figure below shows the main components of the AMI network.

Figure 1 AMI network components



Source: Powercor

The table below outlines the end devices with which we communicate with via the 3G network.

Table 3 Devices with 3G communication

End device	Device purpose	Quantity of control boxes	Quantity of access points
Zone Sub Station Remote Telemetry Units (**RTU**)	Outage detection, remote switching, Remote sensing	111	-
Collector RTU	Outage detection, Remote sensing	66	-
Terminal Station RTU	Outage detection, remote switching, Remote sensing	3	-
Customer Sub RTU	Outage detection	4	-
Automatic Circuit Reclosers	Outage detection, Remote switching	489	-
Single Wire Earth Return Automatic Circuit Re-closers	Outage detection, Remote switching, Regulatory compliance	315	-
Gas Switch	Remote switching, Remote sensing	191	-
Sectionalizes	Remote switching	113	-
Switch	Remote switching	9	-
Regulators	Regulatory compliance	185	-
Cap Balancing Unit	Regulatory compliance	141	-
Fault Indicators	Outage detection	4	-
Fuse Savers	Regulatory compliance	429	-
Access Points	AMI network operation	-	738
Total 3G devices		**2,060**	**738**

Source: Powercor

2.2 3G network shutdown

5G technology has been created to keep up with the constant demand for increased bandwidth. Telstra will be deploying 5G between 2020 and 2025. As a consequence the 3G network will be retired to free up spectrum needed for 5G.

On 9 October 2019, Telstra officially announced that it would shut down its 3G network in 2024, stating:[1]

1 PAL ATT006: Telstra, 3G Service Closure Redefne your business with a new generation of technology, 9 October 2019 <https://www.telstra.com.au/business-enterprise/news-research/networks/announcements/3g-service-closure?elqTrackId=d9f898b2ddfb4c099fbb9c8281641d43&elq=6ab47fbbe0644bf59735fc913116a48b&elqaid=1957&elqat=1&elqCampaignId=1274>

In view of such compelling changes and a global decline in 3G usage, it was inevitable we reconsidered the changing requirements of businesses, such as yours.

So here's our way of offering you a chance to take a leap into the future with our next generation mobile technology, as we decommission our 3G services in 2024.

Telstra's notification of the 3G network shutdown is also attached.

3 Identified need

When the 3G network is retired, we will no longer be able to communicate with the end devices listed in table 3. The identified need in this business case is to:

- maintain compliance
  - we need to continue to receive data from our AMI meters to be compliant with our obligations in the National Electricity Rules (**Rules**) including Chapter 7 Part E on the provision, storage and management of meter data
  - the Victorian Bushfire Royal Commission's recommendation 32, which has been included in our Bushfire Mitigation Strategy Plan, is that 'the reclose function on all Single Wire Earth Return (**SWER**) Automatic Circuit Reclosers (**ACR**) needs to be disabled for the six weeks of greatest risk in every fire season.'[2] This is currently undertaken by remotely switching SWER ACRs using the 3G network twice a year (to supress and then restore their functionality)
  - the Victorian Electricity Distribution Code requires us to manage our assets in accordance with the principles of good asset management.[3] This cannot be met without being able to communicate with our assets to maintain network safety and reliability (discussed below)
- maintain safe network operations—the communications network is used for:
  - condition monitoring, such as sensing oil level in transformers, enabling the remote detection of unsafe oil level
  - reading power quality meters that ensure the voltage is within correct ranges and measuring harmonic content
  - transmitting meter data is used to undertake neutral integrity testing under which we are made aware of faulty neutrals at customers' houses that could lead to electric tingles or shocks, and could potentially even be life threatening
  - transmitting meter data which is used to improve our GIS models of the electricity network, improving customer notifications of planned outages including for life support customers
- maintain efficient network operation—we need communications to access points to perform:
  - remote meter reading—without being able to receive customers' meter data from our access points, we would need to undertake manual meter reads
  - outage detection—AMI meter data alerts us to customer outages and whether electricity has been restored
  - functions such as re-energisation and de-energisation that would otherwise require manual operation
  - remote AMI reprogramming for example for solar customers, which would otherwise require meter removals
  - smart meter voltage management used to reduce load at times of generation capacity constraints instead of load shedding.

