INDEPENDENT
QUANTITATIVE
EVIDENCE-BASED

FINAL REPORT

Review of capacitance forecasts

Prepared for
AusNet services

13 November 2019

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BOXES, CHARTS AND TABLES

Summary and recommendations

Scope of the review

The CIE has been asked to review the logic of the AusNet capacitance forecasting model. The review is from the perspective of whether the forecasts are likely to lead to accurate and unbiased forecasts of capacitance. The CIE does not have expertise in electrical engineering and is not able to review some aspects of forecasts that rely on this expertise.

To test the forecasting model, we have obtained additional data from AusNet to seek to understand whether historical growth in cable, which is the main driver of capacitance, is similar to model predictions. We have also obtained AusNet projections of customer numbers.

The CIE has reviewed an initial capacitance model. Following this, AusNet adopted CIE's recommendations. We have reviewed a final model that incorporate these changes.

Review of initial model

The initial forecasting model could be improved by linking the forecast of capacitance to forecasts of customer numbers. This would resolve difficulties in allocating timing of development of precincts based on Victorian Planning Authority processes. It would also improve the allocation of capacitance increases across AusNet's network, relative to the existing approach.

To implement this approach, AusNet would need to:

- determine the amount of UG cable per new customer
- determine whether this should be different for different types of customers (residential, commercial and industrial) or different types of service areas (greenfield and infill).

Our preliminary analysis of these issues is set out in this report.

Note that the customer number approach would need to be added to forecasts of changes in cable related to replacement programs.

Review of final model

The revised forecasting model adopts an approach to link cable forecasts directly to customer number forecasts, as per the above recommendations. Further work by AusNet has also been conducted to confirm the amount of underground cable per new customer.

The CIE has reviewed this approach and considers it s reasonable basis for arriving at a forecast.

The model used could be further improved by not averaging the customer number forecasts over a 12-year period. Instead, the annual customer numbers could be used directly. This would more accurately align cable requirements to the timing of expected customer numbers. We expect in practice that this will not make a substantial difference to forecasts because customer number growth will be assumed to be relatively smooth over time.

1 AusNet capacitance forecasting model

Purpose of forecasting capacitance

AusNet is developing a forecast of capacitance because this will drive expenditure related to reducing bushfire risk. The forecast of capacitance is only relevant in some areas, where there is bushfire risk, not across all of the areas served by AusNet's electricity distribution assets.

