LRMC computation results

March 2019

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LRMC computation

Results and discussion

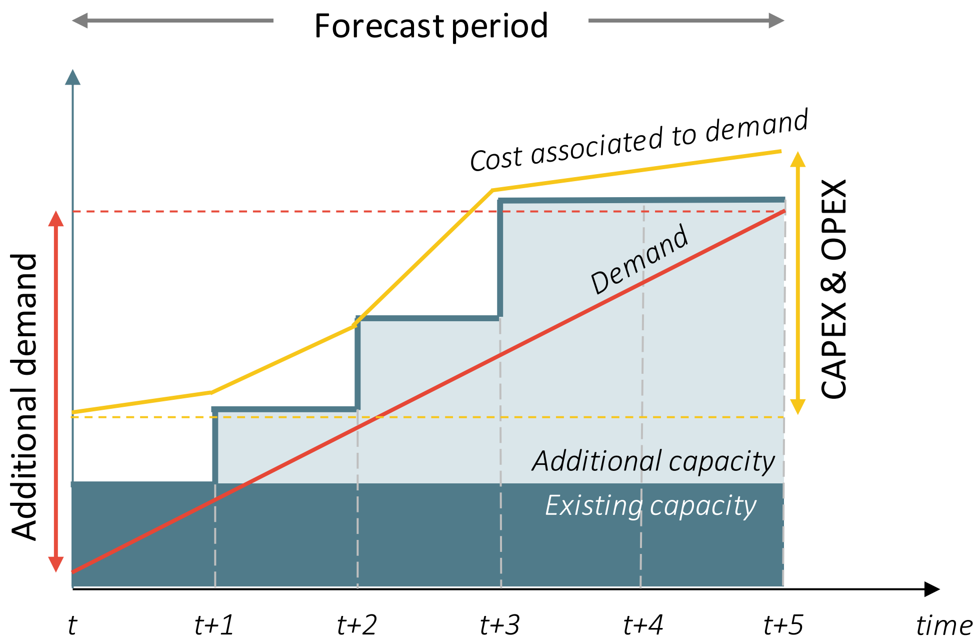
Next steps

Appendix

Two main methods are being used to estimate LRMC: AIC and MIC

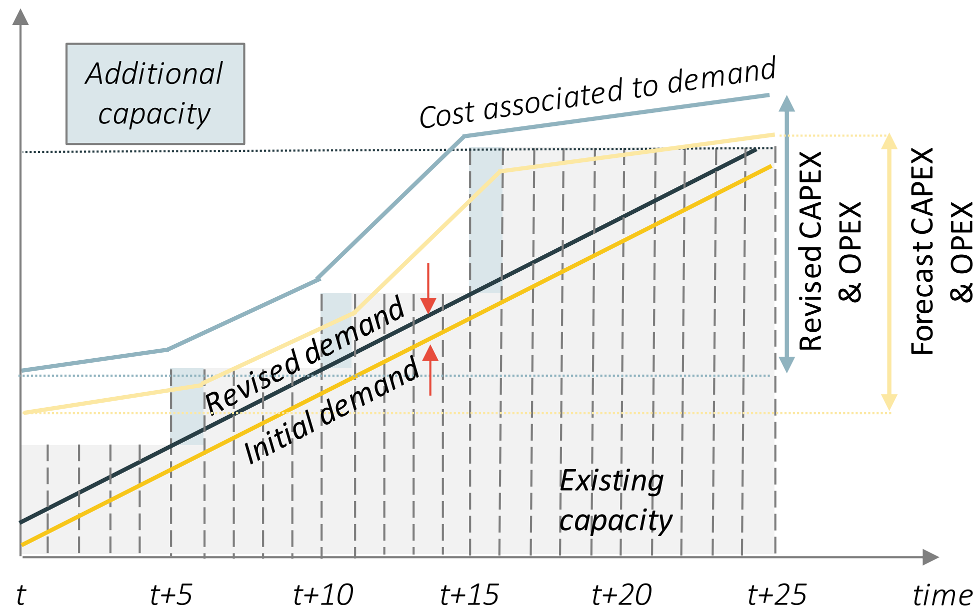
The AIC is

- Marginal compared to today
- Developed on the back of the RIN – AER approved



The MIC approach is

- Marginal compared to the forecast
- Based on timing of the CAPEX event(s)



The MIC approach is the preferred methodology as it aligns best with the AER's objectives on cost-reflective pricing signals

The MIC is more flexible than the AIC

- It can cater for network areas with decreasing/flat demand
- It can be adapted to handle REPEX

The MIC method is better suited to network tariff objectives

- Providing signals to customers for avoiding/deferring network investment
- Allowing direct use for demand response pricing

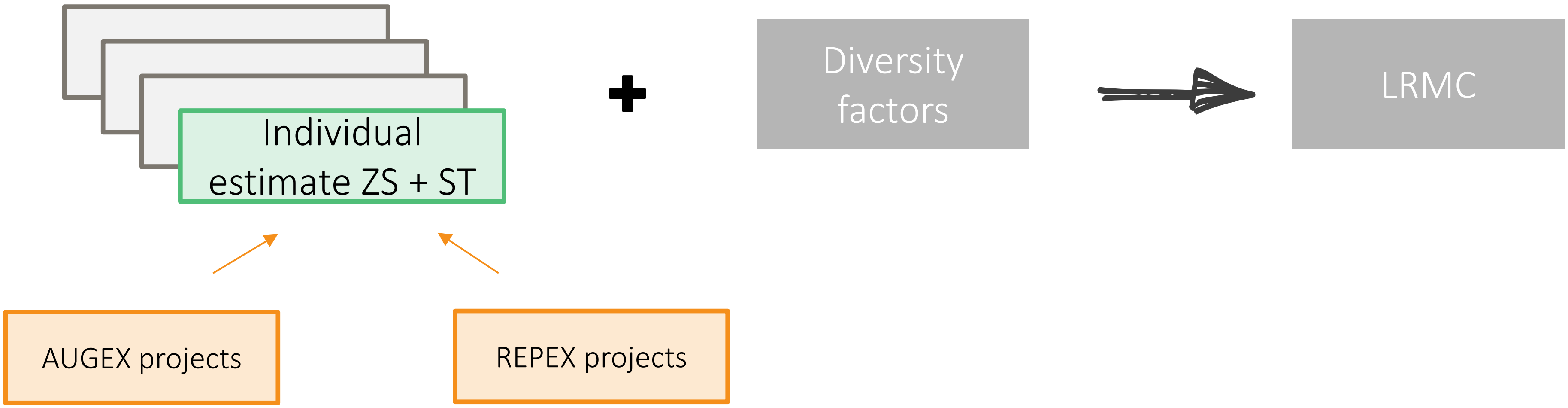
But MIC (and AIC) rely on future project data

- Which is unavailable at LV level as well as for some feeder-level work
- Has been replaced by using marginal cost of reinforcement (MCR) estimates when necessary

A building blocks approach has been used to compute the LRMC from estimates at individual voltage levels

	Low voltage	DSS	HV	ZSS	Sub-transmission
MCR	✓	✓	✓	✓	✓
MIC	✗	✗	✗	✓	✓
LRMC method	MCR	MCR	MCR	MIC	MIC

The individual estimates for ZS and ST level LRMC comes from 2 separate groups of projects



	LV	DSS	HV	ZSS	ST
MCR	✓	✓	✓	✓	✓
MIC	✗	✗	✗	✓	✓
LRMC method	MCR	MCR	MCR	MIC	MIC

The MIC methodology has been applied to 65 projects across networks and voltage levels

Network	Total Projects considered	Projects considered		Of which REPEX
		ST	ZSS	
Powercor	38	1	37	6
CitiPower	12	0	12	7
United Energy	15	7	8	0

Scope has been reduced from the 138 projects initially identified

Included projects

AUGEX:

- Additional transformers
- Additional capacitor banks

REPEX:

- Replacement transformers in substations with 3 or more transformers

Excluded projects

- Any project with investment in 2018 or before

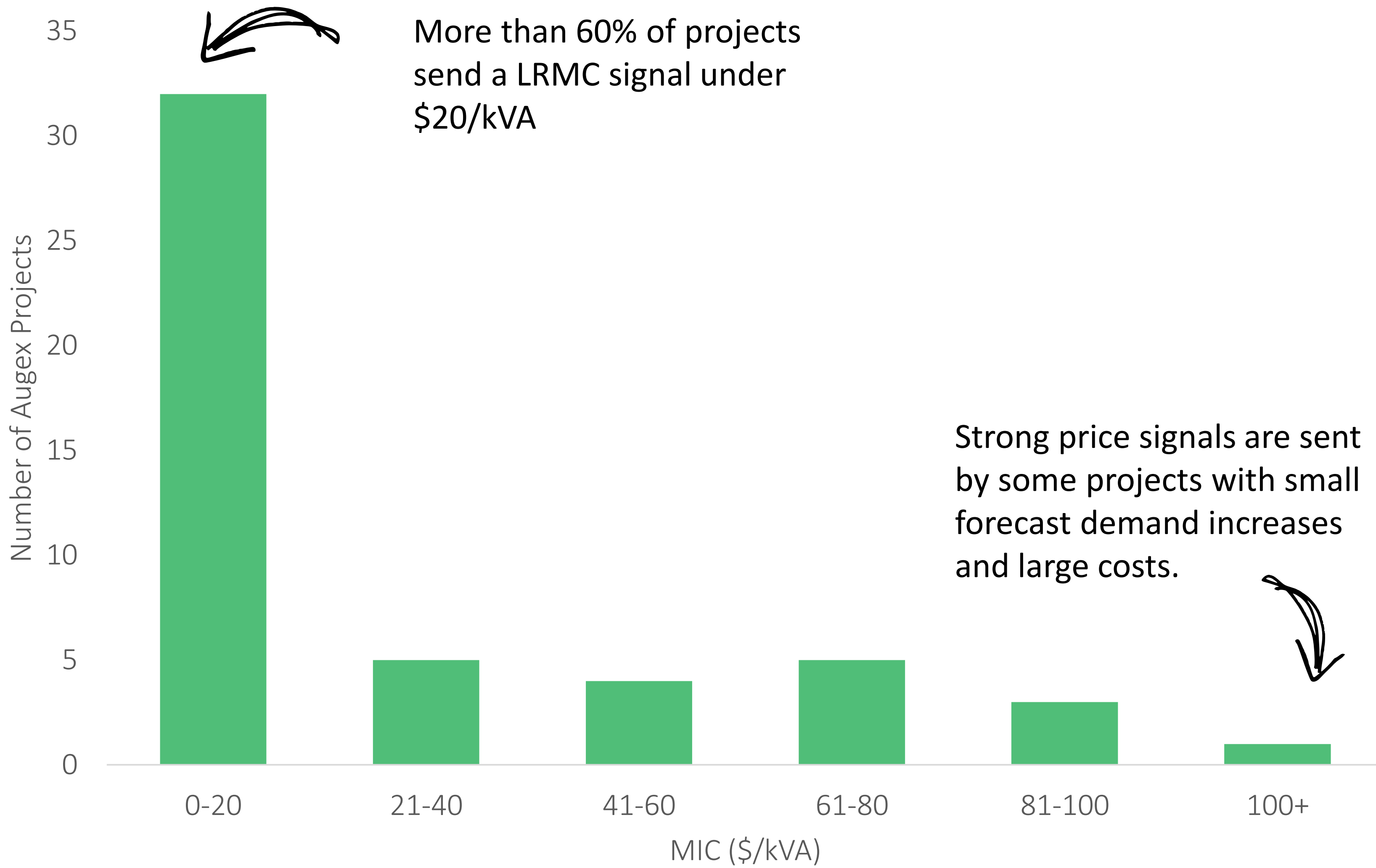
AUGEX:

- Feeders projects, as feeder segment forecasts are not available

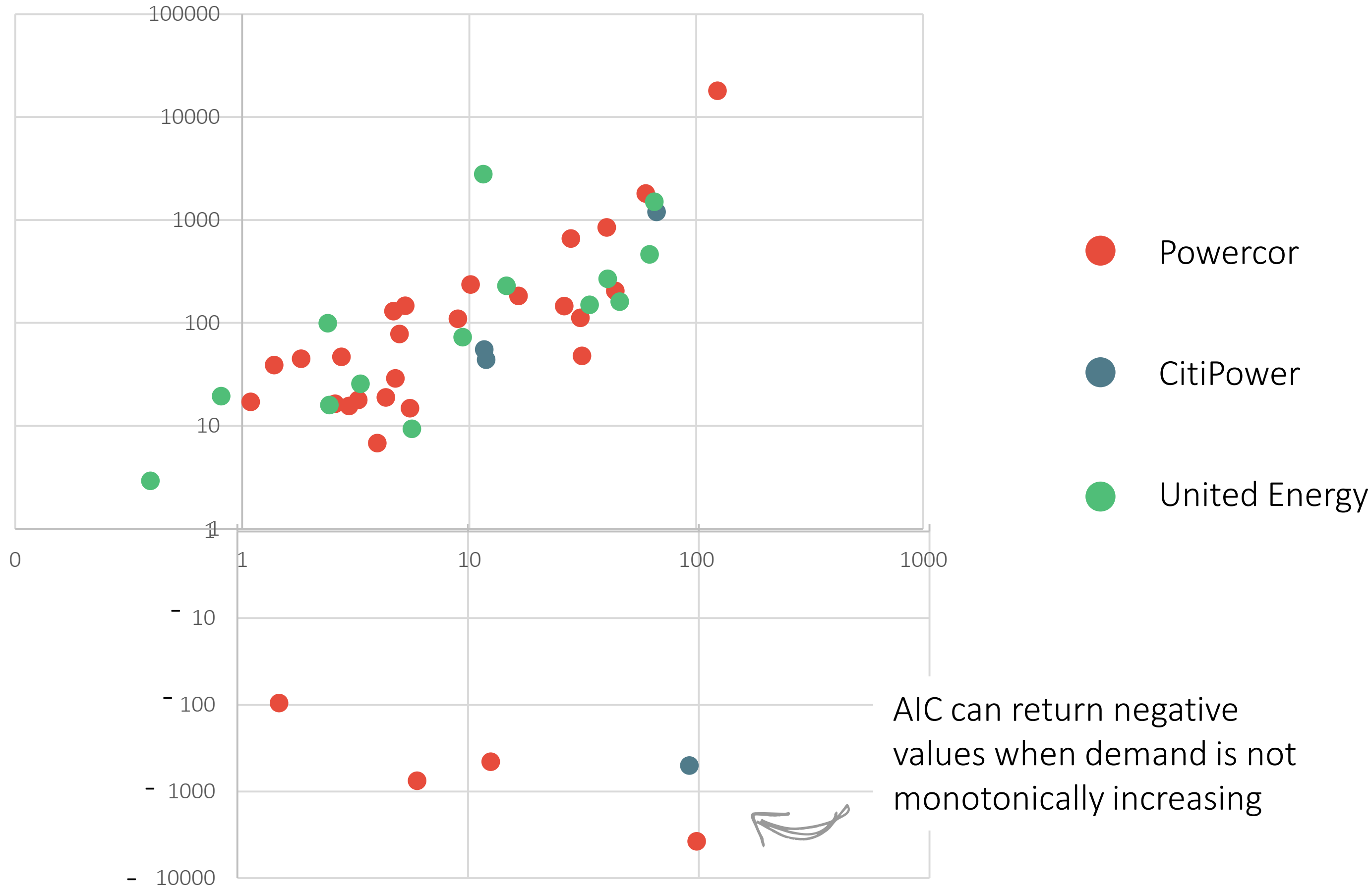
REPEX:

- Replacement transformers in substations with less than 3 transformers, to avoid reducing security of supply

Most AUGEX projects produce modest price signals for customers



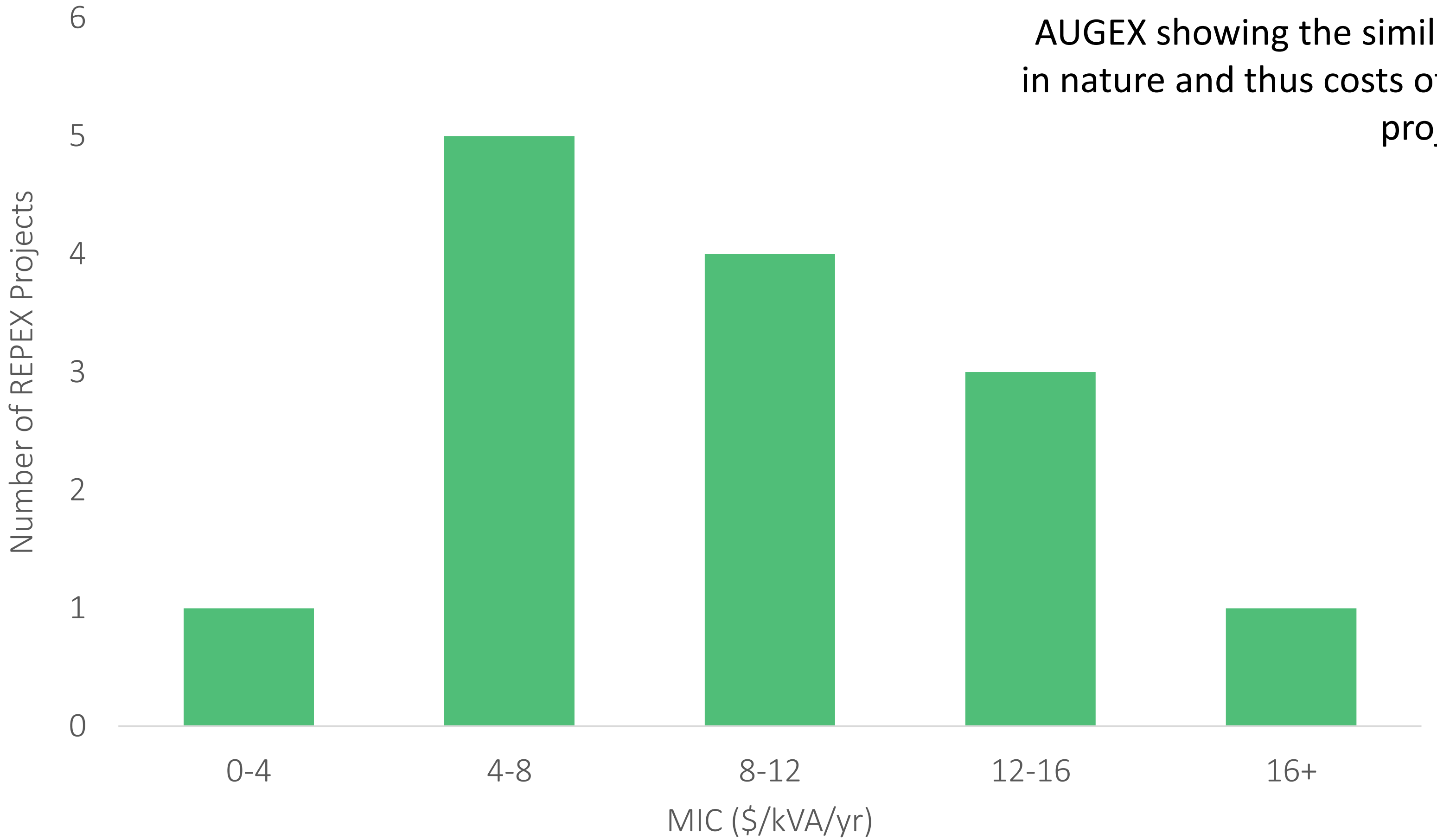
Results confirm MIC versatility: the AIC method is highly volatile and return unusable values for 40% of AUGEX projects



AIC can return negative values when demand is not monotonically increasing

REPEX LRMC are lower than AUGEX LRMC as larger reduction in load is needed to avoid the REPEX projects

Smaller distribution than AUGEX showing the similarity in nature and thus costs of the projects

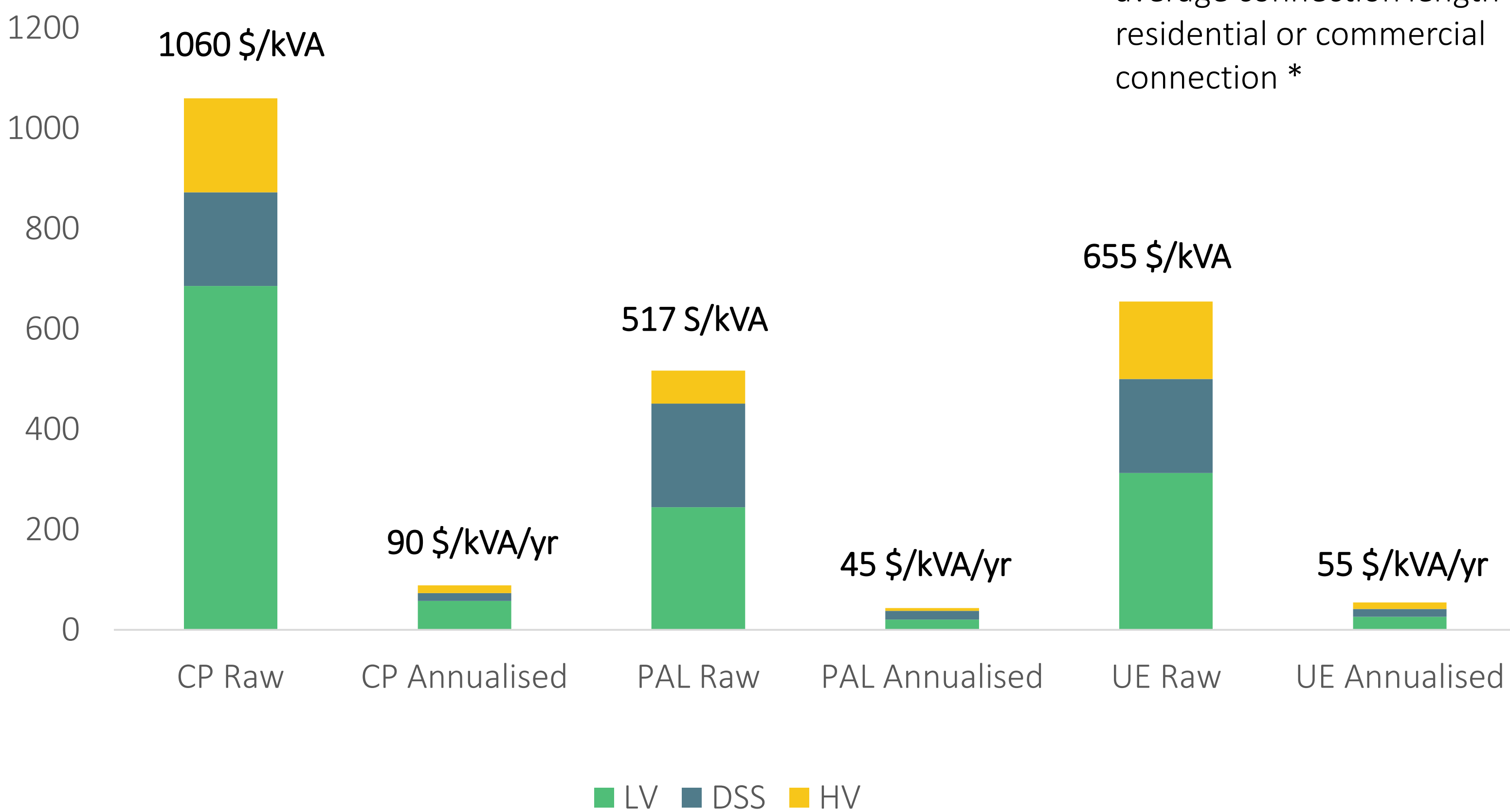


Augmentation unit rate (MCR) was calculated and adapted for low voltage levels LRMC where planning and forecasts are not available