---

2 In practice we go beyond this and disable ACRs on all total fire ban days, however, our analysis is based on the minimum requirement from the Victorian Bushfire Royal Commission (which understands the benefits of our preferred option). Our Bushfire Mitigation Plan has been approved by Energy Safe Victoria and is a regulatory obligation in accordance with the *Electricity Safety Act 1998.*

3 PAL ATT178: Essential Services Commission (Victoria), Electricity Distribution Code Version 10, January 2020, section 3.

- maintain reliability—once a fault is detected the 3G network is used to:
  - communicate with switches to supply customers via an alternative route where possible. Without this, switching could only occur manually at the site
  - narrow down the fault location and dispatch the field crew to the correct position. This is particularly important given the vastness of our network—for example we have six feeders over 1,000 kilometres long, which would need to be patrolled to find a fault without communications
  - use automated switching programs (our Fault Detection Isolate and Restore system) which significantly reduces outage times for customers.

4 Options analysis

This section outlines options to address the identified need. In this analysis, costs are the direct expenditure required to implement the option and benefits are the quantified effects. This means benefits can be presented as negative benefits where the effects are detrimental.

We considered a number of options and scenarios before selecting three options for cost benefit analysis. These, and the reason they were not considered further, are outlined below:

- using other 3G networks—we considered using Optus' or Vodafone's 3G networks. Through previous trials we have established that only Telstra's network is sufficiently reliable and has the coverage needed. These providers have also indicated they will be retiring their 3G networks.
- refurbishing access points—while control boxes can be refurbished (i.e. replacing the modem, antenna and battery, which is the approach we consider in the following options analysis) it is not economically viable to refurbish, rather than upgrade, access points. Access points must be sent back to the vendor to be refurbished meaning it requires two site visits. Additionally these devices were installed during the AMI rollout and are now nearing the end of their life; even if they were refurbished with a new modem, they would need to be replaced within the next 5 years.
- delaying the upgrade of communication boxes and access points—as observed with the 2G shutdown, Telstra may lower the spectrum available to 3G before the final shutdown. This has a detrimental effect on communications reliability.

4.1 Option one—do nothing and lose communications to end devices

Option one is not replacing 3G communications devices. The table below outlines the net present value of this option.

Table 4 NPV of costs and benefits ($ 000, 2019)

Impact	Cost	Benefit
Reliability	-	-144,745
Protection device manual reconfiguration	-	-3,106
Meter reading	-	-48,896
Capital replacement	-	-
Net benefits		**-196,747**

Source: Powercor

4.1.1 Benefits

Reliability

We do not have actual data on the impact to reliability of operating without a communications network. This is because the network has operated with communications for decades.

Therefore we have estimated the reliability impact based on the effects outlined in appendix A, such as not being able to locate the causes of faults without patrolling a feeder or being able to switch electricity to restore power.

The table below outlines the value of unserved energy.

Table 5 Value of unserved energy per annum ($ 000, 2019)

Value of unserved energy	
Total unserved energy (MWh)	558.8
Value of Customer Reliability	37
Value of unserved energy per annum	20,667

Source: Powercor

Meter reading

Without communication to access points we are unable to receive metering data. As a result we would need to undertake manual meter reads as occurred prior to the AMI rollout. We have costed manual meter reads based on our previous experience with this activity as shown in the table below.

Table 6 Manual meter reading ($ 000, 2019)

Cost build up	Quantity
Meters to be read	872,668
Cost to read meters (quarterly)	0.002
Total yearly cost ($,000)	**6,981**

Source: Powercor

Manual reconfiguration

On a total fire ban day, we are required to alter protection settings to high risk areas of the network to reduce the risk of fire ignitions, which is undertaken via the 3G communications network. Without 3G communications this would need to be conducted manually. For the purpose of developing a cost for this business case we have assumed it can be undertaken with the current workforce at a typical field worker's hourly rate. This annual cost estimate is summarised below.

