Voltage Demand Relationship

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Voltage demand relationship introduction

Conservation Of Voltage techniques use the voltage demand relationship in the network to reduce demand.

Networks comprise of mainly three types of load, constant power, constant impedance, constant current.

ENWL model this relationship using “exponential models”.

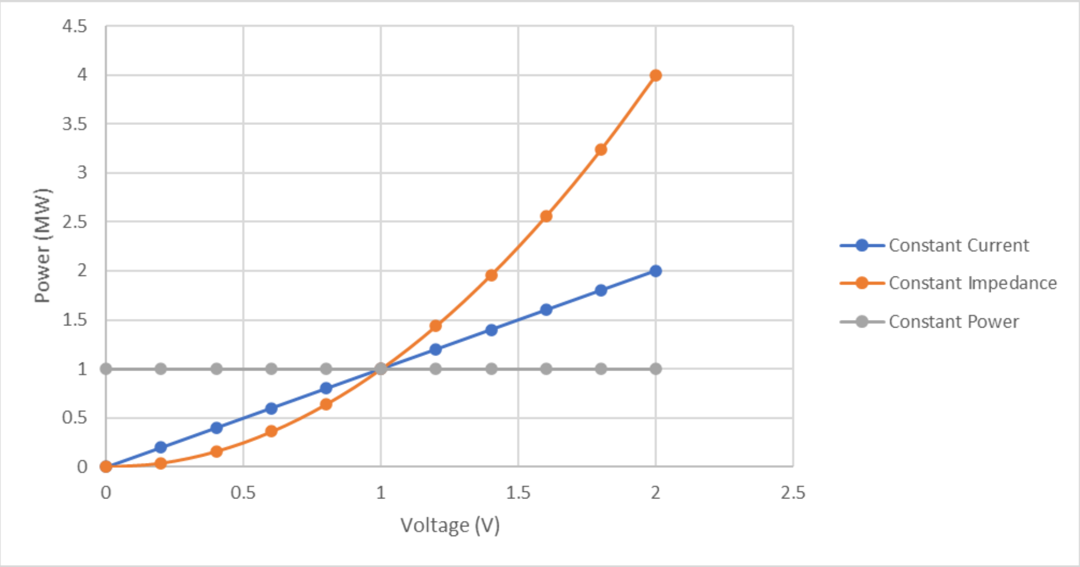
When the Kp value is closer to 2, the loads represent a strong voltage demand relationship (constant impedance), which will result in more impact from voltage changes.

Conversely when the Kp value is closer to 0, the loads represent a weak voltage demand relationship (constant power).

Fundamentals monitor changes to the voltage to encapsulate this relationship at the primary to determine the impact voltage changes would have at this moment in time.

Providing a rich useful data set to model the impact of CVR in the network.

This data set allows us to:
- determine the present voltage demand relationship,
- How that relationship is changing
- How the impact of this changing relationship will affect benefits to the network.