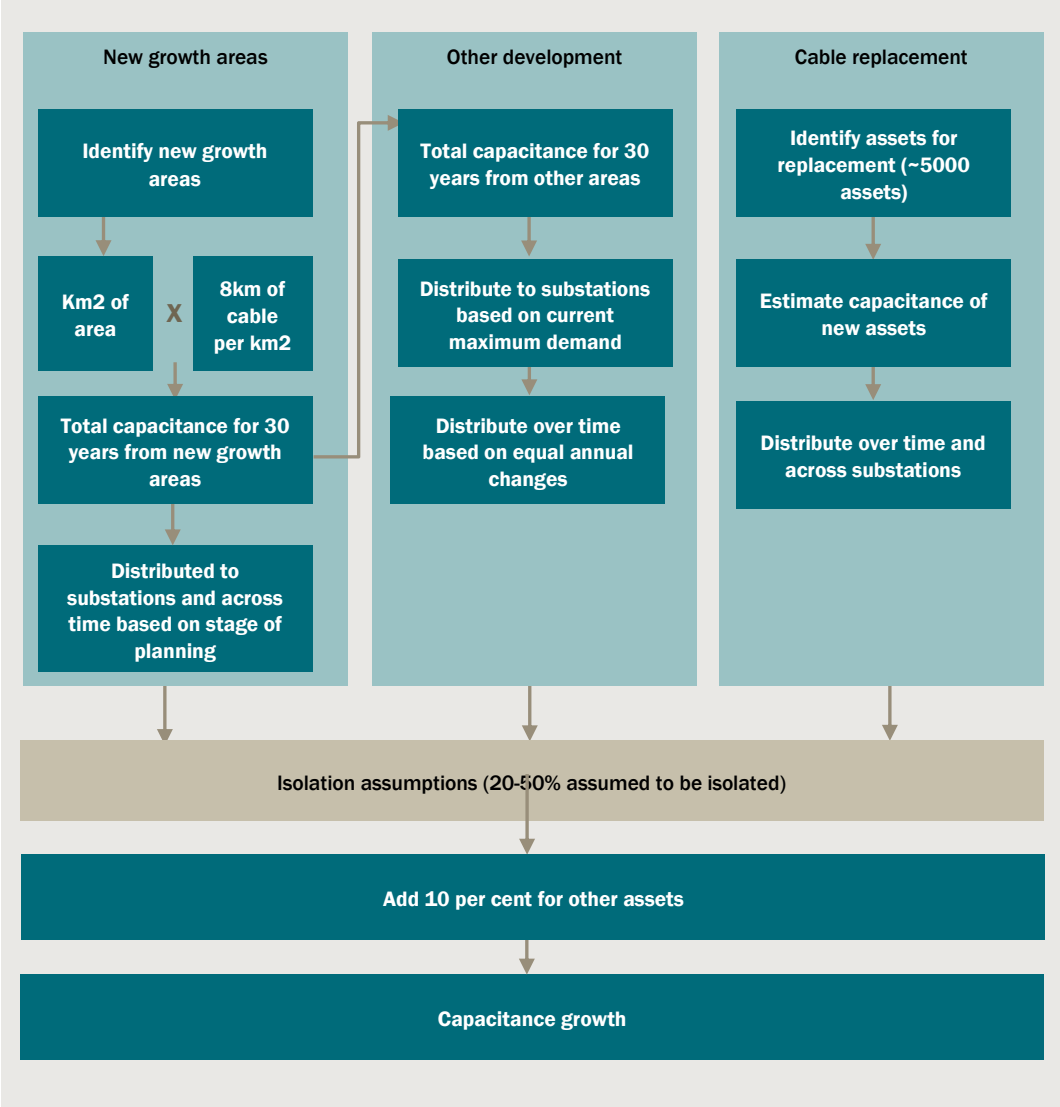
Structure of the initial model

AusNet has developed an initial forecasting methodology for capacitance. Our understanding of the structure of this model is set out in chart 1.1. The model estimates three areas of capacitance growth:

- new growth areas – this is development areas that are subject to precinct planning (i.e. greenfield development areas on the urban fringe)
- general demand growth – this is growth everywhere apart from new growth areas
- asset replacement programs – to replace overground or uninsulated cable with insulated cable that has higher capacitance.

The capacitance growth is added to a measure of current capacitance.

1.1 AusNet capacitance forecasting model



Note: Simplified to core elements.
Data source: The CIE's understanding based on materials provided by AusNet services.

Forecasts from the initial model

The model developed by AusNet produces forecasts of capacitance at five yearly intervals for each zone substation. The forecasts predict substantial capacitance growth across areas where there is bushfire risk, with capacitance increasing by around 5 per cent per year across the REFCL substations from 2019 to 2025. Capacitance increases very rapidly for Kalkallo in particular, tripling from 2019 to 2025.