Table 7 Annual cost to manually adjust devices ($ 000, 2019)

Device	Number of devices	Cost to manually supress and re-enable a device (two visits)	Total
SWER ACR	315	0.596	188
Fuse Savers	429	0.596	256
Total per annum			**443**

Source: Powercor

Compliance

Under this option we would likely be in breach of the Electricity Distribution Code and our Distribution Licence.

We would not have any meter data available to us without manually reading meters. This would mean market settlements could not occur and we would be in breach of our obligations under chapter 7 of the Rules.

Additionally, without the network visibility or remote operations capability we would be unlikely to be meeting our obligations around good asset management.

The compliance dis-benefits are unquantifiable.

4.1.2 Costs

There is a potential one time cost from us needing to remove unused assets from the network. This has not been quantified given the option would already result in uneconomic outcomes.

4.2 Option two—upgrade 3G control boxes and access points

Under option two, we would replace 3G devices with 4G or 5G compatible communications devices. While 5G devices are not yet available in the market they are expected to be so once the 5G communication network is built. Based on our experience in purchasing 3G and 4G devices, the cost of 4G or 5G devices are expected to be the same and so has not impacted on our cost estimate.

The table below outlines the net present value of this option.

Table 8 NPV of costs and benefits ($ 000, 2019)

Impact	Cost	Benefit
Reliability	-	-
Protection device manual reconfiguration	-	-
Meter reading	-	-
Capital investment	14,885	-
Net benefits		**14,885**

Source: Powercor

4.2.1 Benefits

The reliability, manual meter read, manual reconfiguration and non-compliance dis-benefits outlined in Option one will not be incurred.

4.2.2 Costs

We have undertaken a bottom up build of the costs for upgrading from 3G to 5G devices. In so doing, we have separately built up the costs of control boxes and access points used for transmitting AMI data. Access points must be replaced because they do not communicate via a control box, which results in different costs. The key components of the build-up are outlined below:

- materials—material costs are based on the actual quoted rates for purchasing 4G modems, antennas and batteries required to refurbish control boxes, and quoted prices for access points.
- labour
  - rates are based on actual quoted rates from our field services supplier.
  - travel times are modelled using a spatial model, which determines both travel times to, and between, devices. The location of each device has been mapped and assigned to a servicing ring based on its location from the nearest depot. From this, the model determines the average distance from the depot

to the midpoint of the ring (to represent the time to and from depots), the average distance between devices within the ring, and the average speed to determine the average travel time per device.

– the time on site needed to refurbish control boxes and upgrade access points is based on the actual time from our records it takes to undertake these activities when these devices fail (excluding the time taken to find the cause of the failure).

– as this is a substantial project, we have included time for a project manager.

More information on this cost estimation is provided in appendix B and the model (PAL MOD 6.05). The average cost per device is shown in the table below.

Table 9 Average cost of upgrading to 3G ($, 2019)

Item	Cost per control box	Cost per access point
Materials	1,970	9,645
Setup cost	117	-
Field cost	1,427	1,258
Project management	77	77
Total unit cost	**$3,591**	**10,980**

Source: Powercor

The total cost of upgrading 3G control boxes and access points to be 4G and 5G compatible is shown in the table below.

Table 10 Total cost of upgrading 3G devices ($ 000, 2019)

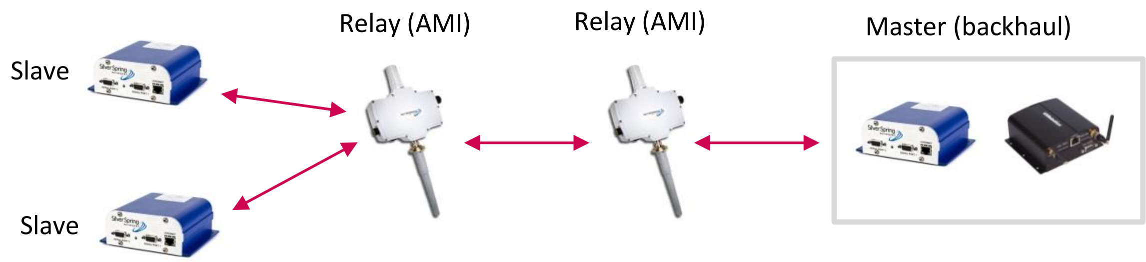
Cost to upgrade from 3G	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Control boxes for devices	3,699	3,699	-	-	-	7,398
Access points	4,052	4,052	-	-		8,103
Total	**7,751**	**7,751**	**-**	**-**	**-**	**15,502**

Source: Powercor

4.3 Option three—develop a communication network using AMI

Control boxes that are currently remotely telemetered with 3G could be replaced with the technology underpinning the Advanced Metering Infrastructure (**AMI**) communications network infrastructure. This technology is known as an eBridge and is illustrated below.