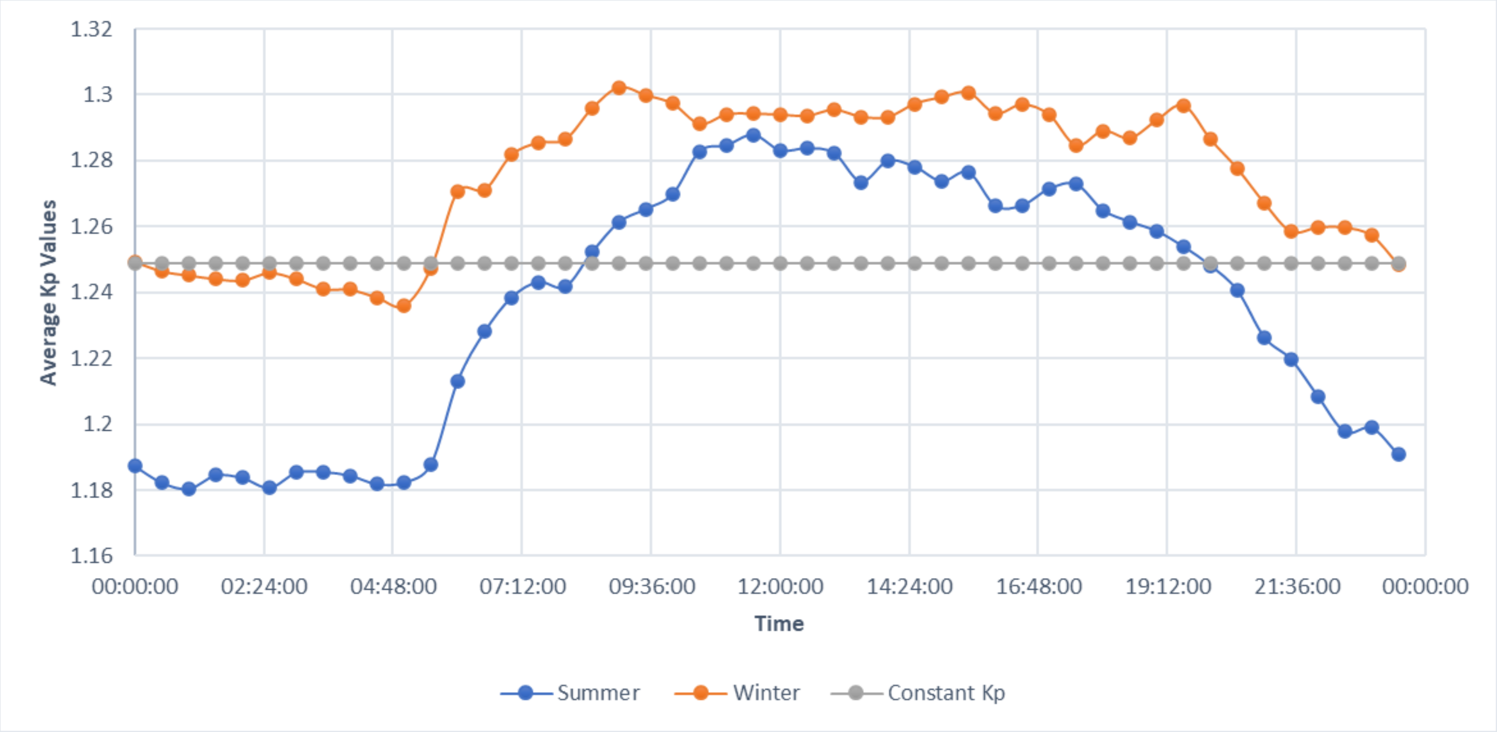


$$P_{EXP} = P_b \cdot \left(\frac{v}{v_b}\right)^{K_p}$$

$$K_p = log_{10}\left(\frac{P}{P_b}\right)/log_{10}\left(\frac{v}{v_b}\right)$$

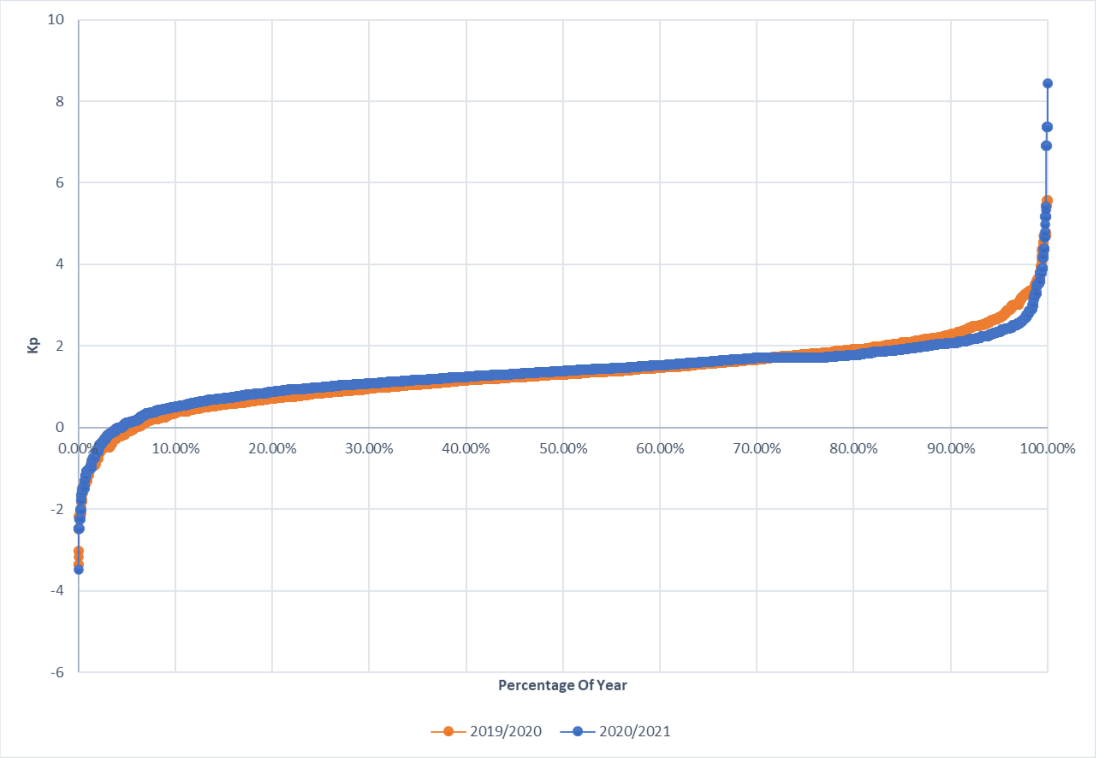
Voltage demand relationship (past)

The historical data set can provide us with information on how the Kp Relationship changes day by day, season to season.



Voltage demand relationship (present)

The historical data sets can be compared against one another to determine how the relationship is changing.



