8.04

Independent appraisal of diseconomies of scale

Ausgrid

SANKOFA
CONSULTING

Diseconomies of Scale in Meter Reading

The impact of declining meter density on meter reading costs

Ausgrid's type 5&6 meter population will decline over time

1

The introduction of competition in the metering services market and the push to replace accumulation meters with smart meters will result in a decline in Ausgrid's Type 5 & 6 meter[1] population. The speed of this decline hinges on a number of different factors such as installation costs, the level of competition among retailers and the appetite among consumers for smart meters. This chapter looks at Ausgrid's meter churn forecasts in the context of the smart meter rollout in New Zealand and Ausgrid's historic meter replacement numbers.

[1] Type 5 metering installations record energy in 30 minute intervals, without the requirement to remotely acquire the data. Often the term MRIM (Manually Read Interval Meter) is used interchangeably for Type 5 Meters. A Type 6 metering installation is defined as a 'general purpose' meter that records accumulated energy data only.

Ausgrid is forecasting a decline in its metering population

The population of meters that Ausgrid is required to manage has recently declined and will continue to do so with the introduction of metering competition and the continued take-up of smart meters in NSW. Over time, Ausgrid's existing manually read type 5&6 meters will be replaced by advanced meters managed by electricity retailers. Ausgrid's type 5&6 meter population forecast is detailed below followed by a description of New Zealand's smart meter rollout which has seen fairly rapid smart meter uptake since 2008 (around 3/4 of meters in New Zealand were smart meters in 2017).

Ausgrid has forecast a 50% decrease in its meter population by 2024

Ausgrid has forecast that the number of customers, measured by the number of National Metering Identifiers (NMI), they are responsible for providing metering services to will reduce by around half over the next seven years as a result of increased competition and the shift away from manually read meters. The Ausgrid forecast and its constituent components and assumptions are detailed below.

Drivers	EOFY17	EOFY18	EOFY19	EOFY20	EOFY21	EOFY22	EOFY23	EOFY24
New & Upgraded Meters Installed by Ausgrid		18,107						
Conversion of SBS sites		(18,667)						
Faulty Type 5/6 meters		(6,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)	(12,000)
Aged meter replacement for 14-19		(31,579)	(63,158)	(5,263)				
Proactively replaced by Power of Choice		(40,000)	(50,000)	(95,833)	(100,000)	(100,000)	(100,000)	(100,000)
Upgrades from 1 Dec 2017		(5,000)	(10,000)	(10,000)	(10,000)	(10,000)	(10,000)	(10,000)
Remaining Meter Population	**1,643,395**	**1,560,256**	**1,425,098**	**1,302,002**	**1,180,002**	**1,058,002**	**936,002**	**814,002**

Table 1: Ausgrid Forecast Meter Population

Each of the line items in Table 1 are described and the assumptions regarding each provided below.

Drivers	Description	Assumption
New & Upgraded Meters Installed by Ausgrid	These are the meters added by Ausgrid prior to the introduction of contestability.	Assume 50.490k pa for 1st 6 mths then 13.899k for July - Nov.
Conversion of SBS sites	These are meters that are converted to smart meters as part of the Solar Benefit Scheme.	42k remaining sites converted by retailers evenly over the next 9 months.
Faulty Type 5/6 meters	These are Ausgrid meters requiring reactive replacement post 1 Dec 2017.	Estimated at 12k per annum.
Aged meter replacement for 14-19	These are the remaining meters identified for replacement in the 14-19 period, post 1 Dec 2017. These will be inherited by retailers.	Estimated at 100k meters to be replaced Dec 17 - June 19.
Proactively replaced by Power of Choice	These are existing meters which are replaced by advanced meters under the new Power of Choice regime.	20k per annum to 30 Sep 17 (this marks completion of SBS). 50k pa until FY19, then 100k per annum thereafter.

Drivers	Description	Assumption
Upgrades from 1 Dec 2017	These are existing sites that require upgrade post 1 Dec 17.	Assume 10k pa from Dec 17, then proportionate volumes dependant on population thereafter (1 site per 160 sites per annum)

Table 2: Ausgrid Meter Forecast Assumptions

This decline is driven by the introduction of metering competition

On November 26, 2016 the AEMC published an amendment to the National Electricity Rules (the Rules) designed to stimulate competition in the supply of metering services in the National Electricity Market (NEM). The change in the Rules means that from December 2017, any registered party (a 'Metering Coordinator") will be able to compete for the provision of metering services in NSW.

Whilst in the past, distribution networks have been responsible for providing metering services[2], the change in the Rules will now mean that over time, as more entrants enter the meter services market, Ausgrid will lose meters to other parties registered as 'Metering Coordinators'. The changes to the Rules will result in electricity retailers overseeing metering either internally or through the use of third party providers.

The changes in the Rules also mean that when manually read meters are ready to be replaced due to age and/or faulty operation they will be replaced with smart meters[3]. The consequence of these rule changes will be the progressive transfer of metering responsibilities from electricity distributors to electricity retailers. Ausgrid's forecast suggests that their type 5&6 meter populations will halve over the next seven years.

Putting Ausgrid's forecast into perspective

Estimating a low case - replacement and upgrades of type 5&6 meters

Two drivers of the transfer of metering responsibilities from distribution networks to retailers will be the replacement of type 5&6 meters and the upgrade of existing meters to enable net readings from solar panels. Changes to the Rules mean that unless consumers opt out, type 5&6 meters that are due to be replaced will be done so with smart meters with this replacement being coordinated by electricity retailers.

The table below shows the number of meters (type 5&6) Ausgrid have replaced since 2009. If historic replacements are reflective of future trends this would suggest that Ausgrid would lose around 33K meters per annum due to meter replacement (with replaced meters being "lost" to electricity retailers)[4] as ageing meters are replaced with smart meters.

	2009	2010	2011	2012	2013	2014	2015	2016	Average
Meters replaced	20,201	45,195	51,804	34,933	21,542	31,720	32,695	27,574	**33,208**

Table 3: Historic meter replacements

[2] *Currently, distribution businesses are required to provide metering services at premises with energy consumption less that 160MWh per annum where Type 5 or 6 metering is installed.*

[3] *Consumers retain the option to opt out of having their meter replaced with a smart meter*

[4] *Data sourced from Ausgrid's meter replacement data (Tab 4.2.2) Category and RESET Regulatory Information Notices*

The anticipated increase in the number of domestic solar panels in NSW will also result in a shift from type 5&6 meters to smart meters as households require net meter readings to take advantage of differences in the cost of consuming electricity and feeding generated electricity back into the grid. The table below shows historic solar panel installation numbers in N.S.W since 2009[5].

	2009	2010	2011	2012	2013	2014	2015	2016	2017 (to 1 June)
Small generation units installed	14,008	69,988	80,272	53,961	33,998	37,210	33,477	29,115	11,747

Table 4: Historic solar panel installations in NSW

The historic solar panel installation figures highlight the impact of the NSW Solar Bonus Scheme with high installation numbers in 2010, 2011 and 2012 followed by a reduction in annual installation numbers from 2013. Similarly to meter replacements, if we were to use historical data (from 2013 onwards) to extrapolate solar installations in N.S.W this would forecast an annual rate of 32,954 generating units per annum. To convert this into an estimate for Ausgrid we have used their ratio of customer connections relative to the other distribution networks in N.S.W (Endeavour Energy and Essential Energy). This results in an estimate of 15,735 new generation units on Ausgrid's network per annum.

The combined impact of type5&6 meter replacements and upgrades is an estimate of 48,943 type 5&6 meters being withdrawn from Ausgrid's meter population per annum. This estimate assumes that voluntary uptake of smart meters beyond replacement and upgrades is minimal and smart meters are introduced organically as older meters are retired.

The likelihood of this scenario is to a large extent dependant on how the costs of smart meter installation are to be shared between retailers and customers. If there is significant cost to consumers in switching to a smart meter (for example reports have indicated $600 for solar customers upgrading to smart meters[6]) then it is unlikely many customers will be willing to incur upfront costs for benefits that may accrue in the future in the form of lower bills. The alternative would be for retailers to incur the upfront costs however this would likely mean customers are required to sign long term contracts as retailers recoup the cost of their meter investment.

Estimating a high case - NSW follows New Zealand's example

The most challenging line item to forecast in Tables 1 and 2 above is the proactive replacement of meters through the Power of Choice. A number of complex market and economic forces act upon this forecast which ultimately dictates consumer behaviour in transitioning to smart meters. The Victorian experience does not provide much insight as to the adequacy of the Ausgrid forecast, as the roll out in that jurisdiction was mandated by the Victorian government. New Zealand, having undergone a market led roll-out of smart meters, provides a useful comparison point for the Ausgrid forecast.

Since 2005 the New Zealand electricity metering market has undergone significant changes with a market led rollout of smart meters (facilitated by electricity retailers) resulting in 76% penetration of smart meters as of May 2017[7]. New Zealand's experience has been identified as a successful example of a market led metering rollout with members of the NSW Smart Meters Task Force travelling to New

[5] *Source: http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#SGU--Solar-Deemed, data current as 1 June 2016*

[6] *http://www.smh.com.au/nsw/households-face-buying-600-smart-meter-to-avoid-electricity-bill-shock-20160308-gndf37.html*

[7] *1,588,632 meters out of 2,091,742 connection points. Data obtained from New Zealand's Electricity Market Information website - https://www.emi.ea.govt.nz*

Zealand in 2013 to meet with a range of stakeholders involved in the deployment, operation and regulation of smart meters[8]. The uptake of smart meters in New Zealand over time is graphed below.

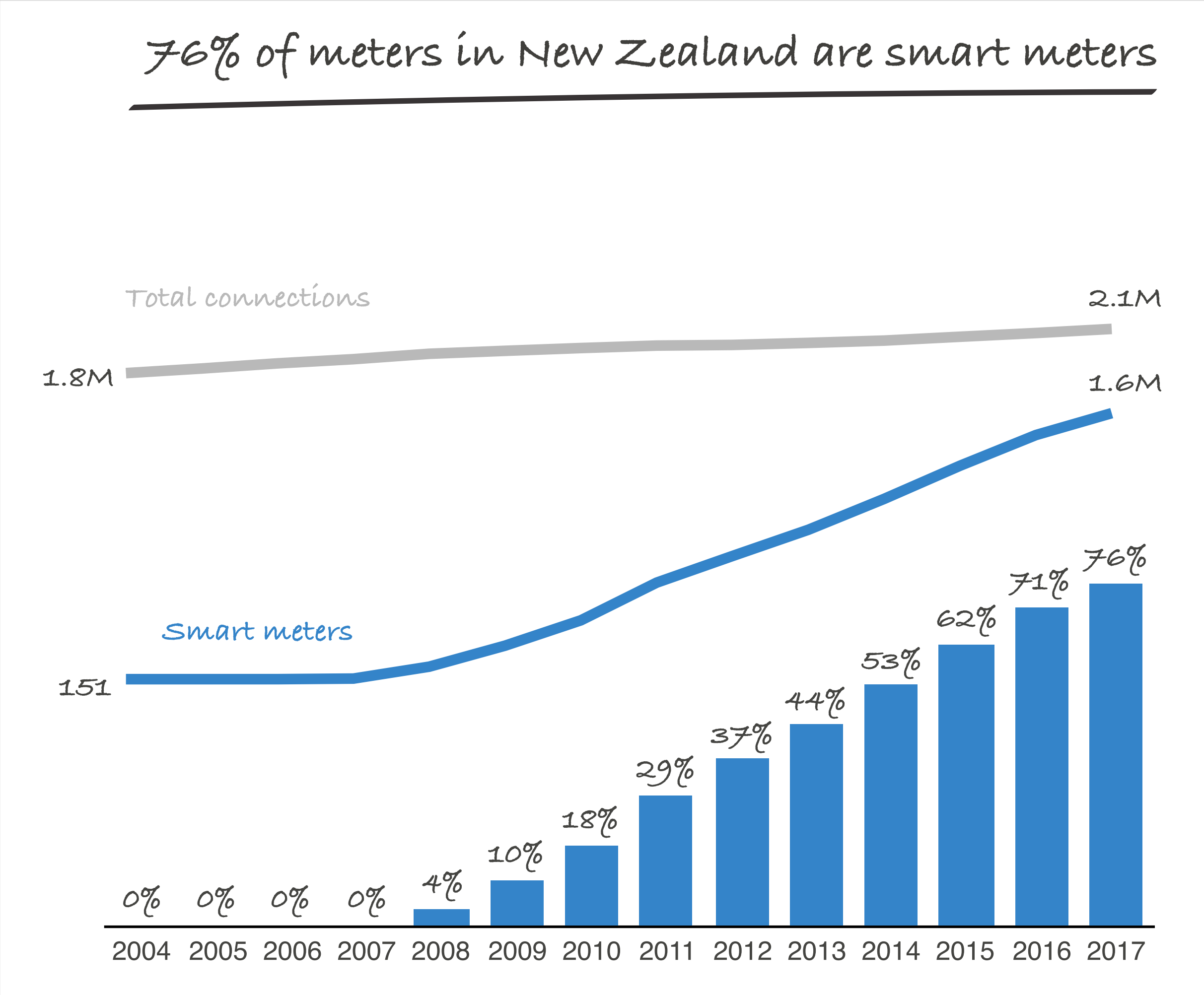


Figure 1: Uptake of smart meters in New Zealand

To gauge the applicability of New Zealand's smart meter up-take with the potential in NSW it is necessary to recognise the key policy differences between the respective roll-outs.

The absence of a "trigger" point in NSW

In terms of policy, whilst the "carrot" of free market competition and the potential to increase market share has influenced smart meter uptake in New Zealand it is also likely that the regulatory "stick" of compliance also played a role in the successful roll-out of smart meters.