Figure 2 eBridge technology



Source: Powercor

A slave device is connected to the end device and then communicated with through AMI relays. These are connected to the master devices, which includes a modem to transmit the communications signal over the 4G or 5G telecommunications network. While a slave device must still be installed at each end device, fewer modems are required compared to the current approach/Option two which use control boxes with cellular modems. Currently eBridges are being used as a solution for sites that have no cellular coverage.

This option only applies to control boxes and not access points. That is, even if adopted, the existing 3G access points supporting the AMI network would still need to be upgraded in accordance with Option two to remain operational. Therefore we have adopted the same costs for upgrading access points as per Option two in this option.

The following table outlines the NPV of developing our own communication technology that does not require 3G devices.

Table 11 NPV of costs and benefits ($ 000, 2019)

Impact	Cost	Benefit
Reliability	-	-
Protection device manual reconfiguration	-	-
Networks communications capital expenditure	16,107	-
Net present value		**-16,107**

Source: Powercor

4.3.1 Benefits

The quantified reliability and manual reconfiguration dis-benefits outlined in Option one would be avoided. In addition to the quantified analysis, this option would present the following qualitative dis-benefits:

- should metering competition be introduced in Victoria we may not be a metering provider in the future. Therefore we would lose the capability to provide this option and would then incur costs to upgrade network devices outlined in Option two in addition to the costs of developing our own communications network.
- this option will take longer to rollout because of the greater volume of devices (shown in table 12) and we are likely to experience communication issues before the eBridge option can be completed.

4.3.2 Costs

We have forecast the cost for this technology based on the actual costs we incur for the sites with no cellular coverage. This is outlined in the table below.

Table 12 Cost of eBridge ($2019, 000)

Device type	Item	Quantity	Unit cost	Total cost
Control boxes	Slaves	2,060	2.4	4,889
	Masters	515	4.6	2,388
	Relays	85	4.5	380
	Cellular backhaul	515	2.0	1,015
Access points (from Option two)		-	-	8,103
Total cost				**16,775**

Source: Powercor

As a sensitivity for this option, we also considered an alternative technology for access point communications; installing 4G Network Interface Cards (**NIC**) in each AMI meter that sends metering data directly from the meter to our AMI software and control systems. This was not considered in detail given the costs were significantly higher than adopting the Option two (access point upgrade costs). The costs of 4G NIC are shown below.

Table 13 Cost of 4G NIC ($2019, 000)

Item	Quantity	Unit cost	Total cost
4G NIC	872,668	0.14	117,810

Source: Powercor

5 Recommendation

The net present value over 10 years of the three options considered is presented below. We recommend adopting Option two, which is to replace 3G capable devices with 4G and 5G capable devices.

Table 14 NPV of options ($000, 2019)

Option	NPV
1—do nothing	-196,747
2—upgrade 3G control boxes and access points	-14,885
3—develop a communication network using AMI	-16,107

Source: Powercor

The capital investment forecast for Option two is outlined is outlined below.

Table 15 Recommended option: expenditure profile ($000, 2019)

Expenditure forecast	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Capital investment	7,751	7,751	-	-	-	15,502