Revised model

AusNet revised its capacitance forecasting approach to link new growth areas and other development directly to customer number forecasts. This approach applies a rate of 8m of

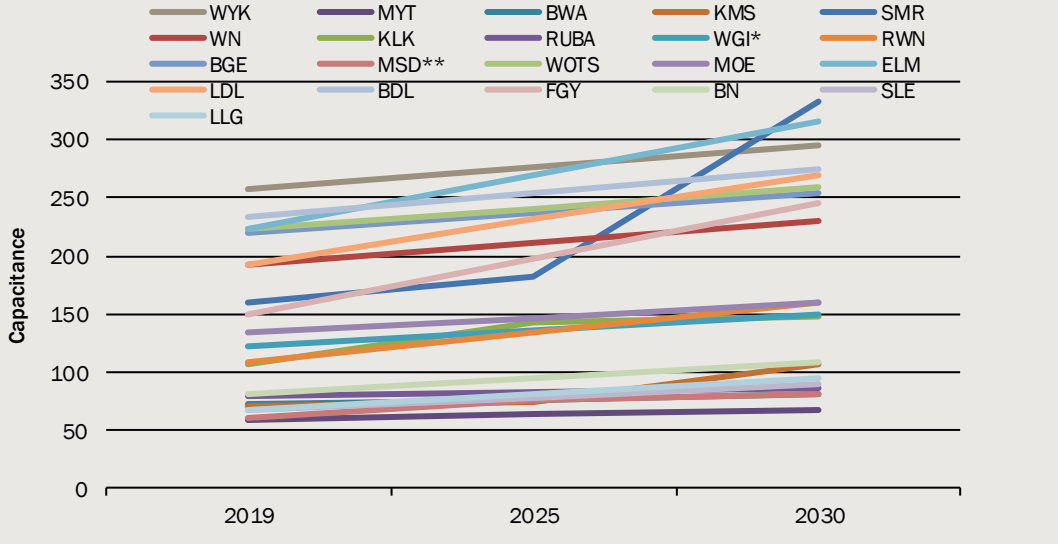
underground cable per customer in urban areas and 12m of underground cable per customer in rural areas. This approach has also been applied at a feeder level, as well as a zone substation level.

2 Analysis of initial forecasts

The forecasts produced by the forecasting model are shown for each REFCL station excluding Kalkallo in chart 2.1 and for Kalkallo in chart 2.2

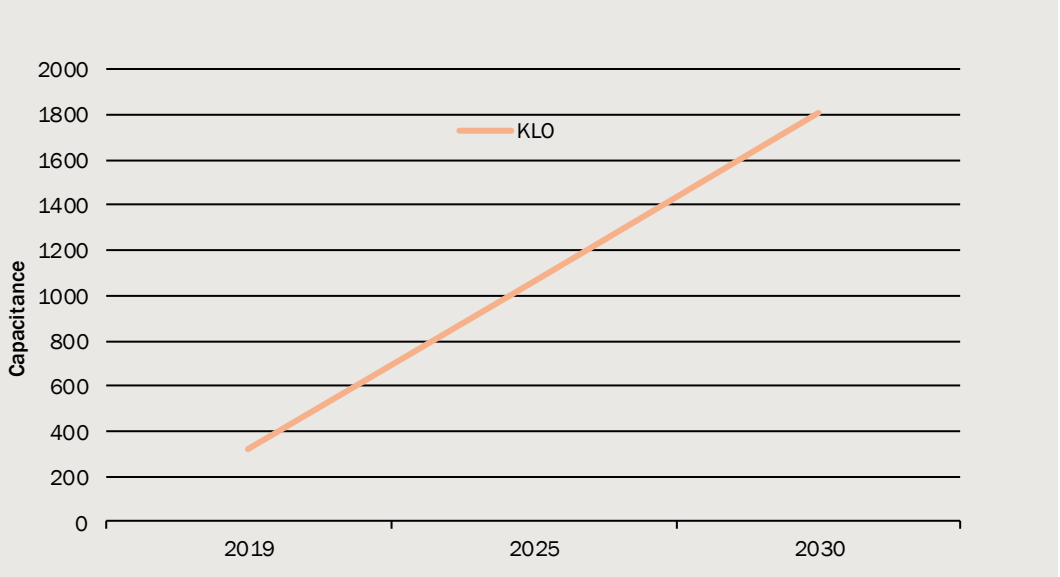
- Most substations have a similar pattern of capacitance growth
- The exceptions are SMR, which has a substantial amount of capacitance added from cable replacement programs and Kalkallo, which is a new growth area.