	LV	DSS	HV	ZSS	ST
MCR	✓	✓	✓	✓	✓
MIC	✗	✗	✗	✓	✓
LRMC method	MCR	MCR	MCR	MIC	MIC

The MCR value is then annualised to align with the philosophies of the MIC approaches

The **MIC MCR** is annualised over **22.5 yrs** to match the average connection length of a residential or commercial connection *



*Sourced from: The AER's conclusion on the benchmark upstream augmentation charge rates for Citipower's network, pg 23

Diversity factors unique to each network and customers are the final step of the computation

	LV	DSS	HV	ZSS	ST
MCR	✓	✓	✓	✓	✓
MIC	✗	✗	✗	✓	✓
LRMC method	MCR	MCR	MCR	MIC	MIC

LRMC is determined by "diversifying" and summing contributions of individual network levels above a given connection level

$$\text{LV customer LRMC} = \left[\text{LV rate} \times D_f \text{ to LV}\right] + \left[\text{DSS rate} \times D_f \text{ to DSS}\right] + \left[\text{HV rate} \times D_f \text{ to HV}\right] + \left[\text{ZSS rate} \times D_f \text{ to ZSS}\right] + \left[\text{ST rate} \times D_f \text{ to ST}\right]$$

Diversity factors (D_f) for each customer type compared to each network level have been provided by the planners

Example for a LV customer connected to United Energy's DC ZSS:

$$\text{LV customer LRMC} = \underbrace{\left[78.30 \times 0.40\right]}_{\text{LV}} \ldots \underbrace{\left[16.97 \times 0.28\right]}_{\text{ST}}$$

$$\text{LV customer LRMC} = \$72.92 \text{ per kVA}$$

As individual diversity factors are unavailable for CitiPower & Powercor, a coarser method is used for now

LV customer LRMC = [LV rate + DSS rate + HV rate + ZSS rate + ST rate] x diversity factor

DSS customer LRMC = [DSS rate + HV rate + ZSS rate + ST rate] x diversity factor

HV customer LRMC = [HV rate + ZSS rate + ST rate] x diversity factor

ZSS customer LRMC = [ZSS rate + ST rate] x diversity factor

ST customer LRMC = [ST rate] x diversity factor

Diversity factors for each network have been provided by the planners

Example utilising Powercor's 2015 LRMC values

LV customer LRMC = [7.1 + 134.4 + 19.6] x 0.6

LV customer LRMC = $96.6 per kVA

The final LRMC result is computed at different voltage levels with or without diversification allowing flexibility in its uses

	LV	DSS	HV	ZSS	ST
MCR	✓	✓	✓	✓	✓
MIC	✗	✗	✗	✓	✓
LRMC method	MCR	MCR	MCR	MIC	MIC

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LRMC computation

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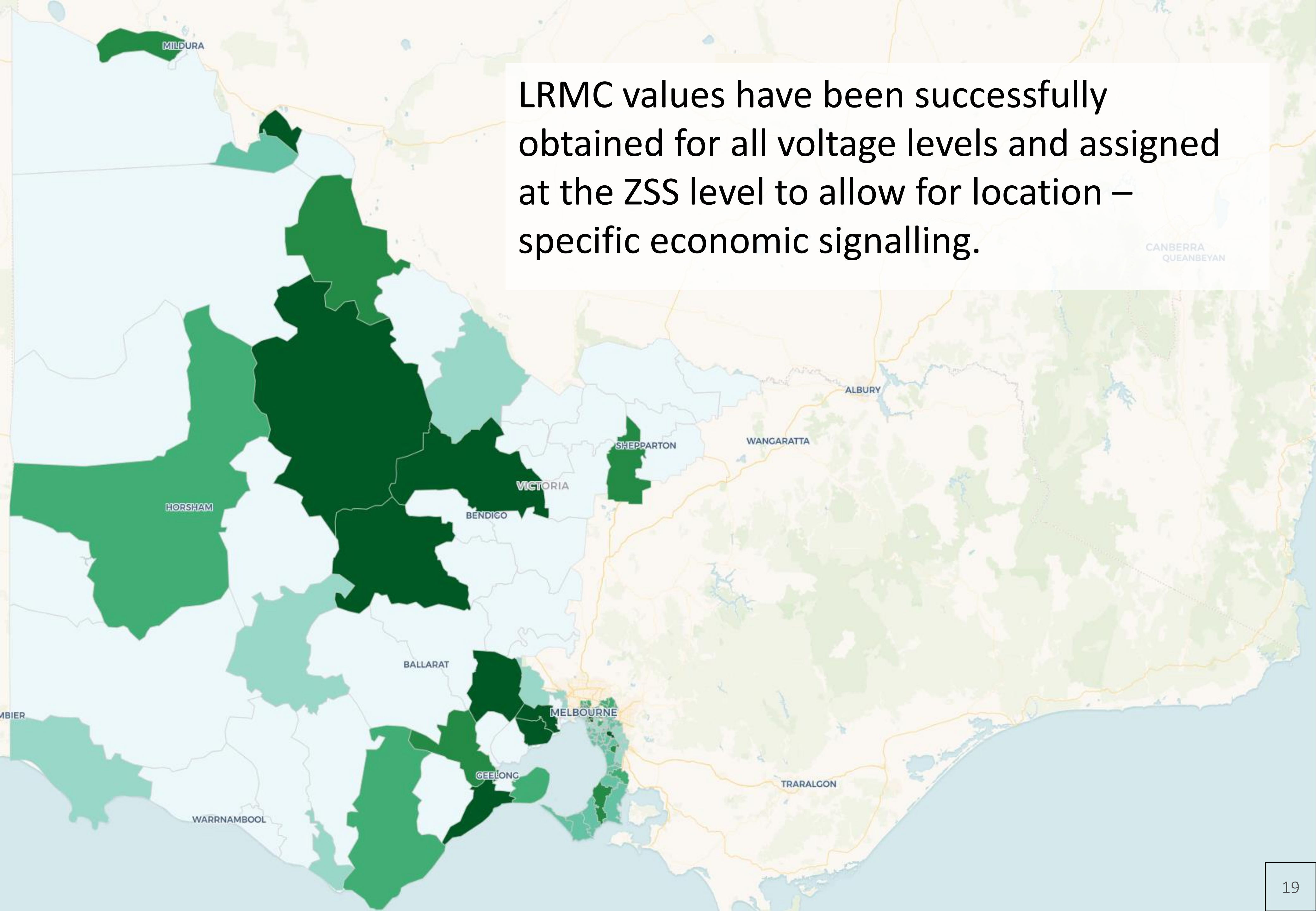
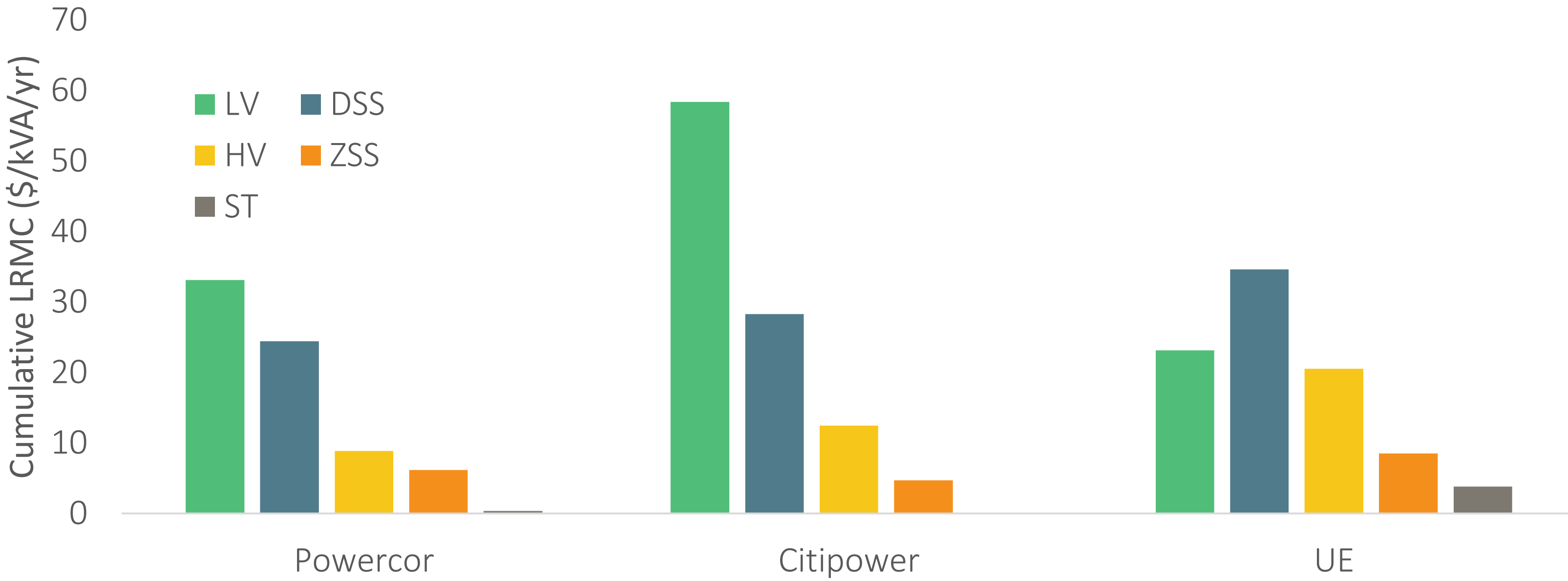
LRMC values have been successfully obtained for all voltage levels and assigned at the ZSS level to allow for location – specific economic signalling.