> *"One driver of AMI in New Zealand has been the metering interim compliance deadline of April 2015 which was agreed upon by the industry in 1999. By this date all meters at residential and small commercial premises were to be fully certified. Many retailers and meter owners have taken this opportunity to install new fully certified advanced meters rather than certifying their existing traditional meters. At the same time they have used recertification as an opportunity to install smart meters to reduce their cost to serve."*
>
> *Source: Keiran Murray and Melleny Black, Developments in the New Zealand market for Advanced Metering Infrastructure and related services*

[8] *Page 31, NSW Smart Meter Task Force Final Report, http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0008/536696/NSW-Smart-Meter-Task-Force-Report.pdf*

In effect, the compliance standards introduced in New Zealand in 1999 created a liability that New Zealand retailers had to address before April 2015. Given this deadline and the declining costs of smart meter installations New Zealand's electricity retailers were encouraged to install smart meters. In addition, prior to the meter rollout responsibility for metering services rested largely with retailers and third party suppliers and not electricity distributors. By owning the existing metering infrastructure retailers were already incurring the costs of manual meter reads, reconciling faulty reads and connecting/disconnecting meters. This meant that the roll-out of smart meters provided tangible benefits to the retailers through reduced meter reading costs. This is different to the situation in NSW where smart meters are likely to increase the costs for consumers in the short run as existing meter infrastructure costs (type 5&6 meters) will continue to be recovered by distribution networks as well as a new cost for smart meter installation.

If the success of New Zealand's smart meter rollout is due in part to metering competition and in part to the April 2015 deadline then we would expect the take-up of smart meters in NSW, absent a "trigger" point deadline, to occur at a lower rate.

The NSW smart meter rollout is likely to be different to New Zealand's

Whilst the rapid uptake of smart meters is evident in the case of the New Zealand roll-out it is also noteworthy that smart meter replacements were negligible until 2008 despite the smart meter compliance date being set in 1999. Murray and Black provide evidence that in 2008 the costs for electricity retailers to lease smart meters from the market were not much higher[9] than for accumulation meters and therefore, when reduced meter reading costs were factored in, the business case for installing smart meters became more attractive for New Zealand retailers.

Whilst there was a fairly significant interval between the 1999 metering compliance date in New Zealand and the uptake of smart meters there are three reasons we believe this will not be the case in the case of the NSW rollout.

1) Technological advancements in metering mean smart meter installation costs are no longer prohibitively expensive for retailers,
2) Changes to the metering rules mean that old meters will be replaced by smart meters unless customers opt out. Using historic RIN data as an indication, Ausgrid has replaced an average 33K meters per annum since 2009. This suggests that at a minimum Ausgrid will lose around 33K meters per annum due to the replacement of old meters alone, and
3) The continued take-up of solar panels within NSW will require accumulation meters to be converted to smart meters so households can take advantage of price differences between the prices to import / export electricity to the grid.

Taking these factors into consideration we believe that compared to the meter roll-out in New Zealand, New South Wales smart meter up-take rate is likely to exhibit slightly different characteristics. As occurred in New Zealand, there is unlikely to be a significant delay with smart meter uptake commencing immediately due to meter replacements (rather than the period prior to uptake in 2008 for the New Zealand rollout) but at a lower take-up rate due to the absence of any smart meter compliance deadline in New South Wales.

[9] *Murray and Black, Page 16 Developments in the New Zealand market for Advanced Metering Infrastructure and related services*

The Ausgrid forecast has a take-up rate that is similar to the New Zealand rollout since 2008

The graph below includes Ausgrid's actual forecast alongside the smart meter roll-out rate in New Zealand since 2008. Also included is an estimated low case based on Ausgrid's historic meter replacement rate (33K per annum) and an estimate for future solar installations on Ausgrid's network (16K per annum).

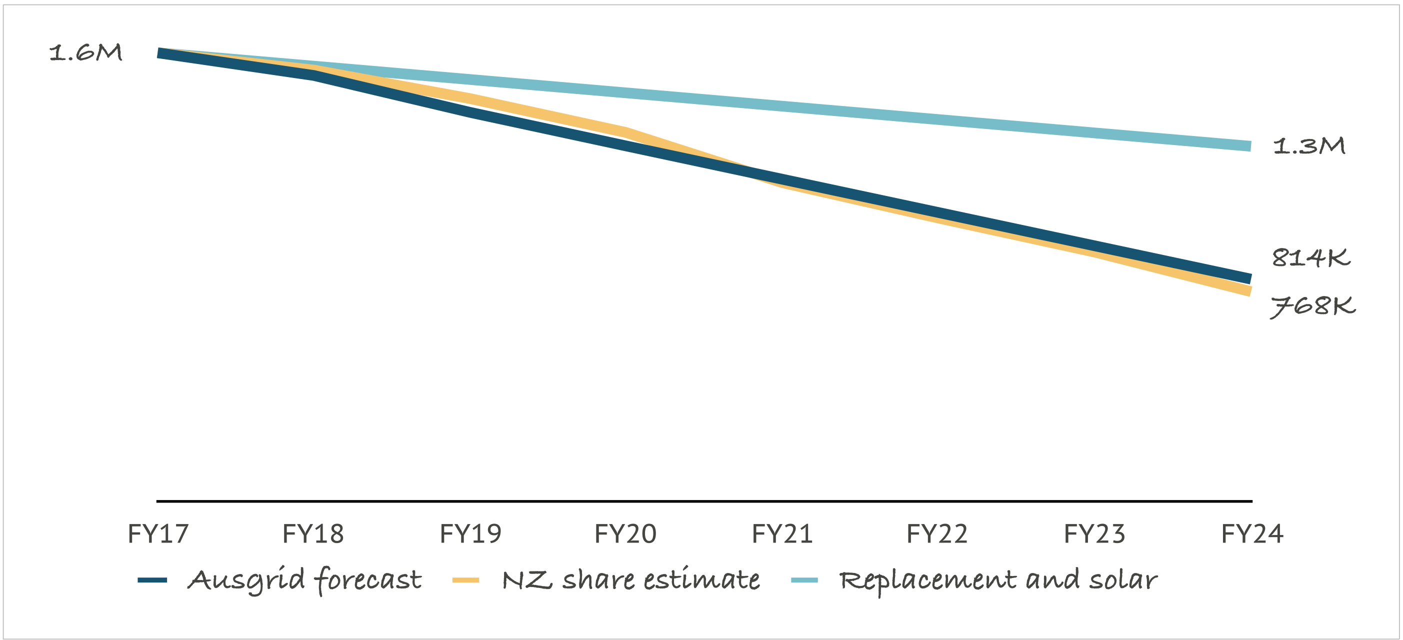


Figure 2: Ausgrid's type5&6 meter forecast

The graph above shows that Ausgrid is forecasting a similar smart meter rollout rate as occurred in New Zealand between 2008 and 2015. Whilst not a mandated rollout, New Zealand did have a trigger date for which electricity retailers were required to certify customer meters and original responsibility for metering services was already with electricity retailers prior to the rollout. It is likely that this deadline, along with declining technology costs, played an important role in driving the smart meter rollout in New Zealand. Meter changes in New South Wales have so far not included a deadline for the rollout of smart meters - for this reason we believe that whilst Ausgrid's meter churn forecast lies within a range of plausible scenarios it should be considered an upper bound of considered scenarios.

2

Average meter reading costs will increase with a declining meter population

The introduction of competition in the metering services market and the push to replace manually read meters with smart meters will result in the eventual decline of Ausgrid's type 5&6 meter population. This reduction will result in lower total meter reading costs over time. However, it also means an increase in average meter reading costs as readers are travelling longer distances between meter reads and fixed costs are spread across a smaller meter population. This chapter identifies the role of fixed and variable costs in providing metering services and examines the changes in average meter reading costs that have occurred in Victoria since 2009.

A declining meter population means a reduction in meter density

In FY17 Ausgrid had 1,650K meters (NMIs) across 39,000 km[10] of network. Ausgrid's forecast indicates that by FY24 this number will have declined to 870K, this represents close to a halving of Ausgrid's meter population and meter density over the next seven years.

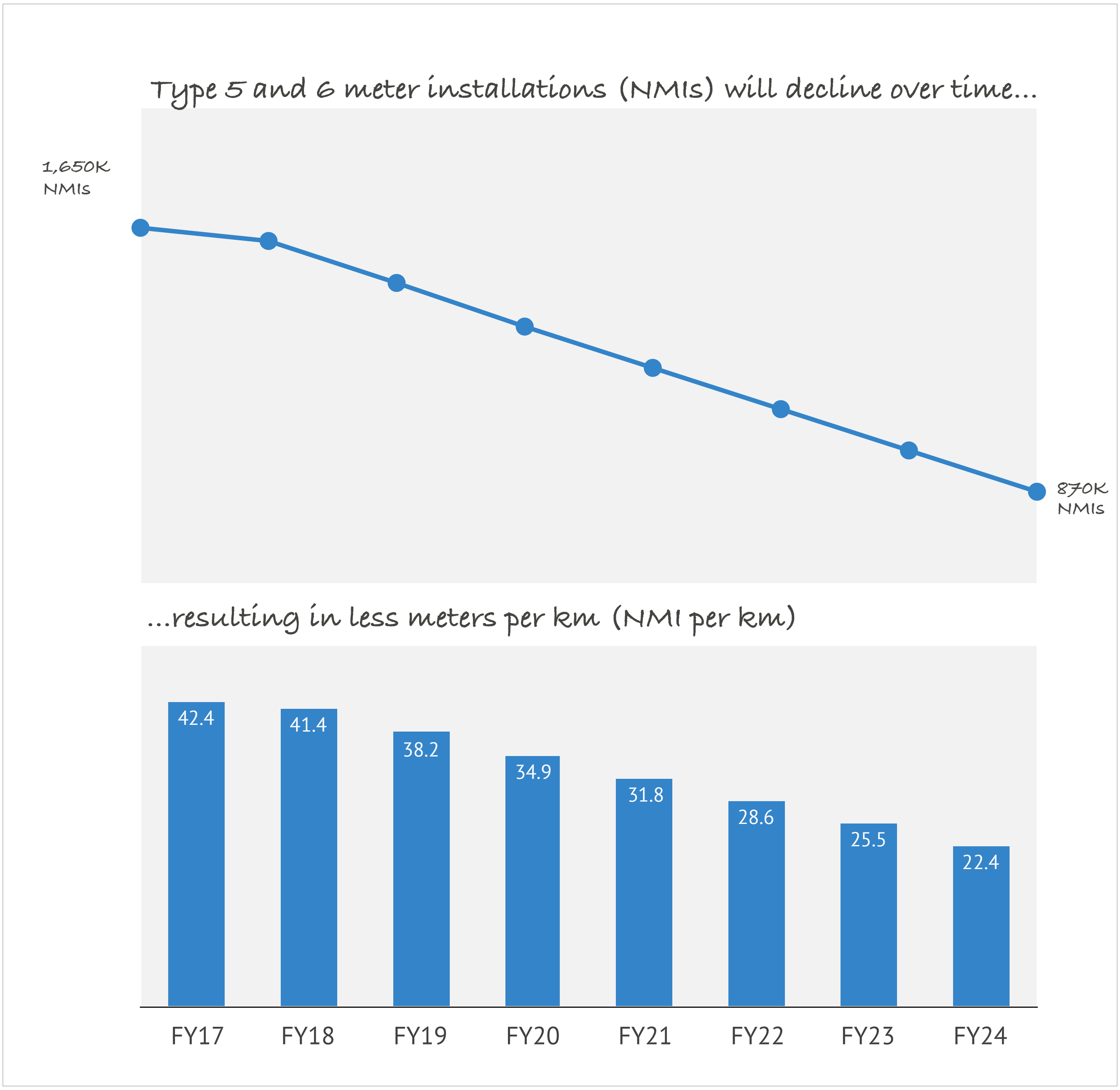


Figure 3: Decreasing Meter Volume and Density

[10] *Network length and densities are measured in route km*

Declining density introduces diseconomies of scale for meter reading

Meter reading costs will not decrease proportionally with Ausgrid's meter population and nor will total metering opex. This is due to the presence of fixed costs in metering opex that are independent of meter numbers (for example, IT and communications costs) and the presence of both fixed and variable costs in the meter reading activity itself.

Identifying costs that are fixed and variable

Ausgrid's FY17 metering opex[11] consisted of:

1. Fixed costs that will remain constant over the forecast period;
2. Fixed costs that will exhibit a step change down with the change in metering regulation (this includes costs that will be eliminated altogether);
3. Fixed costs that will exhibit a step change up with the change in metering regulation; and
4. Variable costs that will:
    - Decrease directly with meter volumes; or
    - Decrease with meter volume, but with a diseconomy of scale factor.

The proportion of each of of these cost categories in FY17 is detailed below, 84% of metering opex can be considered variable, around a third of which is subject to diseconomies of meter density. Each metering activity along with its allocation as fixed or variable is included in Appendix C.