2.1 Forecasts of capacitance growth



Data source: AusNet capacitance model.

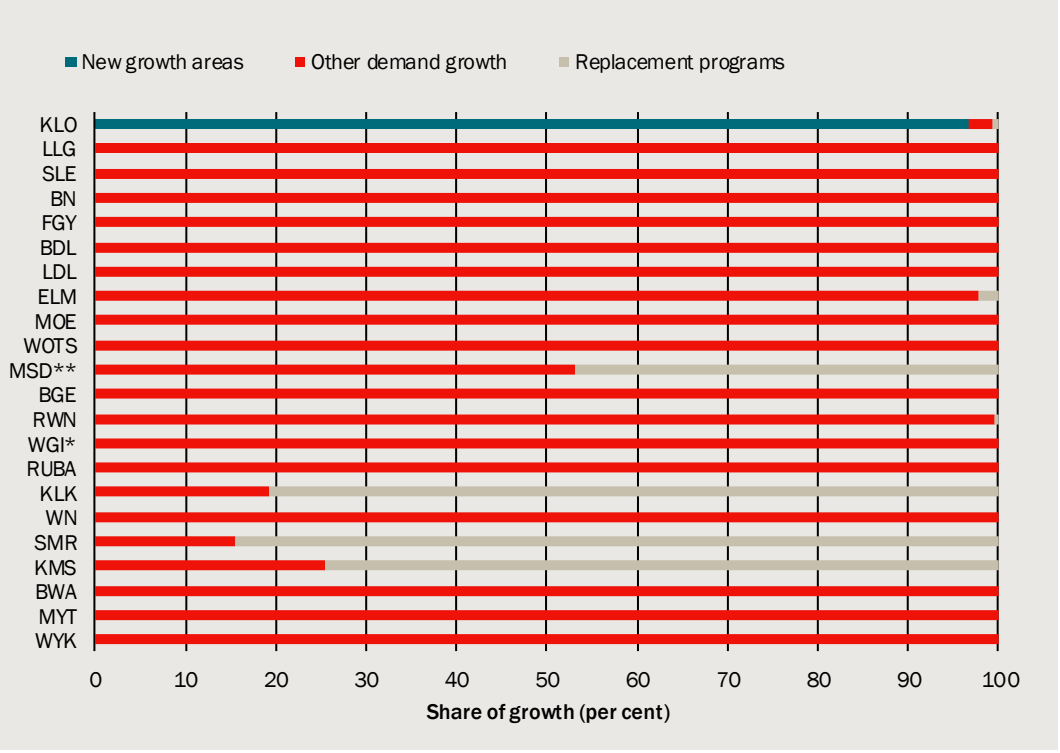
2.2 Forecasts of capacitance growth Kalkallo



Data source: AusNet capacitance model.

The share of capacitance growth forecast for each of the substations is shown in chart 2.3). For most of the REFCL stations, the other demand growth is the only or main driver of capacitance growth. KLA is the only substation that is impacted by capacitance growth from new growth areas.

2.3 Drivers of capacitance growth across REFCL substations



Data source: AusNet capacitance model.

3 Calibration and back casting of the model

Calibration

One way to check the veracity of a model is to compare what the model would predict to the current actual outcomes. In the case of the existing model, this is not particularly useful as the model forecasts growth, rather than the level of capacitance.

We have sought to check how the summation of capacitance from individual cables aligns to the overall measured capacitance. At this stage we have not been able to complete this because we have not matched the individual cable types to their expected capacitance.

Back casting

The model is focused on estimating a change in cable length and hence a change in capacitance. A useful cross-check of the model is whether the historic growth in cable aligns to what is expected in the future. Historically, the amount of cable has increased by ~130kms per year in total, most of which has been additional underground cable.