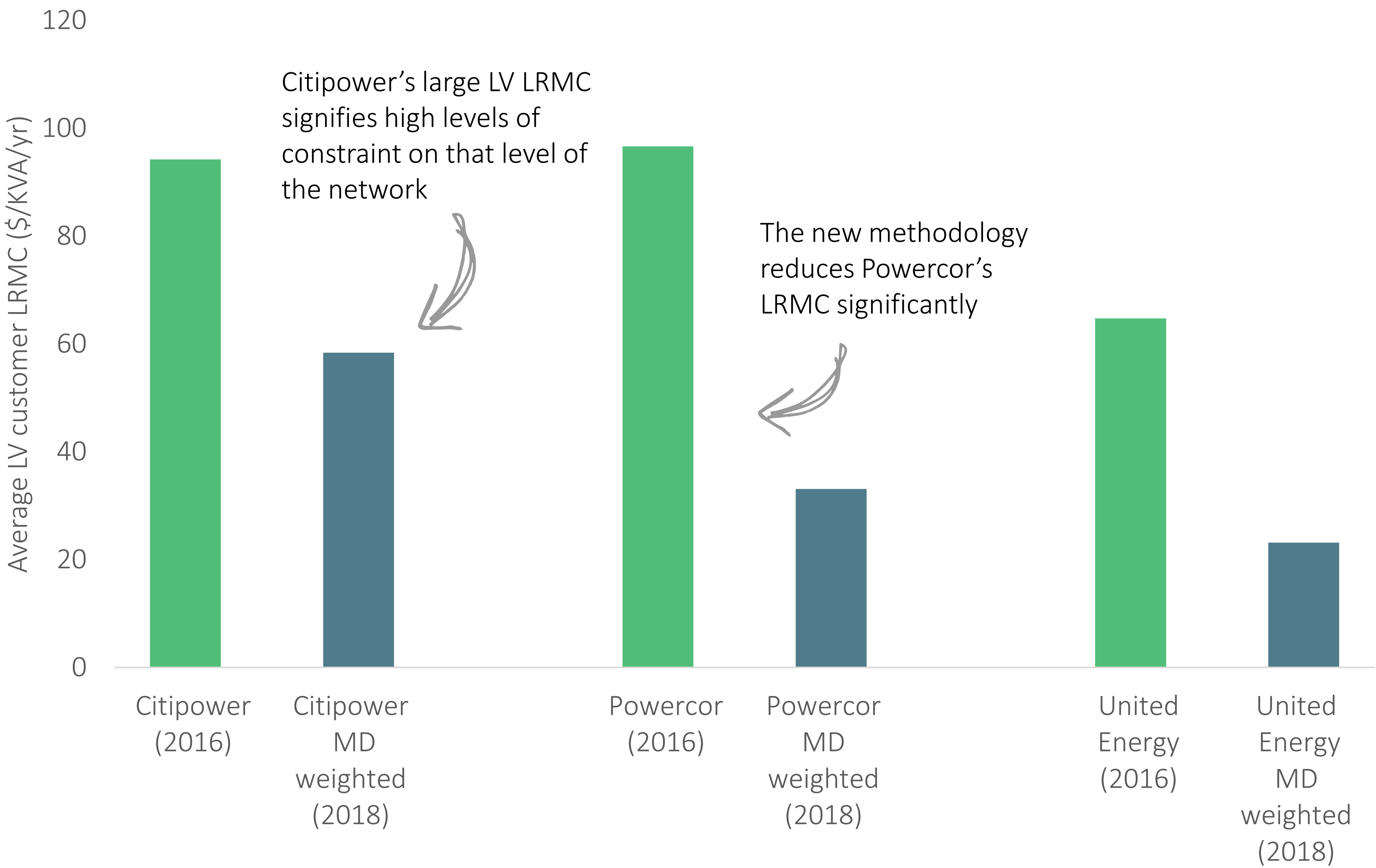
Lower voltage levels contribute more to the overall LRMC than that of the high levels, showing higher localised growth and constraints