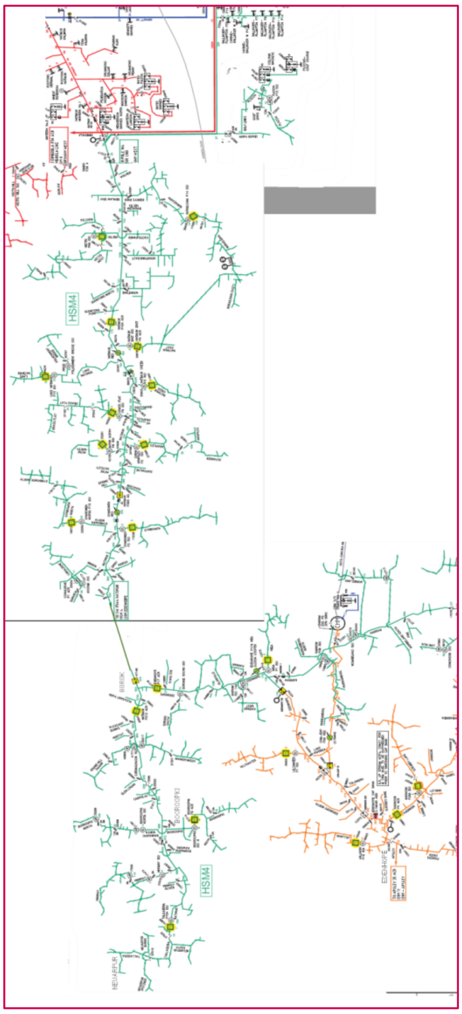
Source: Powercor

A Option one reliability impact

When a fault occurs on a distribution feeder, the initial notification is received via 3G in the Control Room via the Distribution Management System (**DMS**). The network controller reviews the data and dispatches crews to investigate. In some situations the network controller is able to restore healthy sections of the affected feeder using 3G remote switching equipment before the field crew gets onsite. During the fault finding and restoration process the control room will open and close Feeder Circuit Breakers (**CB**), ACRs and Remote switches. They utilise the field crews to further refine outage areas using manual switching devices. Often only one field crew is used to find and isolate a fault.

If the 3G communication network failed to function or was shutdown, the information currently received by our control room would not be received and all the remote switching of ACRs and Remote Switches via the DMS would have to be completed by extra crews in the field.

A.1 Outage example – HSM004 Feeder



The HSM004 feeder consists of around 1,085 km of HV line. It supplies 2,000 customers in an area stretching from Horsham's west to the South Australian Border. It has 3 22KV ACRs, 13 SWER ACRs and 3 remote controlled switches along its length.

For any fault our control room can open and close the devices to assist in the fault finding and restoration process. Without communication to these devices we would need to dispatch extra crews to the zone substation and also along the line so that we could open and close the ACRs and switches.

In most of our depots we would need to divert crews from their normal work to assist in fault finding and restoration. In Horsham's case the extra crews could be 100 kilometres away from this feeder and would take a considerable amount of time to respond and attend.

With remote outage detection and switching, the control room is able to:

- determine which section of the feeder contains the fault
- use remote switching to isolate the section of the feeder
- use remote switching to feed electricity from adjacent feeders to around 1,300 customers back on supply within minutes
- notify the field crew the approximate location of the fault.

Due to the feeder length, this could make the difference of hours for power restoration.

A.2 Outage impact

Remote switching capabilities have made a significant impact to avoiding outages over the last 20 years. Powercor System Average Duration Index (**SAIDI**) 20 years ago was consistently over 200. Today the 5 year average is 134.

Given the abovementioned impacts, we conservatively estimate that losing the ability to remotely switch would increase outage duration as outlined in the following table.

Table 16 SAIDI (zone substation and feeder) impact by feeder type

Feeder type	SAIDI impact (minutes)
Urban	60
Rural short	75
Rural long	90
Combined network impact	**70.2**

Source: Powercor

As the majority of zone substations and terminal stations communicate through optical fibre or microwave radio, the component of SAIDI that relates to outages at the substation level is excluded in the table below.

Table 17 Total network SAIDI impact

Feeder type	SAIDI impact (minutes)
Combined network impact	70.2
Percentage of outages below substation level (5 year average)	55.6%
Total SAIDI impact	**39**

Source: Powercor

A.3 Valuing the impact on network reliability

In the table below we have determined the amount of energy not served due from the SAIDI increasing in table 17.

Table 18 Total network SAIDI impact

Feeder type	
Total SAIDI impact (hours)	0.65 (or 39 minutes)
Average customer usage per hour accounting for network losses (kWh)	1.06
Number of customers	810,000
Total MWh outage	**558**

Source: Powercor

The following table below outlines the composite calculation of Value of Customer Reliability (**VCR**) for our network.