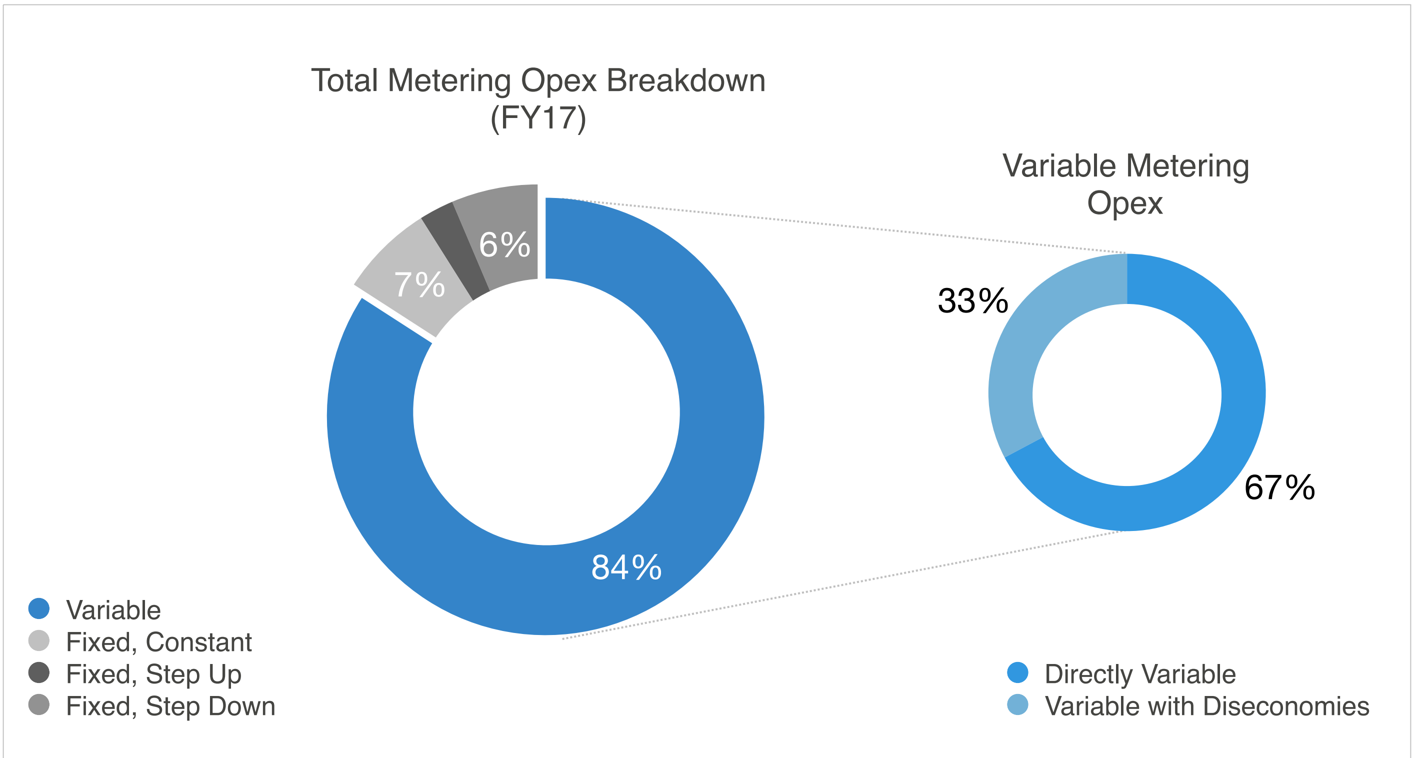


Figure 4: Fixed and Variable Metering Opex

[11] *Unless identified as direct metering, metering opex includes direct metering expenditure and indirect overheads allocated in accordance with Ausgrid's Cost Allocation Methodology. Overheads are included within the Variable category as metering revenue will decline with meter population*

The breakdown of these different costs is displayed in the table below. In FY17, variable costs (costs that decline in proportion to the number of meters) accounted for around 84% of metering opex with the remaining 16% categorised as fixed costs. These fixed costs include activities such as network communications costs, network compliance costs and MBS support services and are costs that are incurred independently of the meter population - i.e it is irrelevant wether the meter population is 1.6M or 870K these costs will remain the same. Whilst most fixed costs are forecast to remain constant or step down there is a small proportion that is forecast to increase - this is for activities such a final type 5 meter reads that will increase as meters are transferred from Ausgrid to retailers.

		FY17 ($)	FY17 (%)
Interval data services	Fixed, constant	$0.57M	16%
	Fixed, step up	$0.32M	9%
	Fixed, step down	$0.37M	10%
	Variable	$2.37M	65%
	Total	**$3.63M**	
Meter data operations	Fixed, constant	$1M	28%
	Fixed, step up	$0M	0%
	Fixed, step down	$0.23M	6%
	Variable	$2.38M	66%
	Total	**$3.61M**	
Metering operations	Fixed, constant	$0.12M	3%
	Fixed, step up	$0.3M	7%
	Fixed, step down	$1.02M	22%
	Variable	$3.1M	68%
	Total	**$4.54M**	
Meter reading	Fixed, constant	$0M	0%
	Fixed, step up	$0M	0%
	Fixed, step down	$0M	0%
	Variable	$12.65M	100%
	Total	**$12.65M**	
Total	Fixed, constant	$1.69M	7%
	Fixed, step up	$0.63M	3%
	Fixed, step down	$1.61M	7%
	Variable	$20.5M	84%
	Total	**$24.43M**	

Table 5: Meter reading fixed and variable costs

Scheduled meter reading opex is the largest opex category subject to diseconomies of scale

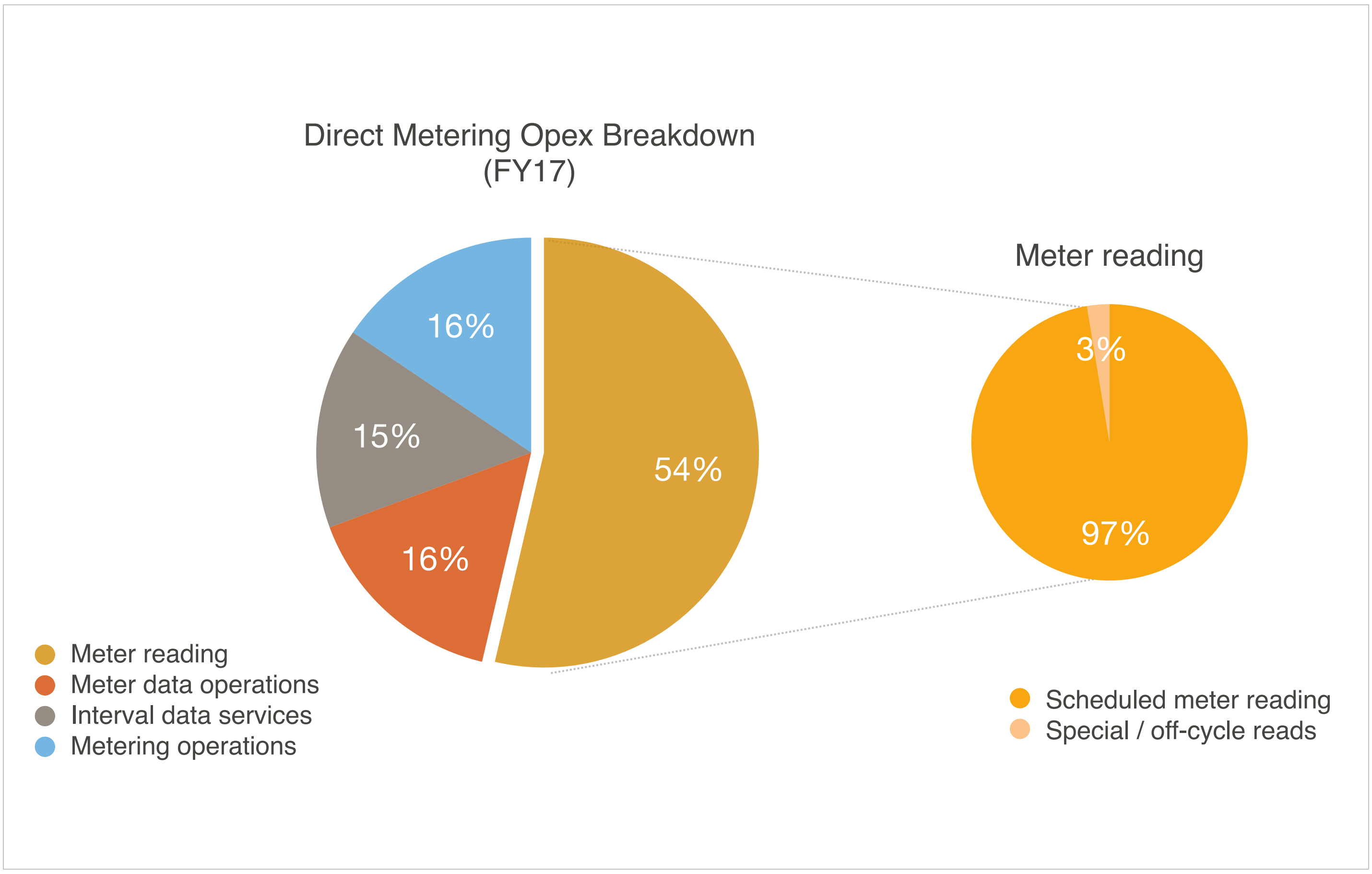


Figure 5: Activity breakdown of direct meter reading costs

Scheduled meter reading expenditure is the most significant cost activity that is variable and subject to diseconomies of density as the meter population declines. In 2017, meter reading costs accounted for just over half of total metering opex. The diseconomies of scale for scheduled meter reading and the non-linear impact on average costs are discussed in the following sections.

Fixed travel costs cause increasing average meter reading costs

When performing meter reading activities there are two types of cost incurred, namely:

1. Costs associated with ***travelling to the meter***, and
2. Costs associated with ***reading the meter.***

Total costs associated with reading the meter are driven by the number of meters read. Costs associated with travelling to the meter (driving and/or walking) are fixed and can be expected to remain fairly constant over time (given the size of the network remains the same size).

This means that as the number of meters in an area declines, the average cost to read each meter will increase as fixed travel costs are spread across fewer meters.

For example, in 2017 Ausgrid had a meter density of 42 meters per km. Considered in terms of one km of network, Ausgrid incurs the cost of travelling one km and the cost of reading the 42 meters - the average cost is therefore the cost of the time taken to travel one km plus the cost of reading 42 meters divided by the number of meters read.

In FY24 Ausgrid are forecasting a meter density of 22 meters per km. Ausgrid will still incur the cost of travelling the one km however the total time taken to read the 22 meters will be reduced. The average cost in FY24 is therefore the cost of the time taken to travel one km plus the cost of reading 22 meters divided by the number of meters read. This leads to a non-linear increase in the average meter reading cost, as shown below.

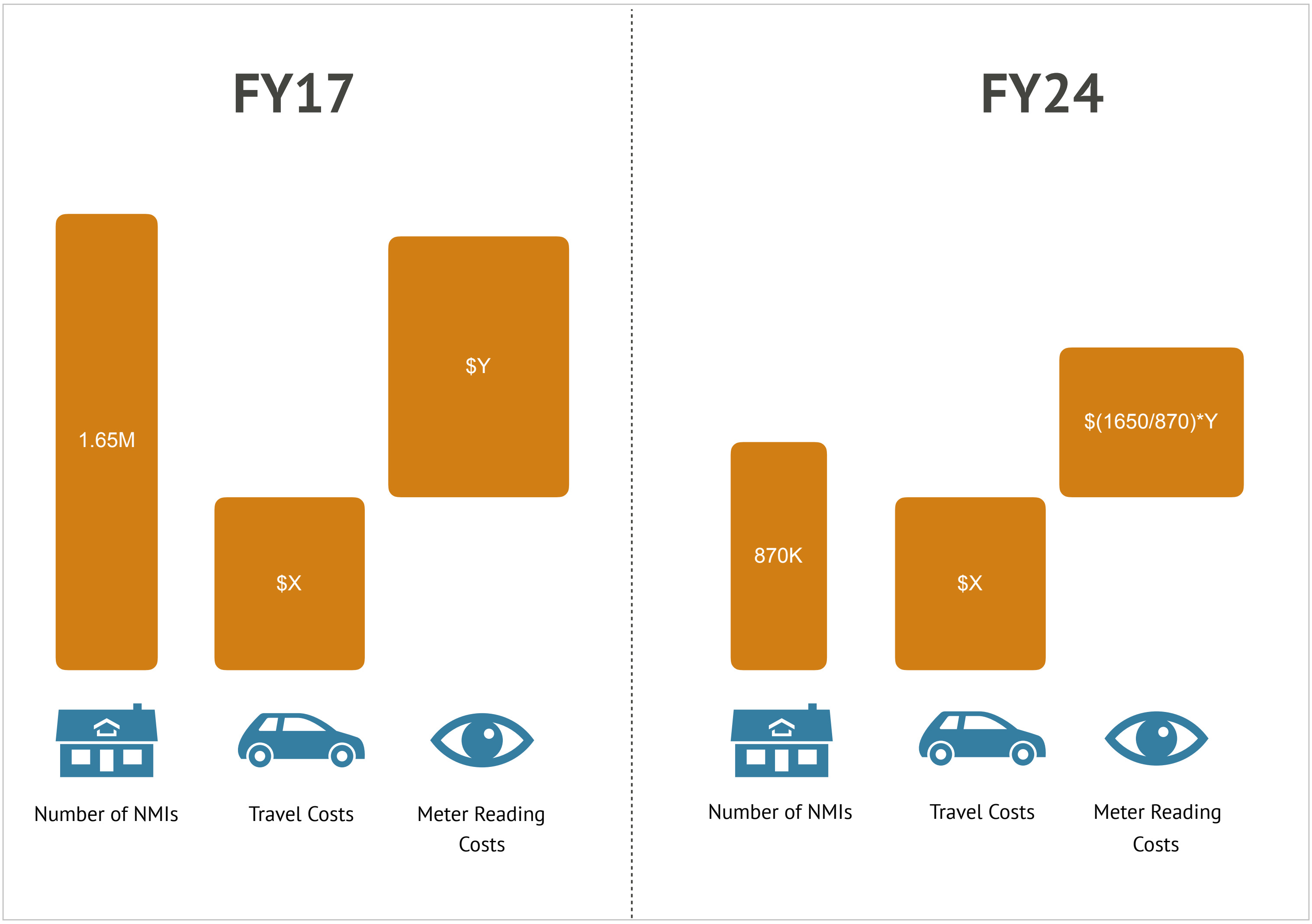


Figure 6: Fixed and variable costs

Increases in average costs are non-linear

When there are fixed costs (travelling to the meter) and costs that vary with output (reading the meter) the average cost of the activity will increase exponentially. This is because as output declines, fixed costs are spread across fewer and fewer units, this relationship is displayed in the example below.