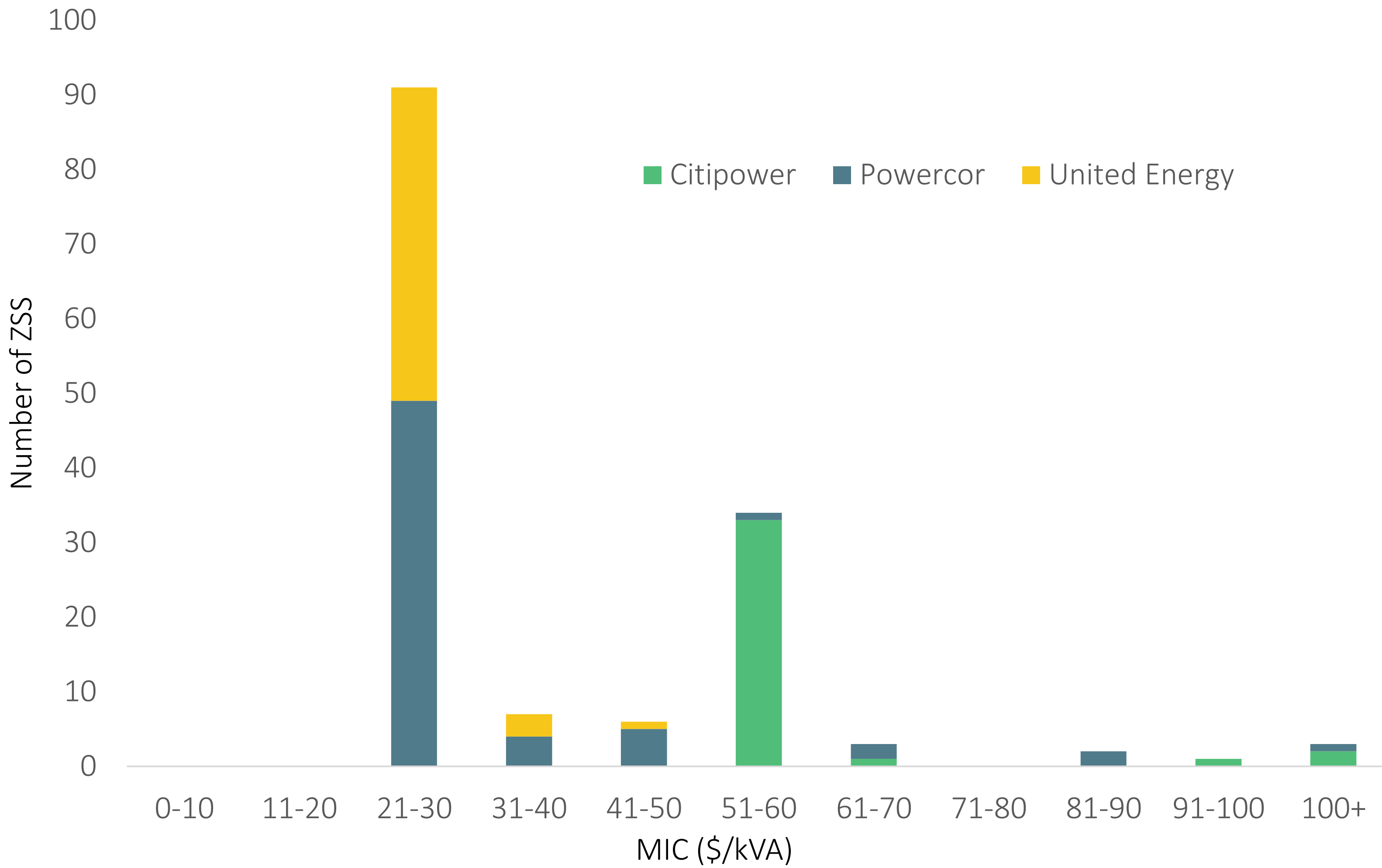
Cumulative LRMC ($/kVA/yr)

5 Level split	LV	DSS	HV	ZSS	ST
Powercor	33.08	24.39	8.85	6.13	0.35
Citipower	58.35	28.26	12.45	4.67	0.00
UE	23.14	34.62	20.52	8.50	3.79

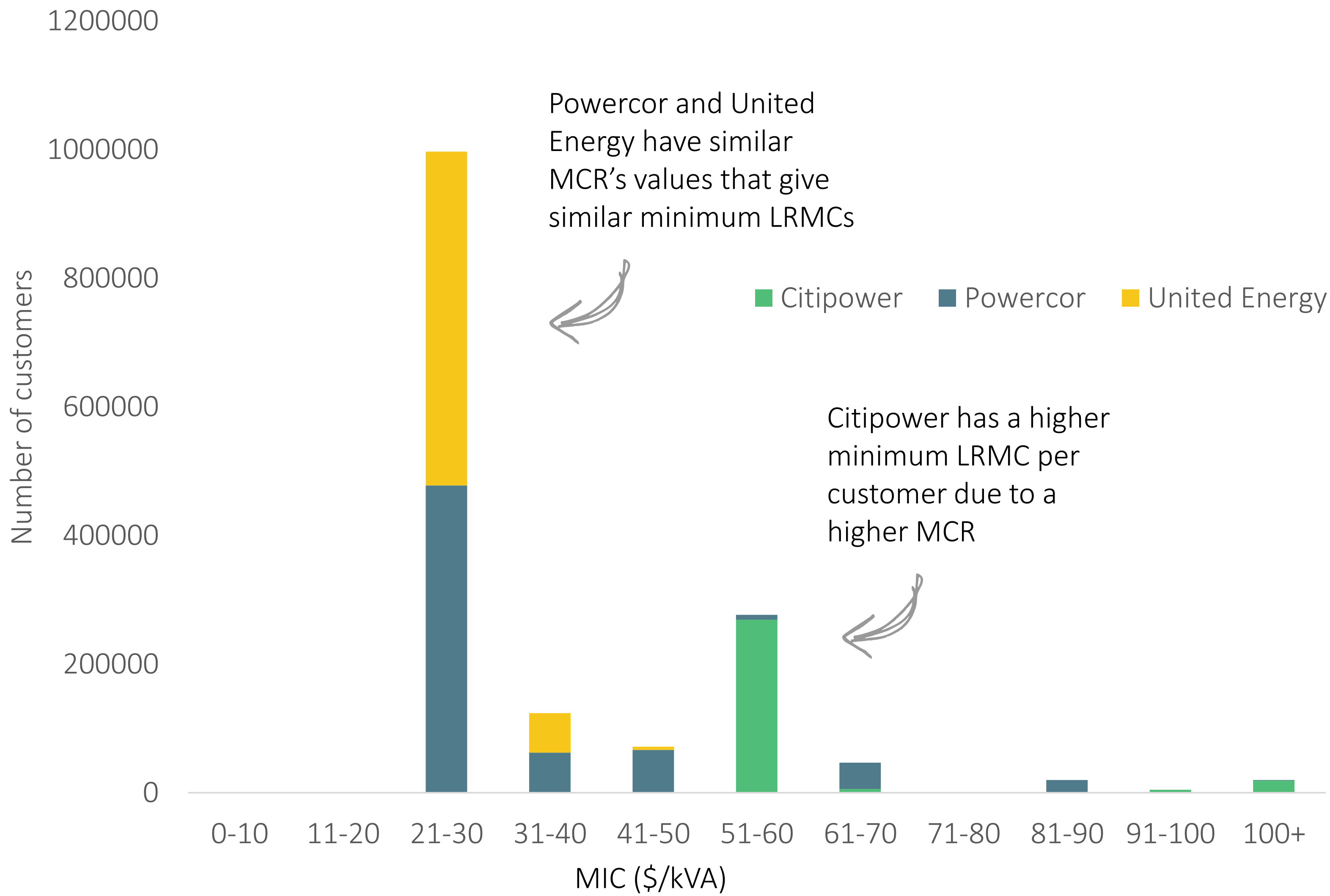
Evolution of LV customer LRMC differ significantly across the three networks



Citipower's larger MCR costs concentrate the higher customer charges within that network



The LRMC for LV customers is mostly dependent on MCR costs where ZS and ST projects are absent



The selected methodology allows a wider diversity of projects to be included within the LRMC computation compared to other methods.

The methodology is robust enough to include all types of demand driven projects

- The assignment of projects to the assets that will benefit and the demand that is driving them is vital to the methodology
- REPEX projects with various demand profiles can be included within the methodology in line with AER expectations

The results can be updated by incorporating changes in project pipelines

The mix of MIC & MCR methods employed is gaining traction

- It is consistent with the Ofgem model from the UK

LRMC can greatly vary, between but also within networks, and are sensitive to some side inputs

Variability across the networks is significant

- Ranging from 9 to 117 $/KVA for LV customers
- Most locational LRMC is far from the average value
- Using an average LRMC is far from being cost reflective

Diversity factors of customers at voltage levels play a strong role in the final LRMC values

Spatial distribution of the LRMC is dependent on the accurate and consistent recording and assignment of projects to assets across the networks.