3.1 Historic cable growth

Year	Overground cable	Underground cable	Total cable
	Kms	Kms	Kms
2015	22,616	1,883	24,498
2016	22,586	1,981	24,567
2017	22,553	2,097	24,649
2018	22,539	2,241	24,780
2019	22,681	2,340	25,022

Note: For HV network only.

Source: CIE analysis based on data provided by AusNet.

The forecasts appear to indicate much higher levels of underground cable growth than has occurred historically. For example, in comparison to the 114 kms per year from 2015 to 2019, underground cable growth from the forecasts appears to be equivalent to 336 kms per year (over a 30 year period). Note that the 2015 to 2019 number may be slightly too low as 2019 has not finished yet.

3.2 Comparison of historic and forecast cable growth

	Underground
	Kms/year
2015 to 2019	114
Forecast additional cable from new growth areas	142
Forecast additional cable from other growth	142
Forecast additional cable from replacement programs	52
Total	336

Source: CIE analysis based on AusNet data.

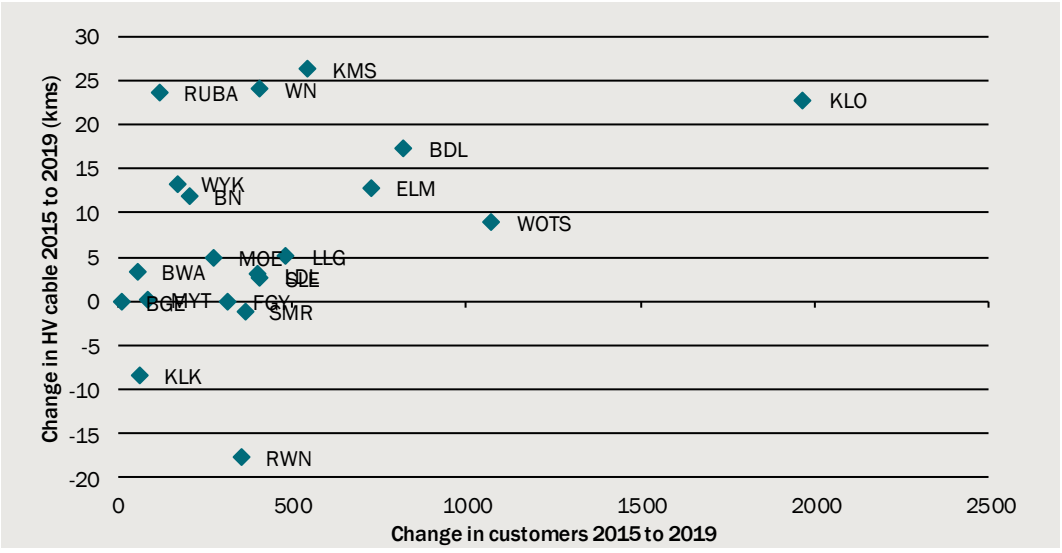
It is not immediately clear why there is such a large discrepancy between historical growth rates in cable and what is expected.

- It seems unlikely that this reflects a plausible increase in development in new growth areas.
- Potentially it could be because the rate of cable of 8km per square km of area is applied to the total area of new growth areas, while residential areas are only ~20 per cent based on the assumption AusNet has used for its analysis of kiosks.

Apparent drivers of cable growth

The clearest driver of growth in cable would be expected to be new customers, which require an expanded HV network. This is the basis of much of the existing model. Historically, there is a weak positive relationship between customer growth and cable growth (overhead and underground). However, there are some substations that have seen substantial reductions in HV cable (KLK and RWN) while still having customer growth. KLO has had the largest growth in customers and cable growth of 20-25 kms per year.

3.3 Customer growth and cable growth for REFCL substations



Data source: The CIE based on data provided by AusNet.

AusNet would likely understand the reasons for some of the outliers.

The weak relationship indicates that there are other drivers of cable outside of customer growth that may need to be accounted for in forecasts.