Diseconomies of scale is the consequence of fixed costs being spread across fewer meters

Assumptions: Meter reader cost is $50 per hour, it takes 30 seconds to read a meter, and the reader walks at 5km/h.

Fixed cost: At 5km/h it takes 12 minutes to walk one km. The cost of walking one km is (12 / 60 * $50) = $10.

Variable cost: The cost of 30 seconds per meter read (30 / 3600 * $50 = $0.42) multiplied by the number of reads.

Average cost for a business with 50 meters per km = ($10 / 50 meters) + $0.42 = $0.62

Average cost for a business with 10 meters per km = ($10 / 10 meters) + $0.42 = $1.42

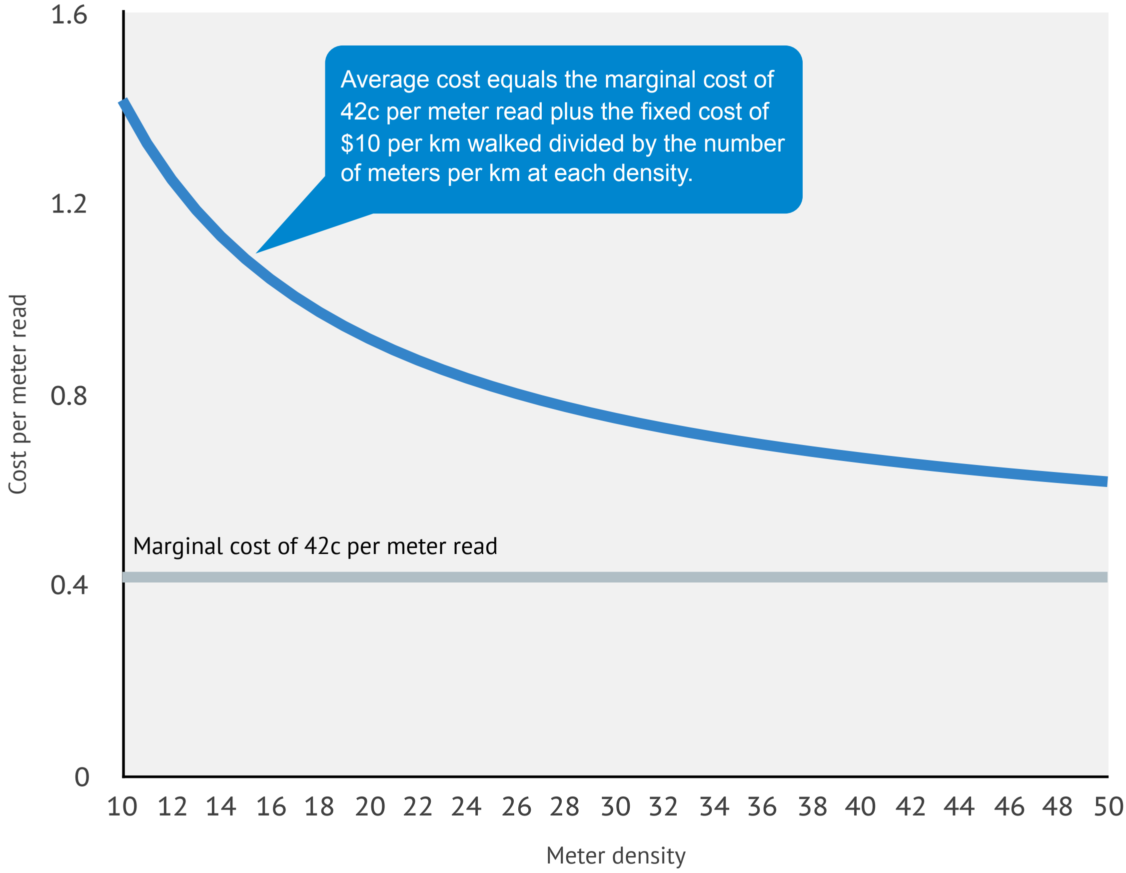


Figure 7: Increases in unit costs are non-linear

Scheduled meter reading costs in Victoria highlight the relationship between density and cost

The average meter reading costs incurred by the Victorian distribution networks since 2009 provides an insight into the relationship between manually read meter populations and scheduled meter reading costs. With the statewide rollout of the Advanced Metering Infrastructure (AMI) program, each of the Victorian networks have experienced significant declines in their respective meter populations[12]. These declines offer a useful example of the impact that declining meter density has on meter reading unit costs. Between 2009 and 2016 the number of scheduled meter reads (type 5&6) for CitiPower, Powercor, AusNet Services and United Energy declined from 10.7M to 1.6M per annum.

The graphs below use the scheduled meter reading costs and the number of type 5&6 meters from the publicly available Category RIN data. The data below includes CitiPower, Powercor, AusNet Services and United Energy - Jemena's data has not been included as it is unavailable.

As the number of type 5&6 meters in Victoria has declined the average cost to read them has increased

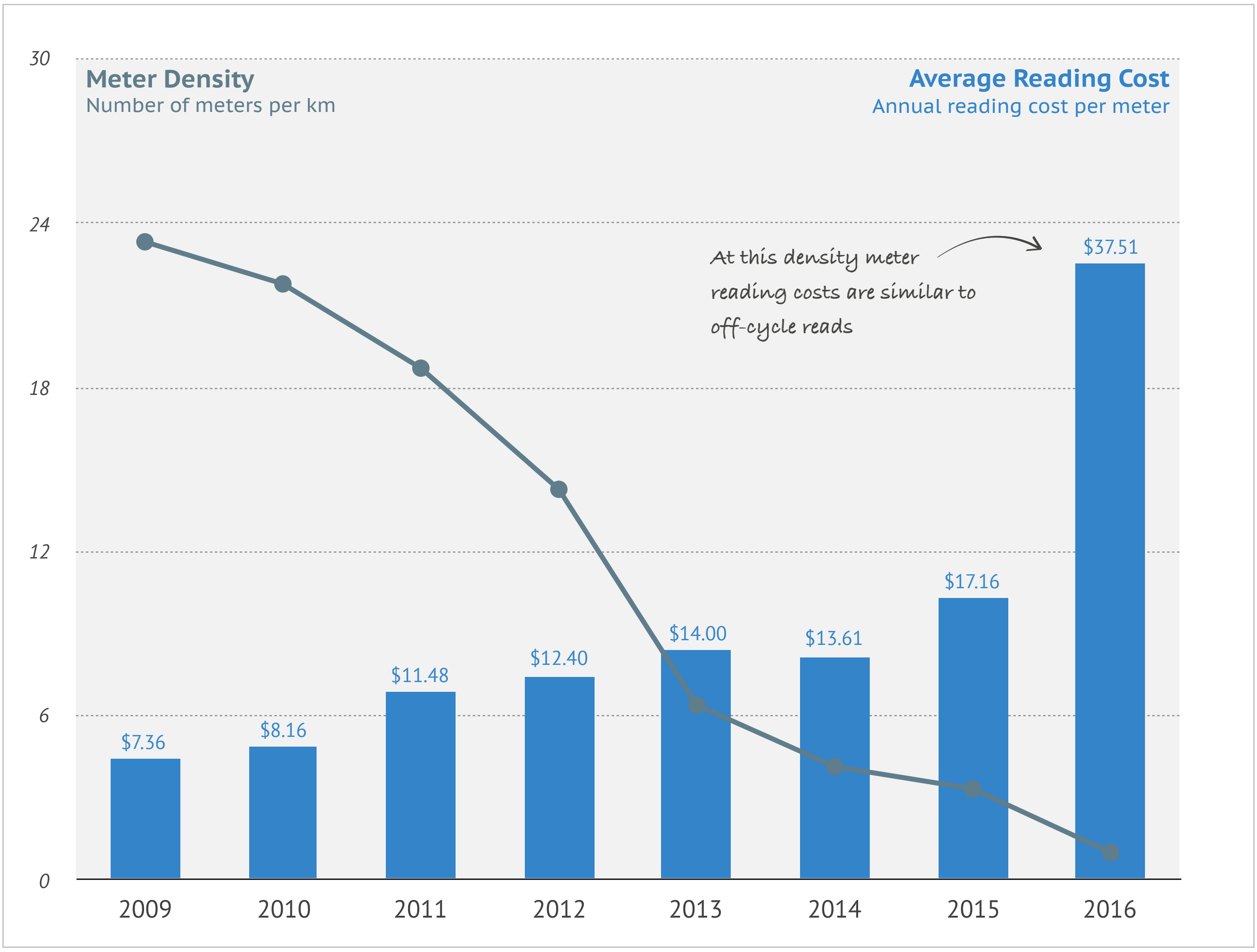


Figure 8: Victorian Increasing Unit Cost with Decreasing Density

[12] *Throughout this report unless otherwise specified, meter refers to Type 5 (manually read interval meters) and Type 6 (Manually read accumulation meters)*

These increases have been non-linear

Disaggregating the average meter reading annual costs for each network shows that declining meter density has resulted in increasing average meter reading costs for all networks in Victoria. Again, Category RIN data has been used (scheduled meter reading costs and the number of type 5&6 meters) and costs have been converted to $16.

The graph below includes data for Powercor, CitiPower, United Energy and AusNet Services.

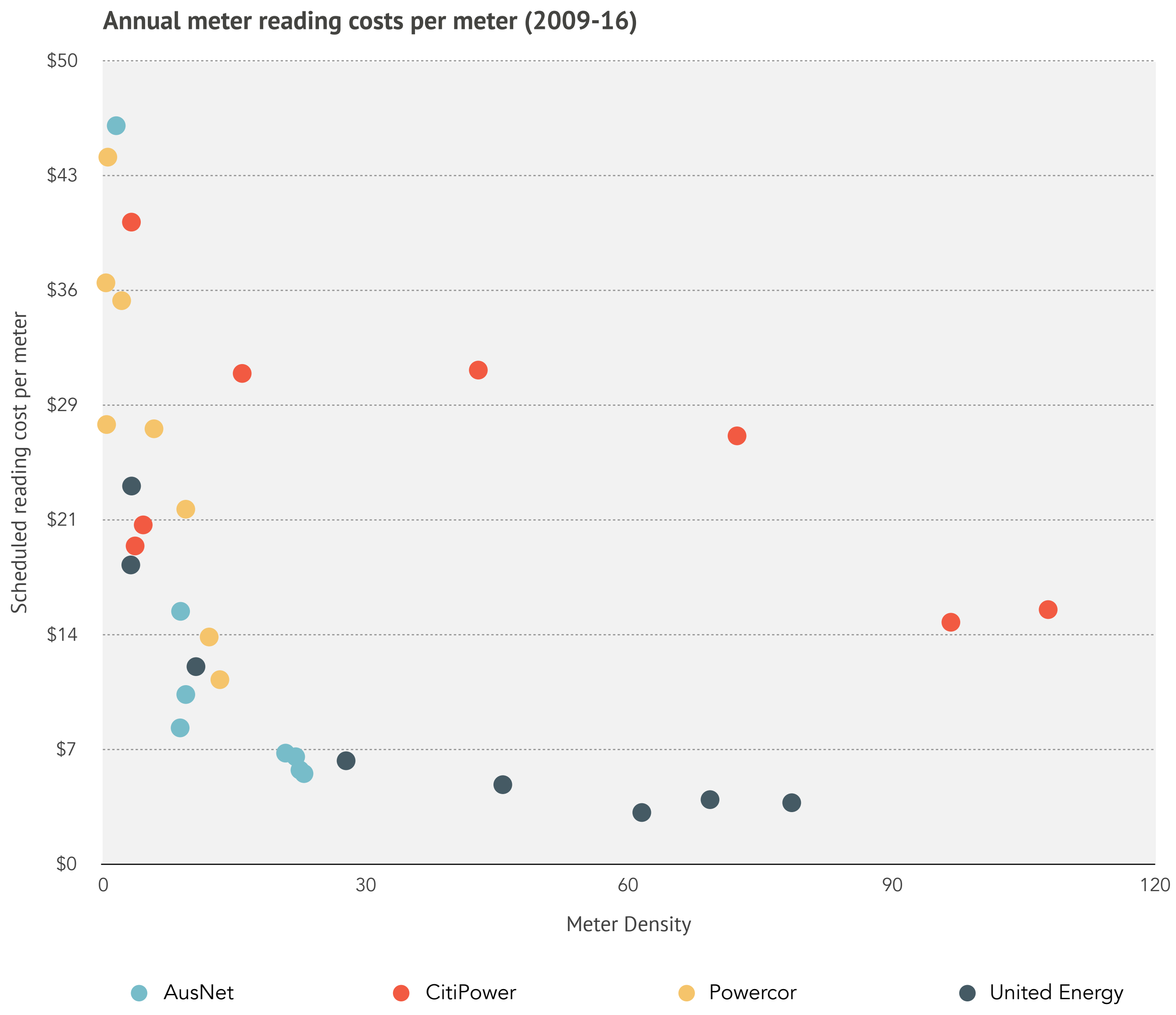


Figure 9: Victorian Unit Costs and Meter Density - 2009 to 2016

The case for combining CitiPower and Powercor

When meter reading costs are disaggregated by network, as in Figure 9, CitiPower appear to be a clear outlier with much greater per unit costs than United Energy despite having similar meter densities over time. With a predominantly CBD network it could be argued that meter reading costs in the CBD are significantly higher than the urban area United operates within. However a 2005 report by Energy Consulting Group (ECG) on behalf of the Essential Services Commission suggested that meter reading costs between a distributor with an Urban-CBD mix (CitiPower) and a predominantly urban mix (United Energy) were likely to be negligible[13].