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Agenda

Methodology to determine LRMC

Results and discussion

Next steps for discussion with AER

Appendix

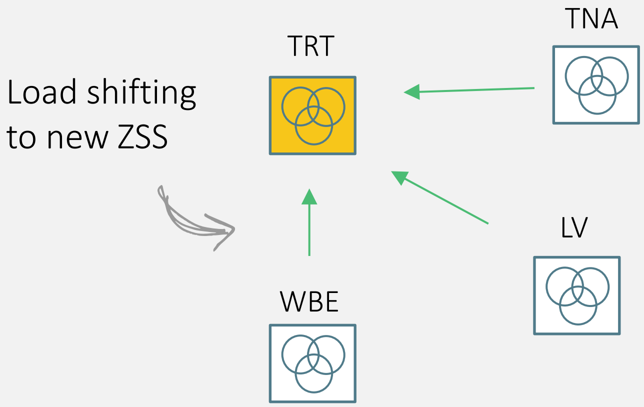
1. Calculation methodology
2. Project summary
3. MCR values
4. Diversification factor

For HV/ZSS, complex projects required benefits per ZSS to be determined

Multi substation projects required costs to be split between the existing substations driving the augmentation based on the project benefits.

- These include augmentation triggered by offloads and new substation projects.

New TRT substation example, shifting load from the 3 neighbouring substations.



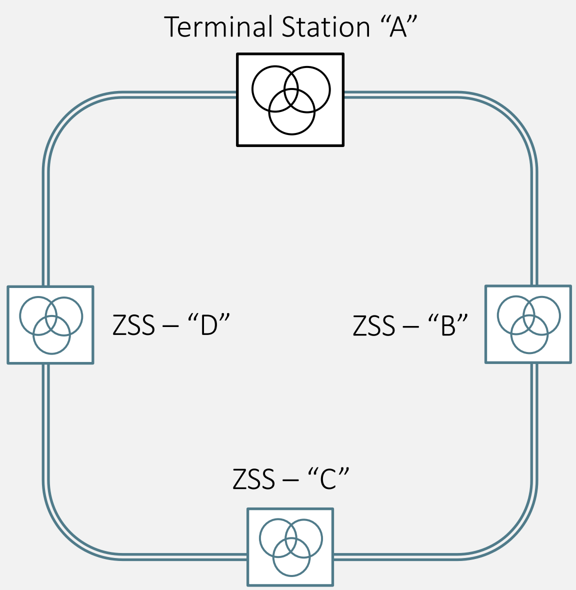
The costs to build TRT substation can be split based on the benefit

- Ideally (as in this example), by using the Energy-at-Risk reduction resulting from the project, or
- Allocating based on the Planners judgement of the location of the potential benefits

For sub-transmission, only network projects can be relied on for determining the LRMC of that voltage level

Two types of sub-transmission projects have been assessed

1. Projects which serve demand at the Terminal Station level driven by single or multiple ZSS on the loop

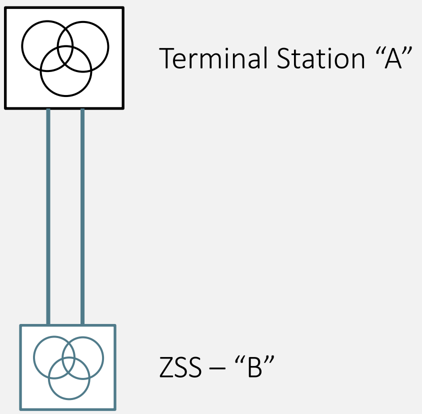


The cost to augment the sub-transmission line from A-B-C-D-A is allocated fully TS

- Demand triggering augmentation is allocated to single or multiple ZSS dependent on recommendations from planners.

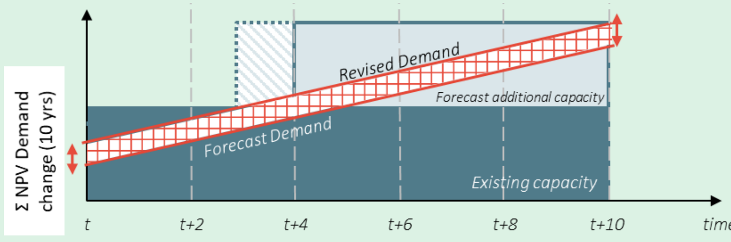
2. Projects which serve demand to a specific ZSS

The cost to augment the sub-transmission line from A-B-A can be fully allocated to ZSS "B"

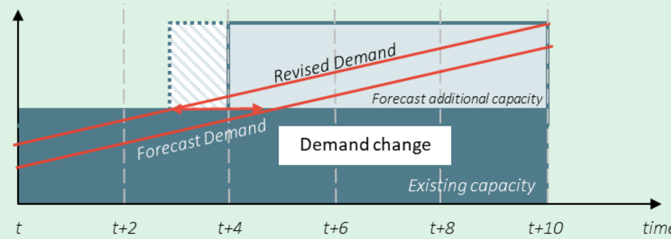


The MIC and LRIC methods both consider small deviations *from the forecast*, but spread the price signal over different periods

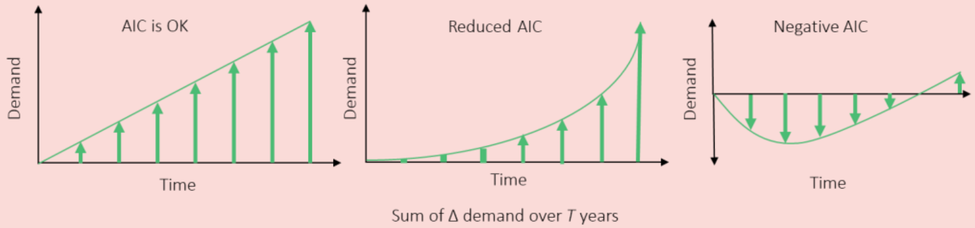
MIC
Spreads the price signal over the forecast period (10 years).



LRIC
Spreads the price signal over the deferral period (1 year)



AIC - not considered
Considers variations *from current situation*, and spreads the price signal over the forecast period. Not usable with REPEX or non linear demand growth.



LRMC - Marginal Incremental Cost (MIC)

Step (i) *Eternalising Capex and Opex*

$$A = \frac{Capex}{(1-(1+WACC^{l}))} + \frac{Opex}{(1-(1+WACC^{l}))}$$

Step (ii) *NPV of Capex*

$$\boldsymbol{B} = \frac{\boldsymbol{A}}{(1+WACC^{i})}$$

Step (iii) *Determining marginal CAPEX*

$$\mathbf{C} = \mathrm{A} \; * (1 - 1/(1+WACC))$$

Step (iv) *Determining the marginal incremental MD in PV terms*

$$\boldsymbol{D} = \sum_{n=1}^{10} \frac{(ForecastMD_{i+1} - ForecastMD_{i-1})}{(1+WACC)^{n-1}}$$

Variable	Definition
i	Year of investment
l	Lifetime of the asset
n	Year (for n in n's)
O_f	OPEX factor (as a % of CAPEX)
$CAPEX$	Refers to the nominal value
$WACC$	Weighted-average cost of capital

Step (v) *Determining the MIC value*

$$\boldsymbol{MIC} = \frac{\boldsymbol{C}}{\boldsymbol{D}}$$

LRMC - Long Run Incremental Cost (LRIC)

Step (i)

$$\boldsymbol{A} = CAPEX$$

Step (ii)

$$\boldsymbol{B} = CAPEX * O_f$$

Step (iii)

$$\boldsymbol{C} = ForecastMD_{i+1} - ForecastMD_i$$

Step (iv)

$$\boldsymbol{D} = \frac{WACC}{1 - \left(\frac{1}{1 + WACC}\right)^l}$$

a.k.a. Annuitisation

Variable	Definition
i	Year of investment
l	Lifetime of the asset
n	Year (for n in n's)
O_f	OPEX factor (as a % of CAPEX)
$CAPEX$	Refers to the nominal value
$WACC$	Weighted-average cost of capital

Step (v)

$$\boldsymbol{LRIC} = \frac{(\boldsymbol{A} * \boldsymbol{D}) + \boldsymbol{B}}{\boldsymbol{C}}$$