4 Changes to AusNet forecasting approach

AusNet revised its approach in response to initial recommendations to link undergrounds cable growth directly to customer numbers. In doing this, it undertook a more detailed analysis of the historic underground cable growth and customer number growth across zone substations. This accounted for known outliers that reflected specific programs. Based on this work, a rate of 12 metres of underground cable per customer has been used for rural areas and 8 metres for urban areas. AusNet's work:

- identified cable lengths that were unrelated to general growth (and area separately included in forecasts) and removed this from the historical data
- calculates the underground cable length per new customer from 2015 to 2019. This ignored overground cable and care conductor, because the capacitance is insignificant
- considered the results across zone substations and potential reasons for outliers, such as LDL, ELM and BGE.

The CIE considers this approach is reasonable and that the analysis undertaken to derive the numbers has provided a more robust relationship between customer numbers and cable requirements than shown in our previous chapter.

5 Review and recommendations

Review of logic of the initial forecasting model

There are a number of logical elements of the forecasting model that could be subject to large errors.

1 Timing of addition of cable and capacitance in new growth areas, and a lack of data to substantiate the amount of cable

2 The assumption that the capacitance added outside of new growth areas will be the same as the capacitance added within growth areas.

3 The distribution of additional capacitance across substations based on the current maximum demand for substations

Each of these is discussed in turn.

Note that we cannot review the replacement programs in any detail. This is largely a view on which parts of the network AusNet will replace over time. The only comment we can make is to ensure that the magnitude of these programs is consistent with history, and any impacts in terms of reducing overall cable can be accounted for.

Capacitance growth in new growth areas

Substantial analysis has been conducted on new growth areas, which are areas where there is not existing development, such as on the urban fringe. These are defined by the Victorian Planning Authority (VPA), based on its Precinct Structure Plans for greenfield areas. However, only one substation serving these areas is relevant from the perspective of expenditure to reduce capacitance and bushfire risk (Kalkallo). The remaining substations that serve growth areas are not REFCL substations.

To forecast the increase in capacitance in new growth areas, a design approach is taken. This simplifies down to estimating the area in square kilometres of each new growth area and then assuming that 8 km of underground HV cable are required for each square km of area. The area is the total area of the growth precinct, based on maps from the Victorian Planning Authority.[1]

To obtain the capacitance, an assumption is made about how much of the underground HV network is of different sizes.

To provide a timing for when growth precincts will be developed, precincts are placed in order using the steps for the VPA in undertaking precinct planning. It is then assumed all

1 There are minor additions related to kiosks. These are unimportant in magnitude for the forecasts.

precincts will be developed within 30 years and the area is allocated to give a constant amount per year developed.

The key assumptions are then:

- that there is 8km of underground HV cable per km of area served, and
- areas are developed in line with when planning was completed by the VPA.

Across the entire Ausnet electricity distribution network there is ~25 000 km of HV cable, of which over 22 500 km is overground. The area that is referenced as being served by the distribution network is 80 000 square kms. This means that there is less than 1km of HV cable per km served. However, this won't be representative of the new growth areas, as the network serves large rural areas. Our understanding is that the 8km is based off existing recently developed areas. This seems like a reasonable basis for the assumption, but we cannot check this. The key part of checking this assumption is that the 8km per km served measures area on the same basis as it is being applied. For example, if the 8km per km served is based on residential areas, but is being applied to the entire precinct, then this would overstate the amount of cable. This should be checked by AusNet if this approach is used.

Using the timing of development of precincts based on when planning was completed may not be accurate. Given that AusNet uses other forecasts for customer numbers, this may be preferable to relying on the order in which a precinct was planned.

Capacitance within and outside of growth areas

Most substations that are subject to expenditure to reduce capacitance do not have new growth areas within the area they service. Growth in these areas will tend to occur through smaller scale developments rather than major greenfield developments.