We believe a more likely explanation of CitiPower's high per unit costs in the context of their meter density is the way costs are allocated between CitiPower and Powercor. Whilst it is difficult to identify exactly how costs have been split, CitiPower and Powercor's meter reading is undertaken through a single fixed price contract managed by CHED Services, with Meter Data Service costs allocated between CitiPower and Powercor on the basis of Full Time Equivalents (FTE) of each business[14].

Between 2009-16 scheduled meter reading costs for CitiPower and Powercor combined were $69M. On average, CitiPower had 515 employees over the sample period whilst Powercor had 1,381. Splitting the total costs between the two businesses by the respective employee numbers would allocate $19M to CitiPower and $50M to Powercor. The actual reported scheduled meter reading expenditure for the two businesses over the period was $20M and $49M respectively. We believe that meter reading costs are more likely to have been split using FTEs' as the cost drivers rather than the actual meter reading costs each business has incurred.

ECG's report to the Essential Services Commission suggested that average unit costs for a network with Powercor's characteristics would be double that of a network with Citlpower's characteristics[15]. Looking at the table below, it is clear that with the exception of 2014 the relative meter reading costs have been much different to those anticipated.

Average Cost (p.a)	2009	2010	2011	2012	2013	2014	2015	2016
CitiPower	15.8	15.0	26.7	30.8	30.6	21.1	19.8	40.0
Powercor	11.5	14.1	22.1	27.1	35.1	44.0	27.4	36.2
Ratio (actual)	**0.7**	**0.9**	**0.8**	**0.9**	**1.1**	**2.1**	**1.4**	**0.9**
Ratio (expected)	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Table 6: CitiPower and Powercor Comparative Unit Meter Reading Costs

The assumption by ECG that the average meter reading costs for Powercor would be double that of CitiPower is a reasonable one, but the manner in which CitiPower and Powercor's metering contract costs are allocated to each business skews the unit costs away from what would be more reflective of the actual costs incurred.

If we are trying to identify the change in average meter reading costs caused by the change in meter density then the best way to overcome the difficulties imposed by CitiPower and Powercor's cost allocation methodology is to treat them as a single company - in effect, taking the total costs of meter reading before they are allocated to each business. By treating CitiPower and Powercor as a single

[13] *Page 40, Review of the Interval Meter Rollout, Energy Consulting Group, 1 June 2005*

[14] *Page 21, Powercor Australia CAM, April 2014*

[15] *Page 40, Review of the Interval Meter Rollout, Energy Consulting Group, 1 June 2005*

business it is more likely that we will get a true indication of the change in costs associated with changing meter densities over time.

Figure 10 below shows the average annual meter reading cost per meter against customer density with available Victorian data and CitiPower / Powercor data combined. There is clear evidence that the unit costs of both the individual businesses and the collective increase as the meter density decreases and that the increase is not linear.

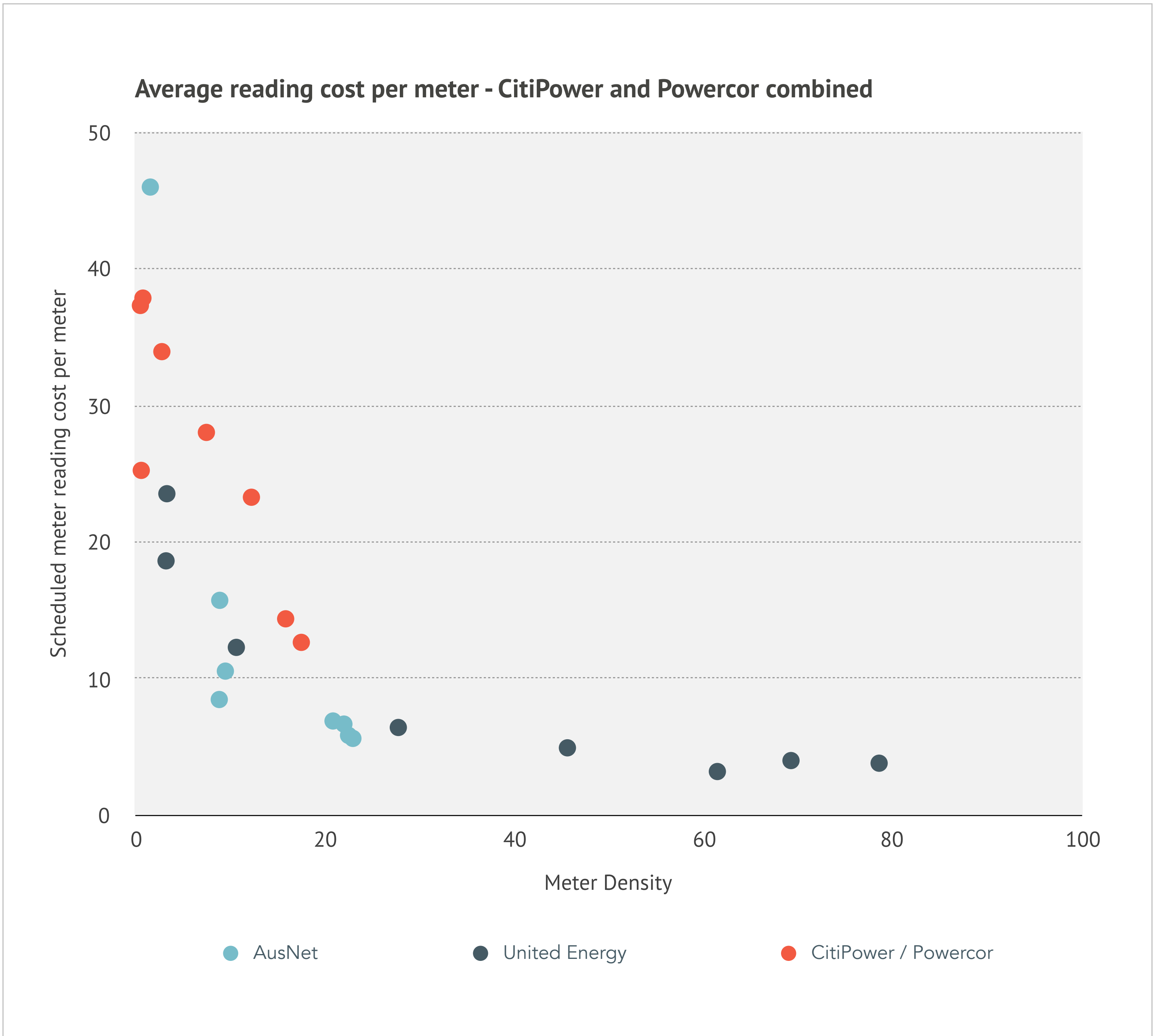


Figure 10: Victorian Unit Costs and Meter Density - 2009 to 2016, CitiPower and Powercor combined

3 Estimating the change in metering costs

We have used three different methods to estimate the relationship between meter density and scheduled meter reading expenditure. These are;

- A bottom up model,
- A top down cost function, and
- the use of models developed in the United Kingdom

Estimates from each of the three approaches yield similar results for forecasts of scheduled meter reading expenditure in FY24 and meter reading unit costs over time. These estimates are then combined with costs that vary directly with the meter population and fixed costs to provide an estimate of total meter costs through to FY24.

Forecasting scheduled meter reading expenditure

To forecast Ausgrid's meter reading expenditure we need to estimate a diseconomies of scale factor that can be applied to scheduled meter reading costs over time as Ausgrid's type 5&6 meter population declines. In this chapter we have used three different techniques to estimate a diseconomy factor. These are;

1) A bottom up model that estimates changes in scheduled meter reading costs based on identified relationships between type 5&6 meter reads,
2) A top down model that incorporates scheduled meter reading expenditure from other DNSPs, and
3) Meter reading models that have been used overseas.

Once a diseconomies of scale factor has been estimated, scheduled meter reading costs have been added to costs identified as fixed or directly variable to estimate Ausgrid's meter reading costs through to FY24.

Estimating scheduled meter reading expenditure from the bottom up

A bottom up approach uses information specific to Ausgrid to build up an estimate of meter reading costs given Ausgrid's meter population forecast.

The benefits of a bottom up approach

The benefits of a bottom up approach are that it uses Ausgrid's actual information rather than an industry average to estimate a relationship between meter numbers and meter reading expenditure. A bottom up approach would be favourable to an industry cost function where there are operating factors unique to Ausgrid that cannot be measured in an econometric model (for example if there is insufficient data or if businesses measure metering activities differently).

The bottom up approach

To forecast meter reading expenditure from the bottom up we have relied on three key relationships. These are;

1. Type 5 cost = Travel cost + Type 5 reading cost
2. Type 6 cost = Travel cost + Type 6 reading cost
3. Type 5 meter read cost = 3 x Type 6 meter read cost

The first two relationships posit that the average costs of a type 5 and type 6 meter read are composed of a travel component and a variable meter reading component and that the average travel cost is the same whether the meter reader is attending a type 5 site or a type 6 site. The third relationship is based on Ausgrid's type 6 meter readings being undertaken through a meter probe that takes 30 seconds to download the required meter information and an estimate of 10 seconds for a type 6 meter read.

Using these three relationships and the average costs of type 5 and 6 meter readings we can solve each of the three unknown variables (travel cost, Type 5 reading cost, Type 6 reading cost) and construct a bottom up forecast of meter reading expenditure. Note that the average costs reflect annual costs per meter. When converting to a per read basis we have assumed that each meter is read quarterly.

Firstly, we can calculate the average Type 5 and Type 6 costs per meter from the RIN data which tells us total scheduled meter reading cost and the number of meters in 2016. Table 4 shows the average cost of each type.

	Scheduled Meter Reading Cost (2015/16)	# Directly Connected Meters (2015/16)	Average Cost (2015/16)
Type 5 meter	$3,056,627	651,680	**$4.70**
Type 6 meter	$4,012,032	1,720,716	**$2.33**

Table 7: Average Meter Reading Costs by Meter Type

Now that we know the average Type 5 and Type 6 costs per meter, and we have assumed that the actual meter read cost of Type 5 is three times that of Type 6, we can solve the three equations for the travel cost and the reading costs for each meter type. The results of that analysis are presented below in Table 8.

Basis	Type	Travel	Read	Total
per annum	Type 5	$1.15	$3.56	$4.70
	Type 6	$1.15	$1.19	$2.33
per read	Type 5	$0.29	$0.89	$1.18
	Type 6	$0.29	$0.30	$0.58

Table 8: Travel, Reading and Total Meter Read Costs per Annum and per Read

Combining the unit costs from Table 8 with the Ausgrid forecast of meter population to 2024 allows us to calculate the annual cost per NMI, quarterly costs per NMI and finally the associated total meter reading opex per annum over the forecast period. These results are shown in Table 9.

	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Cost per NMI (annual)	$4.26	$4.27	$4.31	$4.45	$4.63	$4.83	$5.07	$5.37	$5.75
Cost per NMI (quarterly)	$1.07	$1.07	$1.08	$1.11	$1.16	$1.21	$1.27	$1.34	$1.44
Total cost	$7.08M	$7.05M	$6.95M	$6.62M	$6.28M	$5.96M	$5.64M	$5.32M	$5M

Table 9: Bottom Up Forecast of Annual Meter Reading Costs

Sense check:

We can use these estimates to construct an estimated hourly rate that Ausgrid is currently paying for its scheduled meter reading.

On average an Ausgrid meter reader visits 300 sites a day[1]. Using the ratio of metering customers to directly connected meters from 2015/16 (1.43 meters per NMI) and the proportion of the network with a Type 5 meter (0.275) we can estimate a daily cost per meter reader.

Number of sites visited = 300

Total number of meters read = 300*1.43 = 429

Number of type 5 meters read = 429*0.275 = 118

Number of type 6 meters read = 429*(1-0.275) = 311

Total travelling costs of visiting 300 sites = 300*0.29 = $86

Costs of reading type 5 and type 6 meters = 118*0.30 + 311*0.89 = $197

Daily cost per meter reader = $283

Hourly rate (7 hour workday) = $40.42

An hourly rate of $40.42 is a reasonable estimate particularly given that it includes the markup for overheads and profit by the contractor responsible for meter reading. For example if we assume a 30% markup then hourly rate is $28.30 for the meter reader and $12.13 for the contractor.

[1] http://www.ausgrid.com.au/Common/Customer-Services/Homes/Meters/How-meters-are-read.aspx#.WVRlsRN95-U

Estimating scheduled meter reading expenditure from the top down

A top down approach uses an estimated industry cost function to identify the relationship between changes in meter population (and other variables) and changes in meter reading expenditure. One of the advantages of a top down, econometric approach is that it uses a larger dataset by incorporating data from other businesses that are performing similar tasks and can also allow for year on year noise in the data. For example, if the 2015/16 Ausgrid data (meter readings costs or volumes) had been measured incorrectly or if 2015/16 was an anomalous year then a bottom up estimate using that data will result in a biased estimate, whereas the top down approach "dilutes" this bias across a larger dataset.