Appendix 2. Included and excluded projects
Summary

A total of 138 projects across all three networks were originally considered

Network	Included Augex	Included Repex	Total included	Excluded Augex	Excluded Repex	Total excluded
Powercor	32	6	38	14	2	16
Citipower	5	7	12	34	9	43
United Energy	15	0	15	11	3	14
Totals	52	13	65	59	14	73

Appendix 2a. Included projects, Powercor
Project summary (1 of 10)

Name	Description	Investment year	Type
BMH - Altona-Brooklyn	BMH ZSS new 66/22kV 25/33 MVA Tr-3 and New Control Room	2021	AUGEX
CHA - Kerang	CHA 22kV Tx disconnect switches	2020	AUGEX
COB - Terang	COB - Install Fans on Tx 2	2024	AUGEX
DDL - Geelong	DDL-OGE 66kV line(DDL 31 Fdr)	2024	AUGEX
EHK - Bendigo	EHK- Install 3rd Transformer, 3rd 22kV bus	2026	AUGEX
GCY - Geelong	GCY-Install 3rd 20/33 MVA transformer & associated bus work	2026	AUGEX
GCY - Geelong 2	GCY PPS	2025	AUGEX
GL - Geelong	GL Tx 1 22 kV CB augmentation	2024	AUGEX
GL - Geelong 2	GL Tx 2 22 kV CB augmentation	2025	AUGEX
KGTS - Kerang	CHA TX disconnect sw uprate	2025	AUGEX
MLN - Deer Park 2	Uprate MLN cap bank to 12MVAr	2023	AUGEX
MNA - Shepparton	Establish 66 kV line between MNA and TAT	2028	AUGEX
MRO - Bendigo	Uprate MRO Cap Bk with an additional 3.0 MVAr step and VAR Controller	2020	AUGEX
MRO - Bendigo 2	MRO 3rd Transformer	2028	AUGEX
PLD - Terang	PLD Install high capacity fans on transformer (x2)	2028	AUGEX
RVL - Red Cliff	RVL rebuild to 3 x 10/13.5 MVA transformers	2025	AUGEX
SSE - Keilor	2 x 12MVAR Capbank at SSE	2022	AUGEX
TNA - Deer Park	3rd transformer at TNA and 3rd bus.	2019	AUGEX

Appendix 2a. Included projects, Powercor Project summary (2 of 10)

Name	Description	Investment year	Type
TQY - Geelong	Torquay Zone substation Design & establishment. I x transformer	2024	AUGEX
TQY - Geelong 2	Torquay Zone substation 2nd transformer	2027	AUGEX
TQY - Geelong 3	At TQY 66 kV Feeders	2025	AUGEX
TRT - Deer Park	Rebuild/Reroute BLTS-BMH for TRT 66kV lines	2022	AUGEX
TRT - Deer Park	Establish New DPTS-TRT 66kV line	2022	AUGEX
TRT - Deer Park	Establish New TNA-TRT 66kV line	2022	AUGEX
TRT - Deer Park	New TRT Zone substation with 2 x 33/25MVA Tx+12MVAr Cap bank	2022	AUGEX
TRT - Deer Park	TRT 3rd Tx	2026	AUGEX
WBE - Altona-Brooklyn	WBE 2nd cap bank	2023	AUGEX
WBE - Altona-Brooklyn	Uprate ATS-WBE Exit and HCP-WBE at WBE to 1050A minimum summer	2025	AUGEX
HCP - Altona-Brooklyn	Uprate ATS-HCP Exit and HCP-WBE at HCP to 1050A minimum summer	2025	AUGEX
WMN - Red Cliff	WMN Augment No1 transformer	2024	AUGEX
WPD - Geelong	At WPD -Zone SS 66 kV works for TQY Lines	2025	AUGEX
WPD - Geelong 2	At WPD - 66 kV Line works for TQY Lines	2025	AUGEX
Colac Zone SubstationTx Replacement CLC TR2	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2019	REPEX
Horsham Zone Substation Tx Replacement HSMTR2	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2019	REPEX
Merbein Zone Substation Tx Replacement MBNTR1	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2023	REPEX
Robinvale Zone Subbstation Tx Replacement RVLTR1	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2020	REPEX
Robinvale Zone Subbstation Tx Replacement RVLTR2	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2022	REPEX
Swan Hill Zone Substation Tx Replacement SHLTR3	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2023	REPEX

Appendix 2a. Included projects, Citipower Project summary (3 of 10)

Name	Description	Investment year	Type
Fishermans Bend - FBTS 1	AP NOAC on B/T - 0 -	2020	AUGEX
Richmond - RTS66	NR new 11kV Jumbo Feeder (Load growth-Swan Street Bridge area) - 0 -	2020	AUGEX
Richmond - RTS66 2	B new 11kV feeder - 0 -	2023	AUGEX
Fishermans Bend - FBTS E offloading	ZSS E offload to WG - -	2022	AUGEX
Fishermans Bend - FBTS 6 SB project	SB 3rd 55MVA Transformer - -	2022	AUGEX
North Richmond ZSS Tweedie Place Tx Replacement NR 1	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2022	REPEX
North Richmond ZSS Tweedie Place Tx Replacement NR 2	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2019	REPEX
Richmond (Oddys Lane) ZSS Tx Replacement R 1	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2021	REPEX
Richmond (Oddys Lane) ZSS Tx Replacement R 2	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2020	REPEX
Victoria Market (VMZSS Walsh Street Tx Replacement VM 1	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2020	REPEX
Warratah Place Tx Replacement WA 1	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2022	REPEX
Warratah Place Tx Replacement WA 2	Condition and risk based replacement of zone substation transformer. Based on CBRM condition assessment and risk assessment.	2021	REPEX

Appendix 2a. Included projects, United Energy Project summary (4 of 10)

Name	Description	Investment year	Type
BT-MR 66kV - thermal uprate	BT000290 - Provided BT-MR loop rating/forecast	2025	AUGEX
CBTS 66kV line rearrangement	CBTS000341 - No Capacity added. Just a rearrangement for TS.	2027	AUGEX
EW RTS-EW Upgrade Droppers at EW	EW000369 - Provided RTS-EW loop rating/forecast	2028	AUGEX
GWNO Combine with EB Loop	GW000352 - Provided GWNO loop rating/forecast. Joining Two loops effective added capacity given.	2025	AUGEX
RWTS-NW-BH 3rd 66kV line	RWTS000443 - Provided NW-BH loop rating/forecast	2028	AUGEX
TBTS-HGS line upgrade	TYTS000356 - Provided TBTS-MTN loop rating/forecast.	2022	AUGEX
TSTS-DC No1 Reconductor	TSTS000383 - Provided DC loop rating/forecast	2025	AUGEX
DC 4th transformer	DC000295 -	2024	AUGEX
DMA reactive power compensation	DMA000368 - Estimated Effective load reduction as been given as capacity added.	2028	AUGEX
EM New switchboard	EM000347 - No ZSS capacity just an extra switchboard/load shifted. Could be lumped with feeder costs.	2022	AUGEX
KBH 2nd transformer	KBH000365 -	2023	AUGEX
KBH reactive power compensation	KBH000311 - Estimated effective load reduction as been given as capacity added.	2023	AUGEX
LWN 6MVAr capacitor bank	LWN000386 - Estimated effective load reduction as been given as capacity added.	2026	AUGEX
MTN 3rd Transformer	MTN000376 -	2023	AUGEX
SVW 3rd Transformer	SVW000382 -	2027	AUGEX

Appendix 4.
Diversity factors utilised

United Energy

Diversity factors	LV	DSS	HV	ZSS	Sub-trans
LV	0.4	0.38	0.32	0.29	0.28
LV/DSS		1	0.9	0.8	0.76
HV			0.95	0.88	0.84
ZSS				0.9	0.86
Sub-trans					1

CitiPower and Powercor

	Diversity factor
LV	0.6
LV/DSS	0.7
HV	0.5
ZSS	0.5
Sub-trans	0.5