The current forecasting approach assumes that the capacitance increase from growth outside of new growth areas **will be the same** as that within growth areas. This is based on the level of growth (which we presume is population or demand growth) being the same in growth areas versus other areas.

There is no particular reason to assume that the capacitance increase across existing areas is the same as that from the new growth areas. It would be preferable to think about the drivers of new cable for existing areas directly, rather than using the current assumption. Given that growth outside of new growth areas drives the capacitance forecast for many of the REFCL substations, this approach needs more development.

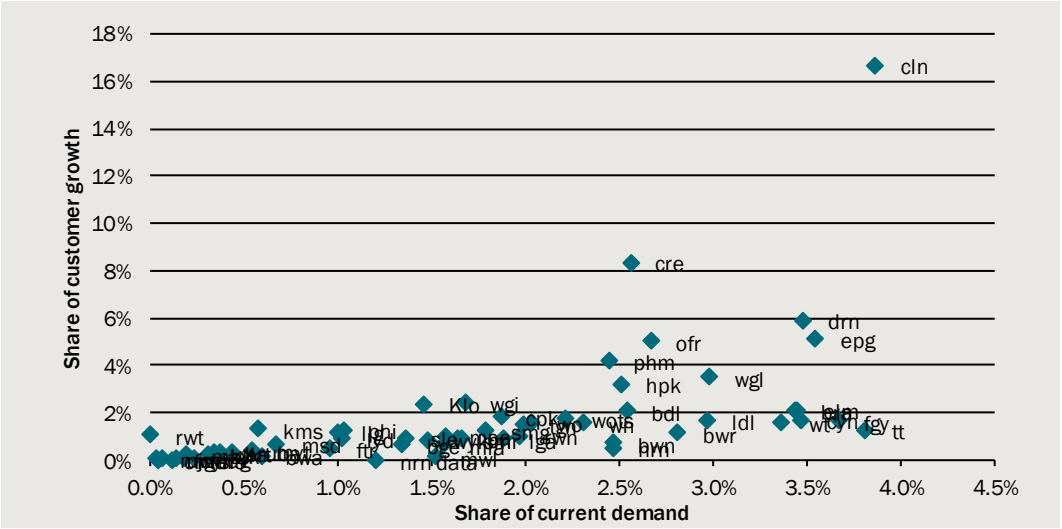
Distribution of new capacitance across substations

The existing approach distributes the capacitance growth that is outside of new growth areas based on the existing maximum demand of each substation.

Our understanding is that additional capacitance will largely be driven by additional underground cable. This will occur in the substation areas where there is greater customer growth.

Given this, it would be more accurate to distribute capacitance growth based on a growth measure, such as demand growth or customer number growth. This will likely give a very different pattern for where additional capacitance will occur (chart 5.1). For example, CLN is expected to have over 16 per cent of the new customers, but only has 4 per cent of current load. This would mean it is allocated a much smaller share of capacitance growth than would be expected.

5.1 Share of existing demand versus share of customer number growth



Note: Customer number growth is to 2030.
Data source: The CIE, based on data provided by AusNet services.

Review of results based on back casting

Based on back casting, the approach proposed appears to lead to higher levels of cable growth and hence capacitance growth than would historically have been the case. This is because it forecasts more cable growth than AusNet appears to have actually required to service new customers.

Alternative approach linking to customer numbers

The current approach has not linked to customer number forecasts that AusNet has, which are at the substation and feeder level. In our view, this would be a preferable approach because:

- there would be consistency across forecasts
- the customer number forecasts are already available on an annual basis and at a feeder level, and hence could easily be used to produce capacitance forecasts at this time scale and spatial level.

Note that we have not reviewed the basis for the customer number forecasts.

The main impediment to moving to a customer number approach is that the historic analysis suggests that there are other drivers of cable growth outside of customer numbers.

To implement a customer number approach, AusNet would need to:

- determine the amount of UG cable per new customer
- determine whether this should be different for different types of customers (residential, commercial and industrial) or different types of service areas (greenfield and infill).