An econometric model is useful in identifying changes in the dependant variable (meter reading opex) relative to changes in the explanatory variables after accounting for other environmental factors. In this case we are seeking to measure the change in meter reading expenditure given changes in the meter population (i.e a 1% change in the meter population will result in an x% change in meter reading expenditure). The environmental factors we have included within the econometric model are the share of type 5 meters between DNSPs and the proportion of business customers. Comparisons of these environmental variables are provided below.

Environmental factors included

Share of Type 5 meters

Relative to other networks in the sample, Ausgrid have a high proportion of type 5 meters. This is compounded by the way in which type 5 meter reads are undertaken for Ausgrid in which a probe is used to download the data, taking a longer time per meter read. By contrast, ActewAGL's type 5 meter population is largely comprised of meters that are being read manually[16][17]. If there are differences between the networks in the way in which different meter types are read then it will be difficult, particularly given the limited dataset and uncertainties around how costs have been allocated among other networks, to use the coefficients from an industry cost function with a high degree of confidence.

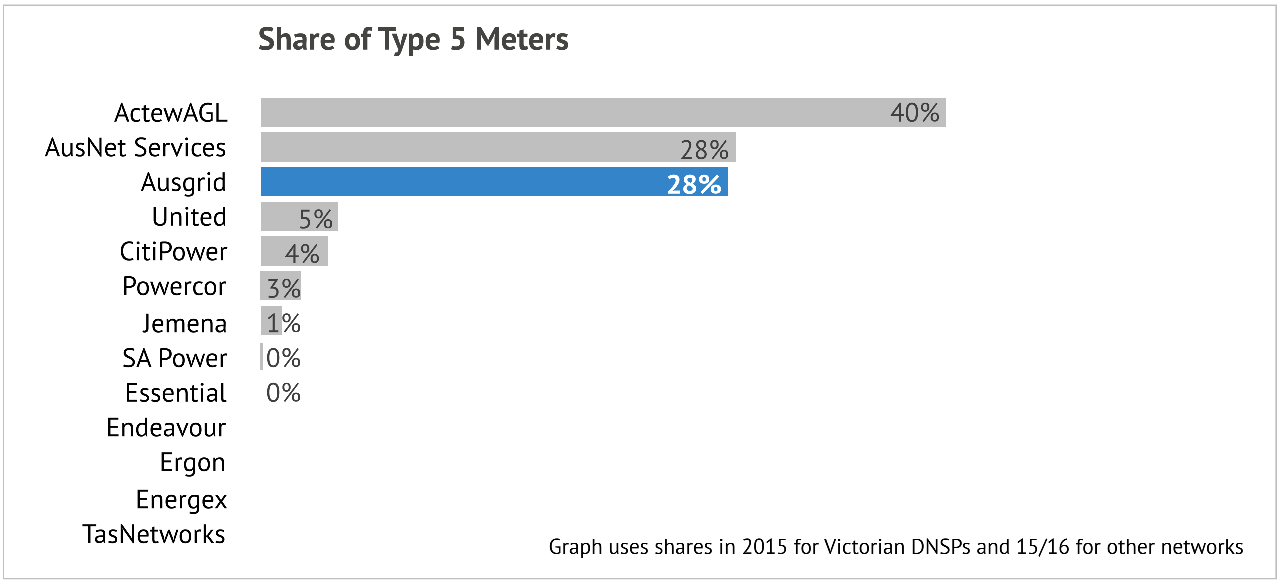


Figure 11: Proportion of Type 5 Meters by Network

Proportion of business customers

The demographics of each network's customer base varies. Meter reading times will vary between site types. Commercial centres may have more meters in close proximity to each other, however access to the site may be more problematic. If the time taken to read meters varies by the type of customer, coefficients from a single industry cost function will exhibit bias against some networks. Figure 12 shows the variation of non-residential customers across networks.

Figure 12: % of customers classified as non-residential

[16] *Page 10, ActewAGL Meter Asset Management Plan, https://www.aer.gov.au/system/files/ActewAGL%20-%20D6%20Distribution%20MAMP_V2%205%20-%202014.pdf*

[17] *Page 254 ActewAGL 2008 Regulatory proposal*

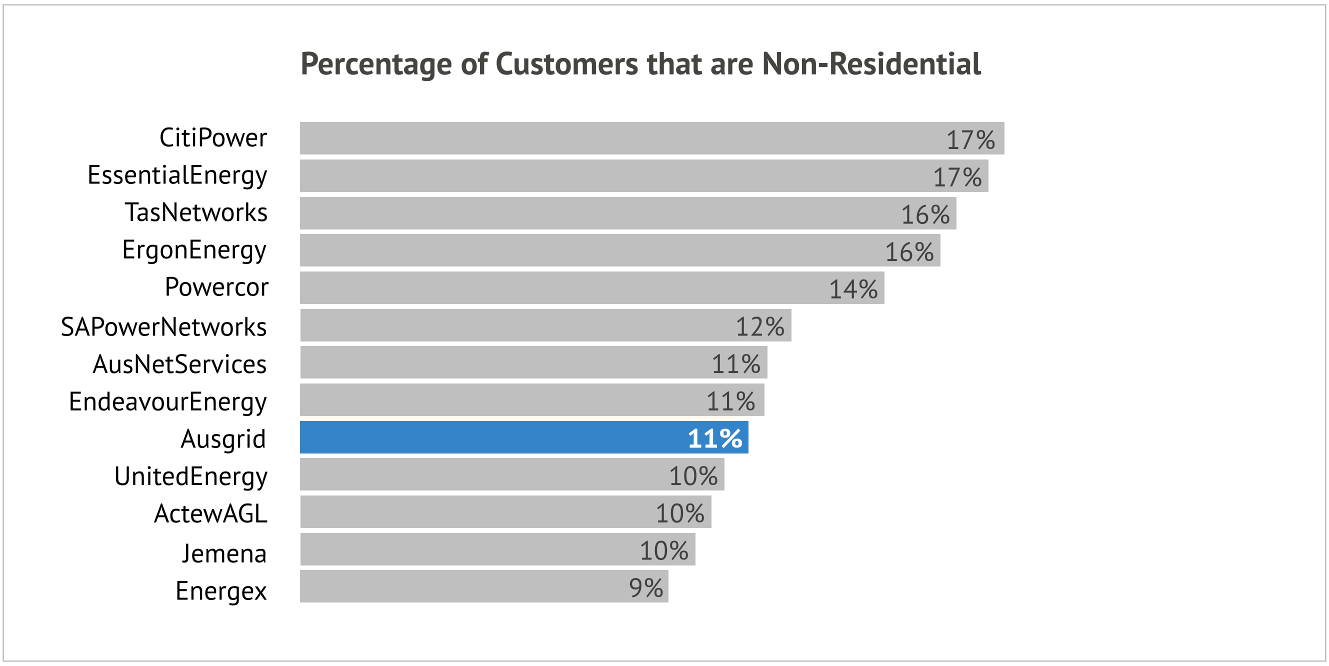


Figure 12: % of customers classified as non-residential

The top down model

The technique we have used to develop a metering cost function is a two-step Prais Winsten Feasible Generalised Least Squares (FGLS) procedure using the *panelAR* package in R[18]. This approach is a variant of Ordinary least Squares (OLS) which attempts to address serial correlation in panel data. We have used a Cobb-Douglas cost function to estimate the relationship between meter reading expenditure and different explanatory variables. The estimated cost function is as follows;

$$Cost_{it} = B_0 + B_1 Meters_{it} + B_2 RouteLength_{it} + B_3 ShareType6_{it} + B_4 ShareCommercial_{it} + Year + u_{it}$$

Where;

Cost = Ln(Meter reading expenditure - real $2016)
Meters = Ln(Type5 + Type 6 directly connected meters)
RouteLength = Ln(Average route line length for each business over the sample period)
ShareType6 = Ln(Proportion of directly connected meters that are type 6)
ShareCommercial = Ln(Proportion of non-residential customers for each network)
u = A random error term assumed to have zero mean and constant variance

Note that the equation includes variables for the proportion of meters that are Type 6 and the proportion of customers that are non-residential - the two environmental factors discussed above. The inclusion of these variables will mitigate some of the bias in the industry cost function caused by different circumstances between each network.

The data

The data used has been taken from the publicly available Category and Economic Benchmarking RINs and is included in Appendix A. The sample size is 88 points and includes information for 12 networks[19].

[18] *Estimation of Linear AR(1) Panel Data Models with Cross-Sectional Heteroskedasticity and/or Correlation, Konstantin Kashin*

[19] *Data for Energex, SA Power and ActewAGL has been estimated using Economic and Category RIN benchmarking RINs, all data used is available in the Appendix.*

An adjustment has been made to AusNet Services directly connected meter numbers, the adjusted numbers are included in the Appendix A. Scheduled meter reading expenditure has been estimated for Energex, SA Power and ActewAGL using the Economic Benchmarking RINs as their data is unavailable in the Category RINs, we were unable to estimate Jemena's costs using publicly available data.

The results

The statistical attributes and outputs of the top down model are presented below for two models - one with CitiPower and Powercor combined and one without.

Combining CitiPower and Powercor

Panel Regression with AR(1) Prais-Winsten correction and panel-corrected standard errors
Total observations: 88 Avg obs. per panel 8
R-squared: 0.9905
Wald statistic: 453.75, Pr(>Chisq(5)): 0

Variable	Coefficient	Standard error	t-ratio	Pr(>|t|)
Ln(AvgRouteLength)	0.29	0.07	4.48	2.4e-05 ***
Ln(Connected Meters)	**0.50**	0.05	10.90	< 2e-16 ***
Ln(shareTypeSix)	0.05	0.21	0.26	0.80
Ln(Share business)	0.49	0.46	1.07	0.29
Year	-0.02	0.01	-1.18	0.24
Intercept	49.68	29.11	1.71	0.09 .

Figure 13: Regression results, CitiPower and Powercor as a single business

CitiPower and Powercor as separate networks

Panel Regression with AR(1) Prais-Winsten correction and panel-corrected standard errors
Total observations: 96 Avg obs. per panel 8
R-squared: 0.9889
Wald statistic: 425.2874, Pr(>Chisq(5)): 0

Variable	Coefficient	Standard error	t-ratio	Pr(>|t|)
Ln(AvgRouteLength)	0.12	0.07	1.80	0.0748 .
Ln(Connected Meters)	**0.59**	0.06	9.32	7.32e-15 ***
Ln(shareTypeSix)	0.13	0.24	0.52	0.6057
Ln(Share business)	1.07	0.68	1.58	0.1189
Year	-0.01	0.02	-0.75	0.4536
Intercept	39.85	32.72	1.22	0.2265

Figure 14: Regression results, CitiPower and Powercor as seperate networks

In both models the connected meters and average route length coefficients are statistically significant.

As identified earlier, given their respective cost allocation methods we believe that combining CitiPower and Powercor will provide a more accurate estimate of the change in meter reading expenditure for a change in the meter population.

The connected meter coefficient of 0.50 suggests that diseconomies of scale exist, with a 1% change in meter population (equivalent to a 1% change in meter density as we are keeping route line length constant) resulting in a 0.5% change in scheduled meter reading expenditure.

Incorporating the meter coefficient into the meter forecast yields the following cost estimates for scheduled meter reading.

	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Cost per NMI (annual)	$4.26	$4.28	$4.32	$4.48	$4.68	$4.92	$5.16	$5.48	$5.80
Cost per NMI (quarterly)	$1.07	$1.07	$1.08	$1.12	$1.17	$1.23	$1.29	$1.37	$1.45
Total cost	$7.08M	$7.06M	$6.97M	$6.69M	$6.39M	$6.08M	$5.77M	$5.43M	$5.07M

Table 10: Top Down Forecast of Meter Reading Costs

The top down forecast provides and estimate that is similar to the bottom up approach. It is important to remember that whilst we have incorporated two environmental factors to ameliorate the existence of variations in environmental and operating conditions, there are many more differences across networks that make an industry wide cost function uncertain. For example, whilst we have accounted for the proportion of Type 5 meters, we have not accounted for the difference in read methods for those meters (manual, probe download by Ausgrid versus manually read for other networks such as ActewAGL). In addition, scheduled meter reading expenditure for businesses that have not provided information in the Category RINs has been estimated from a number of different sources.

Estimating scheduled meter reading expenditure from the literature

Much like Victoria, the United Kingdom has also experienced first hand the impact of declining 'dumb' meter numbers and the subsequent impact on meter reading unit costs. Below we use two models based on reports conducted by:

1. Mott MacDonald for the Department of Business, Enterprise and Regulatory Reform (BERR);
2. Frontier Economics for Centrica (a utility company in the UK).

The Mott MacDonald Approach

> *"Meter reading costs would reduce as smart meters penetrate the system, however costs for reading the remaining meters is expected to rise. This is because as smart metering rises, the density of customers on non-smart meters falls, and so the cost per read increases (more travel time between reads)."*
>
> Page 53, Appraisal of Costs & Benefits of Smart Meter Rollout Options, Mott McDonald

The relationship between meter reading costs and meter density used to estimate the inefficiencies associated with declining meter density assumed in the Mott McDonald report is displayed below.

$$c = \mathrm{PRC}\sqrt{M / m}$$

Where c is the meter reading cost, M is the original number of meters, m is the number of meters remaining and PRC represents the original cost of reading a meter (the cost when M=m).

Using this relationship we can estimate the changes in unit cost for Ausgrid as meter density declines. The results are shown in Table 11.