Table 19 VCR calculation

Sector	MWh	$/MWh	Sector weighting	Sector VCR ($)
Residential	51,000	26,450	49.5%	13,085
Agricultural	3,660	50,930	3.6%	1,808
Commercial	37,308	47,770	36.2%	17,288
Industrial	9,980	47,070	9.7%	4,557
Composite	**103,091**		**100.0%**	**37,031**

Source: Powercor

The total cost to customers of the outages from not communicating with 3G control boxes is shown below.

Table 20 Total annual cost of outage from not communicating with 3G control boxes

Feeder type	
Energy not served (MWh)	558
VCR ($, 000)	37
Total cost of energy not served ($, 000)	**20,667**

Source: Powercor

B Option two cost build-up

This appendix provides detail on the forecast for upgrading control boxes and access points to 4G or 5G in line with Option two of this business case.

B.1 Control boxes

The cost for upgrading control boxes has been forecast using a build-up of materials, set up time, on site time, travel time and project management as outlined below.

B.1.1 Materials

The following is a list of material that is needed to upgrade 3G control boxes and quoted rates. A new modem and antenna is needed due to the frequency ranges of 4G/5G being different to what is needed for 3G, which also results in a larger battery requirement.

Table 21 Material costs ($, 2019)

Cellular component	Cost
Cybertec Modem	1,380
4G antenna (including $10 shipping)	80
Batteries and brackets	510
Total	**1,970**

Source: Powercor

B.1.2 Labour rates

The labour rates used in the forecast are based on contracted supplier rates for the different resources required, as shown in the table below.

Table 22 Hourly labour rate

Labour resource	Hourly rate
Field crew labour hourly rate	159
Supervisory Control and Data Acquisition (**SCADA**) resource	113
Project manager	147
Traffic management	200

Source: Powercor

B.1.3 Labour time

Labour time consists of:

- initial setup time at the depot—modems are assembled, configured and tested to ensure there is no wasted time whilst in the field due to faulty equipment
- travel to devices

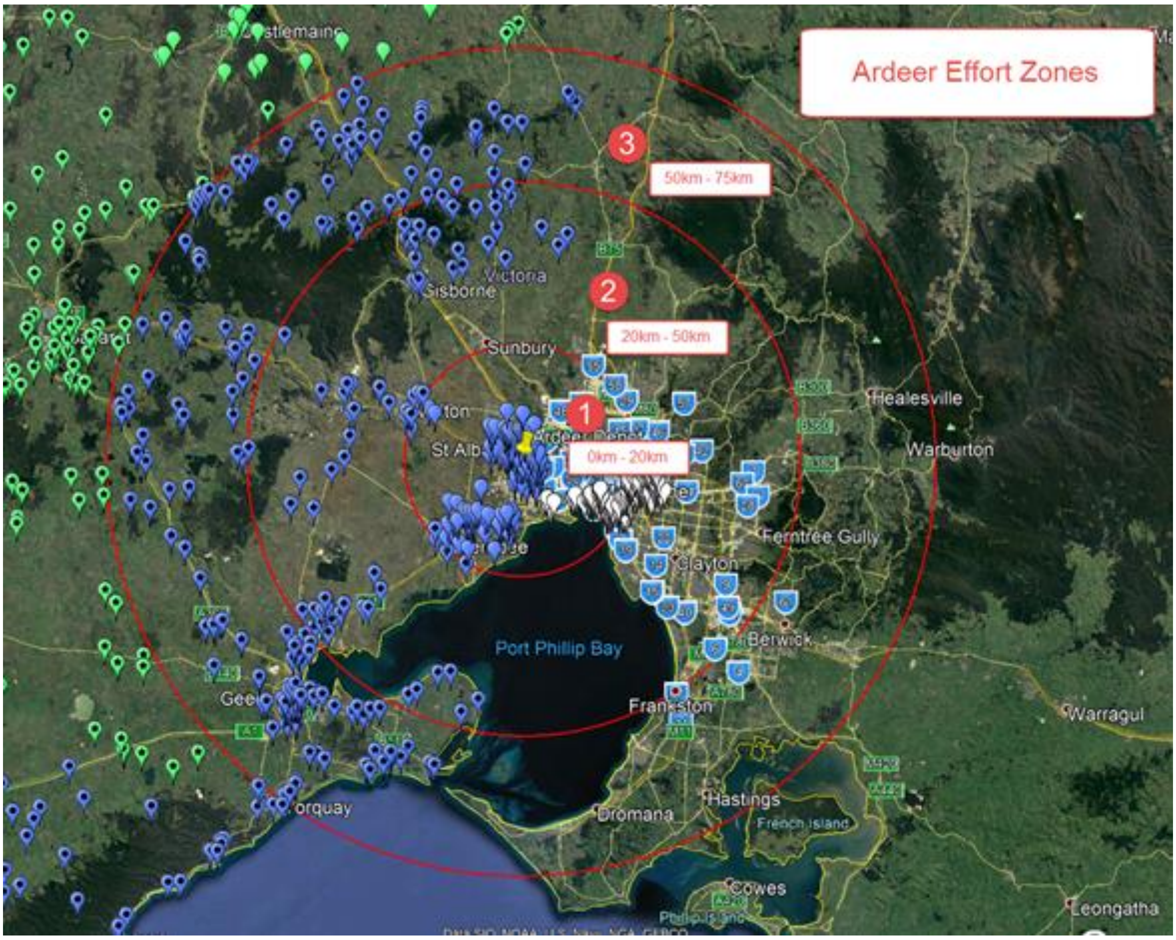
- traffic management for sites situated near major towns (i.e. situated in ring 1 as discussed below)
- time on site to access and upgrade the control box
- office based SCADA resources to sync the new modem to the device being controlled
- project management—with a program of this size a project manager will be assigned; it is estimated one project manager assigned 70% to the project is needed.