This would be used instead of the current approach for new growth areas and other demand growth. The impact of cable replacement would need to be added on.

Our preliminary analysis suggests that ZSSs with growth precincts have not had more cable per new customer than other ZSSs. ZSSs with growth precincts had 5.1 metres of underground cable per new customer, compared to 11.7m for all areas (table 5.2). Note that this does not strip out the impact of past replacement programs. This would need to be isolated so that there is not double counting in the forecasts.

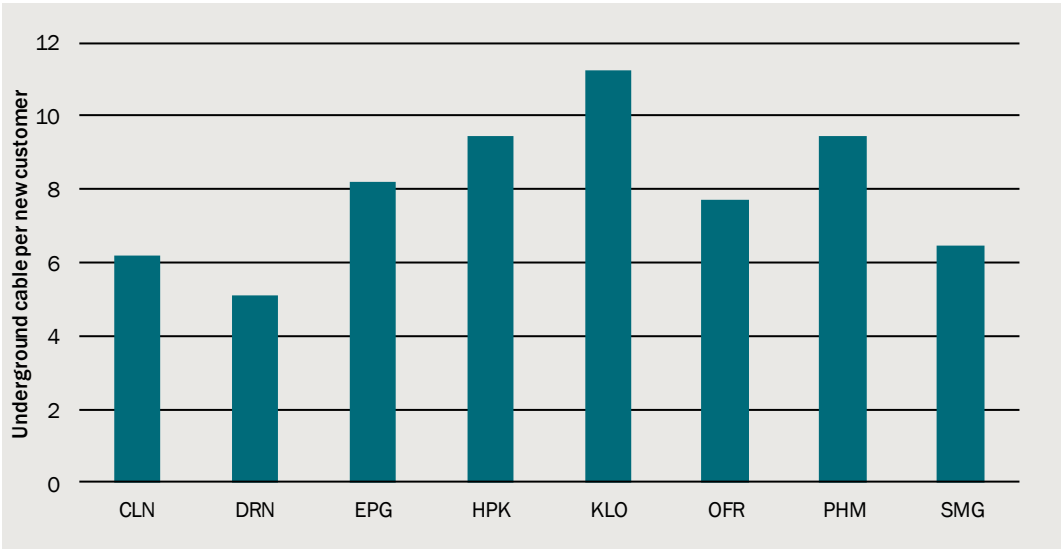
5.2 Cable per new customer 2015 to 2019

Average cable per new customer	Total	Underground
	m/new customer	m/new customer
Whole network	10.4	9.1
ZSSs with growth precincts	6.1	5.1
Other ZSSs	16.0	11.7

Source: The CIE based on data provided by AusNet.

The amount of new cable per new customer has varied substantially across substations. However, across the substations with growth precincts this has been somewhat more stable (chart 5.3). This has ranged from about 5 to 11 metres of underground cable per new customer. Note that this could presumable be impacted by timing as HV cable would occur before customers were connected.

5.3 Underground cable per new customer for ZSSs with growth areas 2015 to 2019



Data source: The CIE based on data provided by AusNet.

Review of revised forecasting model

AusNet has adopted the CIE's initial recommendations. We have reviewed the revised approach and consider this to be a reasonable basis for arriving at capacitance forecasts. Note that we cannot make comment on issue such as the extent of isolation of current, as that is outside of our skill set.

We consider that further improvements could be made to the forecasting model to:

- use annual customer number data rather than an average over a 12-year period. If there are differences in the timing of customer number growth then this will be better included by using annual data. We expect this to have a minimal impact, because customer number growth appears to be fairly constant over the 12-year period for each zone substation
- improve model useability by not using pivot tables and placing assumptions at the front of the model. Using pivot tables can lead to mistakes as changes do not flow through the model. A sheet outlining all assumptions, such as metres of cable per customer, would enable better clarity on the model. Note that this will not impact on the actual forecast.