	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Unit cost (per quarter)	$1.07	$1.07	$1.08	$1.13	$1.18	$1.24	$1.30	$1.38	$1.47
Total cost	$7.08M	$7.06M	$6.97M	$6.7M	$6.4M	$6.11M	$5.8M	$5.47M	$5.12M

Table 11: Mott MacDonald Approach Estimate

The Frontier Economics Approach

"Although the costs of meter reading will be lower once all meters can be read remotely, for the period of the rollout there will be an increasing unit cost of dumb meter reads. This is associated with the lower density of such meters and therefore the increase in distance between each dumb meter, leading to higher travel costs and, hence, higher cost per read."

Page 42, Benefits of smart meters for domestic and small business customers, Frontier Economics

The relationship used by Frontier Economics is similar to that of Mott McDonald and is displayed below.

$$c = k / \sqrt{n}$$

Where c = unit meter reading cost, n is the number of meters and k is a constant.

The Frontier Economics report was conducted on behalf of a single business Centrica where k was modelled based on Centrica's advice. We have altered the model slightly to incorporate Australian RIN data by using meter density instead of the number of meters. The results of the approach are shown below in Tables 12 and 13, with CitiPower and Powercor data combined and kept seperate respectively.

	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Unit cost (quarterly)	1.10	1.08	1.09	1.14	1.19	1.25	1.32	1.41	1.51
Total cost	$7.27M	$7.11M	$7.03M	$6.77M	$6.48M	$6.2M	$5.9M	$5.59M	$5.26M

Table 12: Frontier approach estimate with CitiPower and Powercor combined

	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Unit cost (quarterly)	1.06	1.06	1.08	1.12	1.18	1.24	1.31	1.39	1.49
Total cost	$7.03M	$7.01M	$6.93M	$6.67M	$6.39M	$6.11M	$5.82M	$5.51M	$5.18M

Table 13: Frontier approach estimate with CitiPower and Powercor as separate networks

Summary of scheduled meter reading estimates

The forecasts of unit costs, meter reading opex and the associated productivity factor of each of the three approaches (four models) to estimating future scheduled meter reading costs are summarised below.

Unit Costs

All four models employed in this report resulted in a similar forecast of increasing unit cost with decreasing meter volume (and therefore density). Each model supports the hypothesis that the increase in unit cost is non-linear and not directly proportional to the decrease in meters - indicating diseconomies of scale.

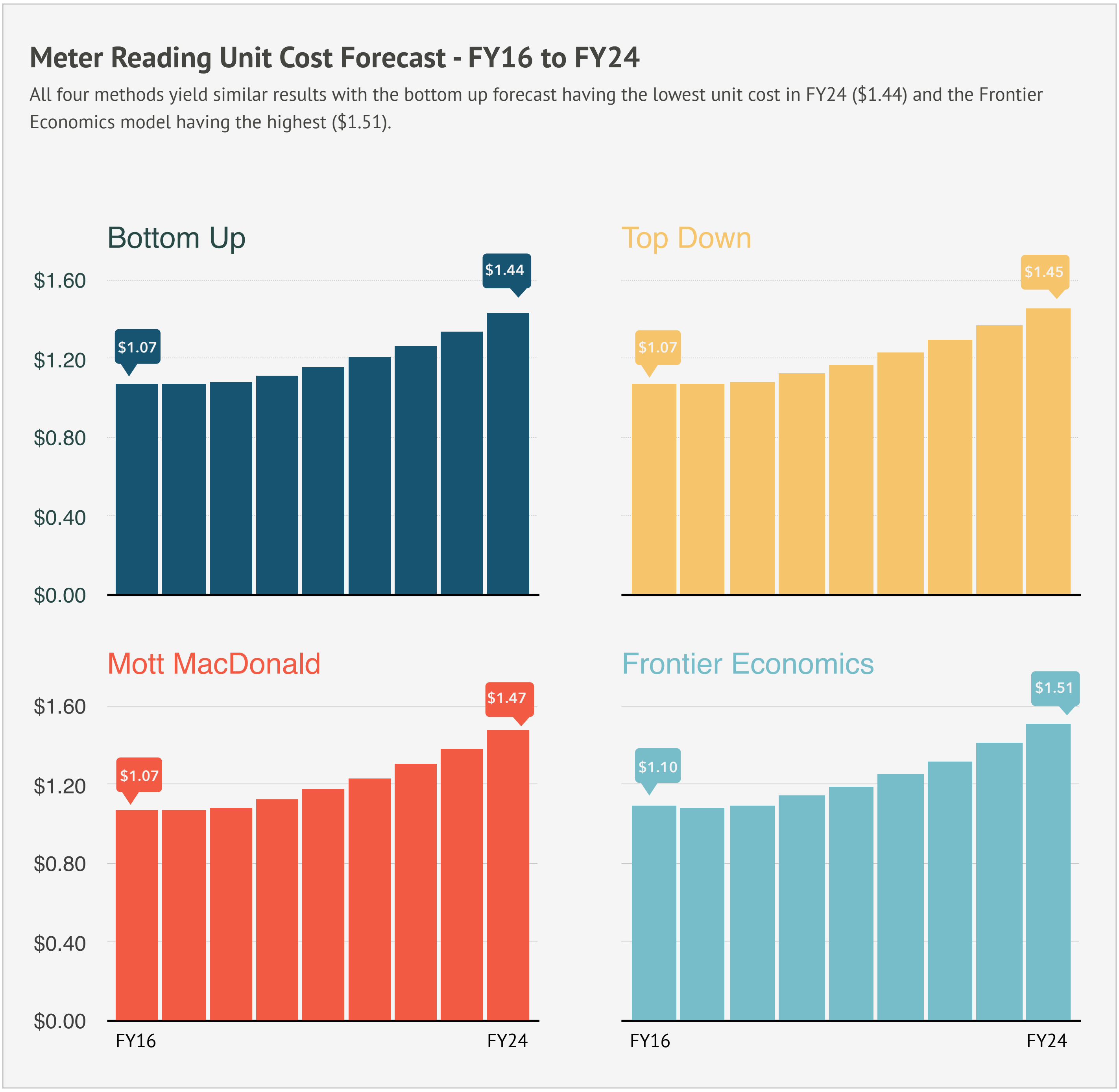
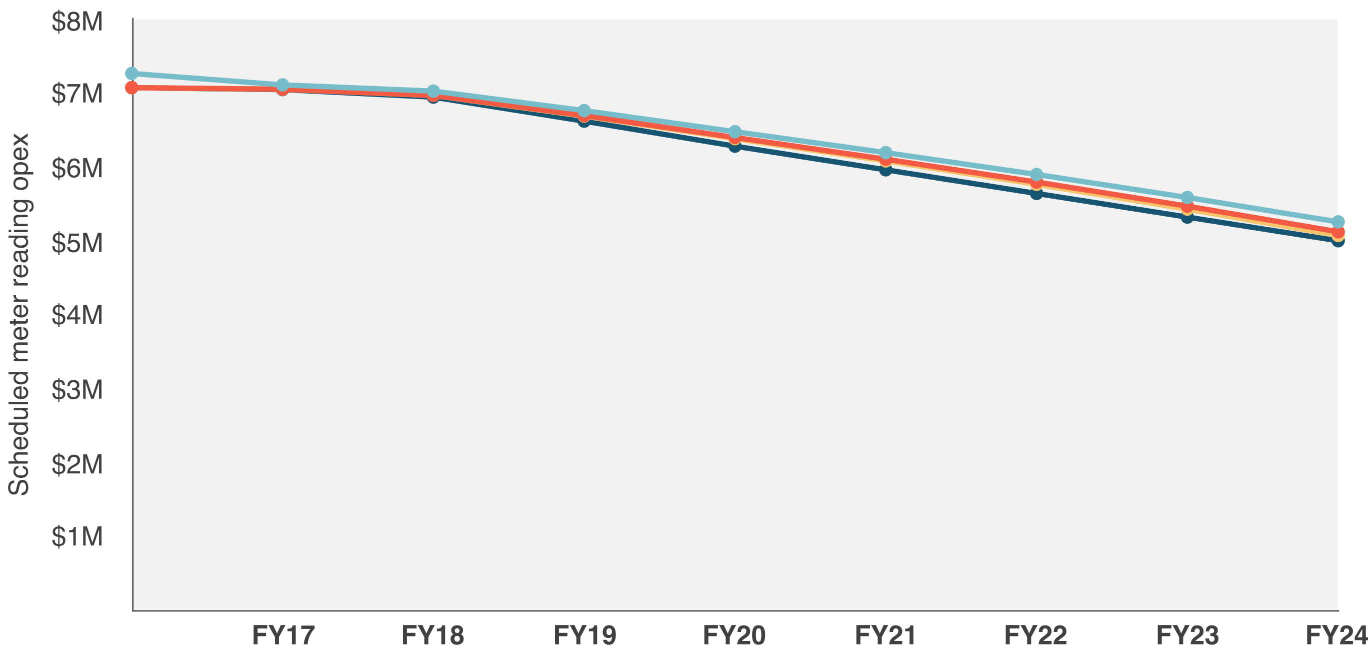


Figure 11: Meter Reading Unit Costs

Scheduled meter reading opex

The unit cost estimates can be combined with the meter volume forecast to produce a meter reading opex forecast over the period to FY24. The forecast using the Frontier Economics approach is consistently higher than the other methods. The top-down method decreases more rapidly in the later years. All four forecasts are very similar over the period, with the Frontier model having the highest meter reading opex and the bottom up method having the lowest as shown below.

Scheduled Meter Reading Cost Forecast - FY17 to FY24*



Frontier	$7.12M	$7.03M	$6.77M	$6.48M	$6.2M	$5.9M	$5.59M	$5.26M
Mott McDonald	$7.06M	$6.97M	$6.7M	$6.4M	$6.11M	$5.8M	$5.47M	$5.12M
Top down	$7.06M	$6.97M	$6.69M	$6.39M	$6.08M	$5.77M	$5.43M	$5.07M
Bottom	$7.05M	$6.95M	$6.62M	$6.28M	$5.96M	$5.64M	$5.32M	$5M

* Note these figures represent direct scheduled meter reading costs

Figure 15: Meter Reading Opex Forecasts

Diseconomies of density factor

A diseconomies of density factor is useful for forecasting opex where a base-step-trend approach is taken. The productivity factor associated with the diseconomy of scale of decreasing meter populations can be interpreted directly from the top down method, using the coefficient for the directly connected meters variable (0.50). That is, for a 1% decrease in meter volume, a resultant 0.5% decrease in meter reading expenditure occurs. For the other methods, a productivity factor can be derived by analysing the relationship of cost with volume over time. The productivity factors associated with each of the methods employed are shown below.

Method	Productivity Factor Approach	Productivity Factor (for 1% change in meters)
Frontier	Derived	**0.48**
Mott MacDonald	Derived	**0.50**
Top down	Observed	**0.50**
Bottom up	Derived	**0.54**

Table 15: Productivity Factors for a 1% Decrease in Meter Population

Incorporating other metering activities

Whilst scheduled meter reading opex comprises the largest direct expenditure category there remains a significant quantity of fixed and directly variable costs that need to be incorporated into a forecast of total meter reading costs. Below we incorporate costs that have been identified as directly variable with meter population, fixed costs (constant, step down and step up) along with a scheduled meter reading estimate to forecast metering opex over time as Ausgrid's meter population declines. The diseconomies of scale factor used to estimate activities classified as 'variable with diseconomies' is the 0.5 coefficient obtained from the top down model. We have used Ausgrid's actual scheduled meter reading costs in FY17 ($6.7M) as the starting point from which to apply the 0.5 scale factor. Costs are reported in $FY17 and an implied productivity factor associated with a 1% change in the meter population is displayed (calculation included in Appendix C).

Cost type	Category	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Fixed	constant	$1.69M	$1.69M	$1.69M	$1.69M	$1.69M	$1.69M	$1.69M	$1.69M
	step up	$0.63M	$1.01M	$1.01M	$1.01M	$1.01M	$1.01M	$1.01M	$1.01M
	step down	$1.61M	$0.53M	$0.38M	$0.16M	$0.16M	$0.16M	$0.16M	$0.16M
Variable	directly variable	$13.78M	$13.52M	$12.46M	$11.38M	$10.35M	$9.33M	$8.31M	$7.29M
	variable with diseconomies	$6.72M	$6.64M	$6.37M	$6.08M	$5.79M	$5.49M	$5.17M	$4.83M
Total		**$24.43M**	**$23.38M**	**$21.91M**	**$20.31M**	**$19M**	**$17.68M**	**$16.34M**	**$14.98M**

Table 16: Forecast metering opex over time

Productivity factor = **0.72** (i.e a 1% change in the meter population results in a 0.72% change metering opex).

Appendix A

Data used

The data used for the top down analysis along with the Victorian annual meter reading costs is included below. All data has been sourced from DNSP Category RIN and RESET RIN data with the exception of the following which have been estimated.