Setup and onsite times are based on current replacement activities that are arising due to faults. Time to find faults have been excluded.

Travel times are determined using a spatial model of device locations. 3G devices are located all over Victoria—we cover a vast geographical area, ranging from higher density urban environments in the west of Melbourne to very low density rural.

First, we have developed travel radius rings from each depot to estimate travel distance. We have 3 depots that centrally cover the population of sites and have the resources needed to carry out the work; Ardeer, Bendigo and Horsham. The image below shows how the distance rings are created around the Ardeer depot (marked by a yellow pin) and blue pins are 3G devices in the area.

Figure 3 Travel rings around the Ardeer Depot



Source: Powercor

Travel speeds are dependent on the population density, with urban centres being slower than rural areas. Using Google maps, travel speeds for each ring was estimated.

Using the radius rings and travel speeds, we determined the travel time to the midpoint of the radius (i.e. devices can either be close to the inside of the ring or near the outside, therefore the midpoint on average will be the travel distance). In addition to the travel time to the ring midpoint, the average distance between devices was calculated for each ring.

The table below shows the average distance between devices, travel speeds and travel times.

Table 23 Travel time from depots and between devices

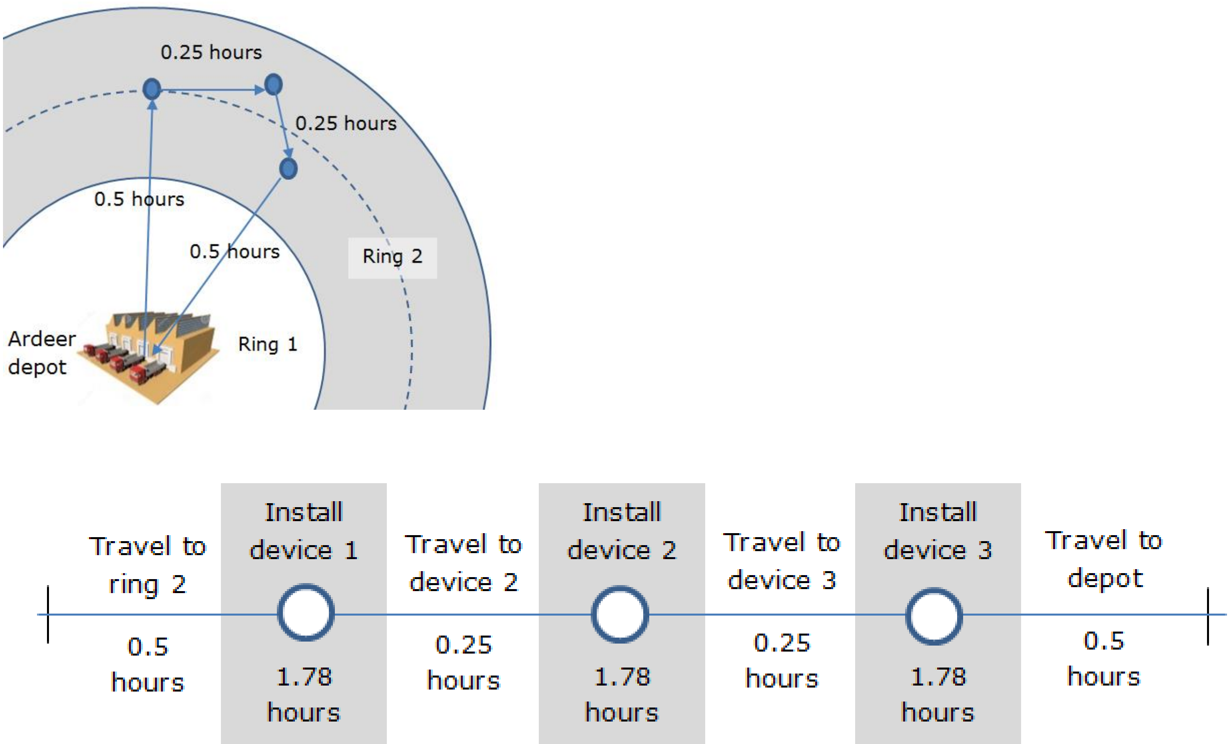
Depot	Distance inner (km)	Distance outer (km)	Mid point radius	Travel speed (km/h)	Avg distance between devices (km)	Daily travel time (hours)	Total travel time (hours)*