SA Power scheduled meter reading expenditure (2009-16),

Energex scheduled meter reading expenditure (2009-16),

ActewAGL scheduled meter reading expenditure (2009-13)

Network	Year	Meters (Type 5&6)	Scheduled meter reading $	Customer connections	Residential customers	Route length (Average)	CPI
SAPN	2009	1,261,843	3,104,724	814,467	710,517	81,247	0.87
SAPN	2010	1,102,727	3,157,901	826,964	722,673	81,247	0.89
SAPN	2011	1,113,269	3,165,579	836,055	732,016	81,247	0.91
SAPN	2012	1,128,922	3,153,028	844,153	740,569	81,247	0.94
SAPN	2013	1,107,419	3,333,226	847,766	744,732	81,247	0.96
SAPN	2014	1,108,562	3,273,968	851,767	749,228	81,247	0.98
SAPN	2015	1,112,398	3,323,696	853,939	750,596	81,247	1.00
SAPN	2016	1,093,753	3,319,493	858,647	756,227	81,247	1.01
Energex	2009	2,162,613	5,075,958	1,287,436	1,166,386	42,223	0.87
Energex	2010	2,177,052	8,818,265	1,307,554	1,186,164	42,223	0.89
Energex	2011	2,182,845	7,605,666	1,326,564	1,204,327	42,223	0.91
Energex	2012	2,180,107	8,126,868	1,343,865	1,220,644	42,223	0.94
Energex	2013	2,173,927	8,216,843	1,359,712	1,236,601	42,223	0.96
Energex	2014	2,171,379	8,315,900	1,376,483	1,251,769	42,223	0.98
Energex	2015	2,176,294	9,000,137	1,397,191	1,270,554	42,223	1.00
Energex	2016	2,169,611	9,256,636	1,421,522	1,293,967	42,223	1.01
ActewAGL	2009	171,000	805,725	161,092	145,520	4,017	0.87
ActewAGL	2010	176,000	820,036	164,900	149,171	4,017	0.89
ActewAGL	2011	181,000	731,111	168,937	152,911	4,017	0.91
ActewAGL	2012	187,000	1,136,486	173,186	156,926	4,017	0.94
ActewAGL	2013	193,000	919,674	177,255	160,773	4,017	0.96
ActewAGL	2014	205,470	1,246,291	178,710	163,001	4,017	0.98
ActewAGL	2015	201,900	1,481,167	181,851	163,664	4,017	1.00
ActewAGL	2016	204,338	991,494	184,962	166,469	4,017	1.01
Ausgrid	2009	2,048,084	6,744,516	1,586,138	1,408,558	36,986	0.87
Ausgrid	2010	2,116,075	7,786,605	1,596,898	1,417,556	36,986	0.89
Ausgrid	2011	2,231,006	6,931,788	1,608,735	1,426,776	36,986	0.91
Ausgrid	2012	2,307,414	7,136,399	1,621,659	1,437,057	36,986	0.94
Ausgrid	2013	2,375,862	7,710,755	1,635,053	1,448,242	36,986	0.96
Ausgrid	2014	2,360,620	7,614,000	1,651,160	1,463,205	36,986	0.98

Ausgrid	2015	2,379,192	7,740,411	1,669,559	1,482,986	36,986	1.00
Ausgrid	2016	2,372,396	7,077,659	1,688,282	1,504,478	36,986	1.01
AusNet	2009	775,677	3,902,028	638,614	561,907	35,177	0.88
AusNet	2010	791,530	3,934,483	645,695	569,316	35,177	0.90
AusNet	2011	758,778	4,601,145	654,641	579,329	35,177	0.93
AusNet	2012	719,084	4,612,233	668,703	592,782	35,177	0.95
AusNet	2013	304,266	2,458,606	681,299	605,679	35,177	0.97
AusNet	2014	326,542	3,361,786	685,194	611,407	35,177	0.99
AusNet	2015	306,038	4,776,341	706,424	625,706	35,177	1.01
AusNet	2016	52,848	2,450,078	712,767	631,775	35,177	1.02
Citipower	2009	327,435	4,482,310	305,985	253,671	3,093	0.88
Citipower	2010	293,745	3,924,829	310,175	256,753	3,093	0.90
Citipower	2011	219,673	5,345,425	314,440	260,118	3,093	0.93
Citipower	2012	130,064	3,735,443	318,643	264,068	3,093	0.95
Citipower	2013	48,276	1,411,529	322,736	268,024	3,093	0.97
Citipower	2014	14,000	289,000	325,917	271,323	3,093	0.99
Citipower	2015	11,190	219,973	327,907	273,528	3,093	1.01
Citipower	2016	9,917	399,652	336,070	278,713	3,093	1.02
Endeavour	2009	1,521,129	10,775,663	878,612	777,275	27,518	0.87
Endeavour	2010	1,532,378	10,483,832	886,064	783,921	27,518	0.89
Endeavour	2011	1,547,645	8,172,395	895,088	791,909	27,518	0.91
Endeavour	2012	1,562,908	7,656,330	903,747	799,805	27,518	0.94
Endeavour	2013	1,577,720	7,674,287	919,385	813,234	27,518	0.96
Endeavour	2014	1,606,565	8,867,515	940,029	830,658	27,518	0.98
Endeavour	2015	1,630,037	10,750,281	955,833	843,867	27,518	1.00
Endeavour	2016	1,649,450	9,205,729	968,355	859,445	27,518	1.01
Ergon	2009	1,237,959	10,330,250	663,216	561,386	141,250	0.87
Ergon	2010	1,243,782	10,295,768	676,960	570,854	141,250	0.89
Ergon	2011	1,238,156	9,416,173	688,959	577,958	141,250	0.91
Ergon	2012	1,232,245	10,141,493	699,264	585,538	141,250	0.94
Ergon	2013	1,211,301	9,970,821	710,431	595,439	141,250	0.96
Ergon	2014	1,195,801	9,915,106	721,930	607,276	141,250	0.98
Ergon	2015	1,185,820	6,898,937	728,291	615,781	141,250	1.00
Ergon	2016	1,180,272	7,871,294	739,354	624,525	141,250	1.01
Essential	2009	1,341,813	13,064,646	821,578	687,148	179,687	0.87
Essential	2010	1,352,799	13,011,281	825,215	691,209	179,687	0.89
Essential	2011	1,371,219	13,623,791	834,416	699,303	179,687	0.91
Essential	2012	1,417,427	15,767,798	838,385	703,529	179,687	0.94
Essential	2013	1,451,499	12,832,801	844,244	707,207	179,687	0.96
Essential	2014	1,444,945	12,218,900	854,231	715,400	179,687	0.98
Essential	2015	1,446,253	13,188,009	867,001	725,879	179,687	1.00
Essential	2016	1,447,291	10,395,696	879,065	732,081	179,687	1.01
TasNetworks	2009	432,000	3,049,982	265,464	226,406	20,332	0.87
TasNetworks	2010	393,500	3,068,990	270,606	230,792	20,332	0.89
TasNetworks	2011	393,500	3,076,997	275,852	235,266	20,332	0.91

TasNetworks	2012	404,000	3,367,352	278,392	236,622	20,332	0.94
TasNetworks	2013	438,500	3,140,830	279,868	237,022	20,332	0.96
TasNetworks	2014	433,400	1,951,782	280,750	235,170	20,332	0.98
TasNetworks	2015	433,300	2,030,228	283,059	237,366	20,332	1.00
TasNetworks	2016	433,331	2,228,221	285,325	239,781	20,332	1.01
United	2009	618,388	2,020,101	628,120	562,161	8,030	0.88
United	2010	545,068	1,922,679	633,823	566,110	8,030	0.90
United	2011	483,818	1,397,942	641,130	573,270	8,030	0.93
United	2012	359,062	1,643,439	647,892	580,052	8,030	0.95
United	2013	218,380	1,336,301	656,516	587,851	8,030	0.97
United	2014	83,633	1,003,310	658,453	591,489	8,030	0.99
United	2015	25,830	603,637	664,549	597,595	8,030	1.01
United	2016	25,144	471,473	669,826	600,698	8,030	1.02
Powercor	2009	884,668	8,765,655	701,005	593,969	66,754	0.88
Powercor	2010	803,716	10,081,018	715,220	608,034	66,754	0.90
Powercor	2011	626,975	12,637,550	731,282	624,040	66,754	0.93
Powercor	2012	386,797	9,787,145	743,562	636,405	66,754	0.95
Powercor	2013	142,423	4,782,902	753,913	646,907	66,754	0.97
Powercor	2014	38,000	1,637,000	765,241	658,280	66,754	0.99
Powercor	2015	28,635	778,331	777,161	670,230	66,754	1.01
Powercor	2016	23,550	859,220	799,540	685,964	66,754	1.02
CitiPower/ Powercor	2009	1,212,103	13,247,965	1,006,990	847,639	69,846	0.88
CitiPower/ Powercor	2010	1,097,461	14,005,847	1,025,395	864,787	69,846	0.90
CitiPower/ Powercor	2011	846,648	17,982,974	1,045,721	884,159	69,846	0.93
CitiPower/ Powercor	2012	516,861	13,522,588	1,062,205	900,473	69,846	0.95
CitiPower/ Powercor	2013	190,699	6,194,431	1,076,649	914,931	69,846	0.97
CitiPower/ Powercor	2014	52,000	1,926,000	1,091,158	929,604	69,846	0.99
CitiPower/ Powercor	2015	39,825	998,304	1,105,068	943,758	69,846	1.01
CitiPower/ Powercor	2016	33,467	1,258,872	1,135,610	964,677	69,846	1.02

Appendix B

Classification of activities as fixed or variable

Cost category	Classification	Activity
Interval data services	Fixed, constant	Comms Costs - Network
		Data ERIC Resolution - Network
		Meter Testing
		Network Compliance - ACS CC4608
		Night Shift
		Release Management - DNSP
		Settlements - Network
	Fixed, step up	Business Analysis - DNSP
		CMDG UAT - Network
		MDSS UAT - Network
		NIDM UAT - Network
		MDA Quality Assurance
		Meter Data Converter - MRIM Laptops
		Type 5 Final Reads
	Variable	MDSS Operational Support - Network
		Missing Data Report - Network
		MRIM Emails
		NIDM Quality Assurance
		Substitutions - Type 5 Network
		Type 5 Billing Engine Exceptions
		Type 5 HHF Log Exceptions
		Type 5 Validation Exceptions - Alternate
		VMD Inbound
	Fixed, step down/eliminated	Contracts
		Goldsborough Mort AMR Meters - Support
		ITRON
		NAIC Support

		Remote MRIMs
		XML Load errors Type 5 - Network
Meter data operations (MDO)	Fixed, constant	BRD Preparation
		MBS - Support
		MBS Other Activities
		MCS Help Desk
	Fixed, step down/eliminated	Acceptance Testing MBS
		MBS Training for EA Staff
		NAIC Assistance MDS Team
		Network Customer Mngt (NCM) Project
		Regional Structure/Route Zero
	Fixed, step up	COMMS Network billing project
		MCS Training/Testing
	Variable	ISF Type 6 - IA - ACS
		MBS NEMMCO Activities
		Meter Data Export - IA
		Output Status
		Type 5 Help Desk
		Type 5 meters
	Fixed, constant	Develop and Maintain AMR Systems
		Failed Probe Read Investigation
		Licence Compliance - Regulator Liaison
	Fixed, step down/eliminated	Main Controlled Load Survey
		Metering Equipment Handling
		ZINV Account Query - CC
		ZINV Account Query - Hunter
		ZINV Account Query - Syd Nth
		ZINV Account Query - Syd Sth
		AMI Maintenance - CC
		AMI Maintenance - Hunter
		AMI Maintenance - Syd Nth
		AMI Maintenance - Syd Sth
		Battery Life Investigation Risk Analysis

Metering operations (MO)	Fixed, step down/eliminated	Investigate & Reduce Emerg. Maint. Tasks
		LVCT Compliance
		Meter Contract Management
		Refurbish Polyphase WC Meters
		Refurbish Single Phase WC Meters
		Technology Evaluation
		Tender Evaluation
		Type 5 & 6 CT Testing - CC
		Type 5 & 6 CT Testing - Hunter
		Type 5 & 6 CT Testing - Syd Nth
		Type 5 & 6 CT Testing - Syd Sth
	Fixed, step up	In Serv. Meter Sample Testing - CC
		In Serv.Meter Sample Testing - Hunter
		In Serv.Meter Sample Testing - Syd Nth
		In Serv.Meter Sample Testing - Syd Sth
		Type 5 Emergency Maintenance - CC
		Type 5 Emergency Maintenance - Hunter
		Type 5 Emergency Maintenance - Syd Nth
		Type 5 Emergency Maintenance - Syd Sth
	Variable	Investigate Meter Malfunctions
		LVCT Inspections Type 5-6 - CC
		LVCT Inspections Type 5-6 - Hunter
		LVCT Inspections Type 5-6 - Syd Nth
		LVCT Inspections Type 5-6 - Syd Sth
		MTG Engineering Support
		Time Tolerance Resets - CC
		Time Tolerance Resets - Hunter
		Time Tolerance Resets - Syd Nth
		Time Tolerance Resets - Syd Sth
		ZMET Meter Accuracy - CC - ACS
		ZMET Meter Accuracy - Hunter - ACS
		ZMET Meter Accuracy - Syd Nth - ACS
		ZMET Meter Accuracy - Syd Sth - ACS

Meter reading (MR)	Variable - special reads	Off Cycle Meter Reading - Skilltech -ACS
		Special Reads - MR North - ACS
		Special Reads - MR South - ACS
	Variable - Scheduled meter reading	Chronic Access Review
		Contractor Audit - ACS (Meter Reading Se
		Contractor Mgmt - ACS (Meter Reading Ser
		Laptop Reads
		Meter Reading Probes
		Route Maintenance
		Routine Meter Reading - Skilltech
		Time Resets
		Type 5 Probe Surcharge - Skilltech

Note: Overheads have been classified as a variable cost declining with the meter population over time.

Appendix C

A productivity factor has been calculated for use in a base step trend model for Ausgrid. The productivity factor estimates the proportionate change in total metering costs for a change in the type 5&6 meter population. The numbers used are below.

	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Meter forecast	1,610,941	1,487,045	1,357,918	1,235,918	1,113,918	991,918	869,918
Metering total cost	23,384,469	21,914,877	20,312,212	19,000,101	17,676,827	16,337,884	14,978,592