Ardeer Depot							
Ring 1	0	20	10	40	10.5	1.5	51
Ring 2	20	50	35	70	17.2	1.8	55
Ring 3	50	75	62.5	80	14.3	2.2	140
Ring 4	75	200	137.5	80	68.7	4.9	399
Bendigo Depot							
Ring 1	0	50	25	40	25.9	3.0	186
Ring 2	50	100	75	70	27.2	3.2	255
Ring 3	100	175	137.5	80	39.3	4.4	1,076
Ring 4	175	200	187.5	80	248.1	6.8	50
Horsham Depot							
Ring 1	0	50	25	70	27.6	2.0	37
Ring 2	50	100	75	80	28.4	2.9	139
Ring 3	100	175	137.5	80	40.0	4.4	762
Ring 4	200	300	250	80	78.0	6.9	606
							3,756

Source: Powercor
*Based on number of devices within the ring

From this we determined the average travel time and associated cost per device.

The figure below shows an example of how travel times have been calculated based on this information for the Ardeer depot ring 2.

Figure 4 Example of travel time and time between devices



Source: Powercor

B.2 Access points

The cost for upgrading access points has been forecast using a build-up of materials, on site time, travel time and project management as outlined below.

B.2.1 Materials

The following is a list of materials needed to upgrade access points and the quoted material rate.

Table 24 Material costs ($, 2019)

AMI Access point	
ACCESS POINT 5.0, CELLULAR	5,450
BACK UP BATTERY, AP 4.5/5.0	500
ANTENNA, CELLULAR AP - 2G, 3G, 4G	55
LIGHTNING ARRESTOR	164
CABLE, AP 4.5	75
ANTENNA, DUAL BAND	75
MOUNTING KIT	325
CABLE REMOTE ANTENNA	108
Total USD	6,752
Total AUD (0.7 exchange rate)	**9,646**

Source: Powercor

B.2.2 Labour rates

Labour rates are as outlined in section B.1.2

B.2.3 Labour time

Labour time has been determined using the same approach outlined in B.2.3. Setup costs are not included as the vendor provides access points ready to install.