	Periods with Weak VDR	Periods with Strong VDR	Number Of Periods
2019/2020	4496	13024	17520
2020/2021	5694	11826	17520
2019/2020	25.66%	74.34%	1
2020/2021	32.50%	67.50%	1
Change	6.84%		

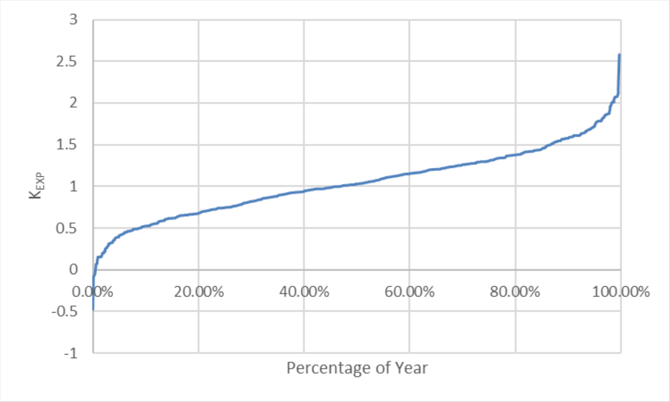
BSP	Pry	% Change
Chadderton	Middleton Junction	3.46
Greenhill	Willowbank	2.61
Royton	Royton	11.51
Royton	Heyside	-3.44
Royton	Shaw	6.84
Average		~4

Voltage demand relationship (future)

The trends in data relationship changes can be coupled with the magnitude growth of the future energy scenarios.

To determine how values may change in the future, and enable the benefits and limitations of control methods to be planned for more accurately.

Exponentials models may not be suitable for load growth projection, since certain load growth may not exhibit an exponential model relationship, but a singular constant impedance, constant current, constant power trend. For example, heat pump design recommendations should be voltage independent, similar to EVs- the two biggest load growth potentials. Therefore, Kp models can be converted into ZIP models and then used to project growth more precisely based on trends into the future.



$$P_{EXP} = P_b \cdot \left(\frac{v}{v_b}\right)^{Kp}$$

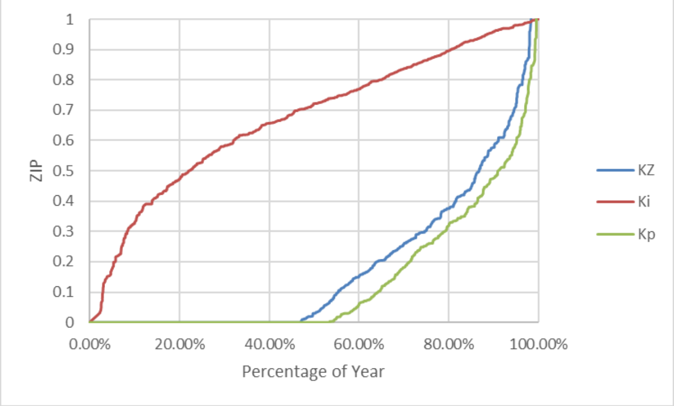
Kp Distribution

$$K_{EXP} \leq 0 \rightarrow \begin{cases} K_Z = 0 \\ K_I = 0 \\ K_P = 1 \end{cases}$$

$$0 \leq K_{EXP} \leq 1 \rightarrow \begin{cases} K_Z = 0 \\ K_I = K_{EXP} \\ K_P = 1 - K_{EXP} \end{cases}$$

$$1 < K_{EXP} < 2 \rightarrow \begin{cases} K_Z = K_{EXP} - 1 \\ K_I = 2 - K_{EXP} \\ K_P = 0 \end{cases}$$

$$K_{EXP} \geq 2 \rightarrow \begin{cases} K_Z = 1 \\ K_I = 0 \\ K_P = 0 \end{cases}$$



$$P = P_0 \left(aP \cdot \left(\frac{v}{v_0}\right)^{e\_aP} + bP \cdot \left(\frac{v}{v_0}\right)^{e\_bP} + (1 - aP - bP) \cdot \left(\frac{v}{v_0}\right)^{e\_cP} \right)$$

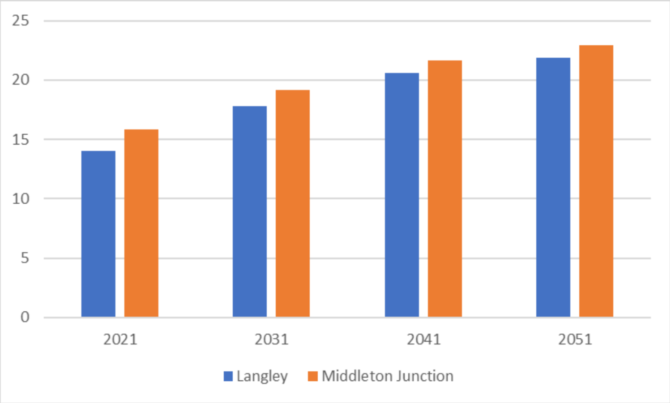
ZIP Distribution

Voltage demand relationship (future)

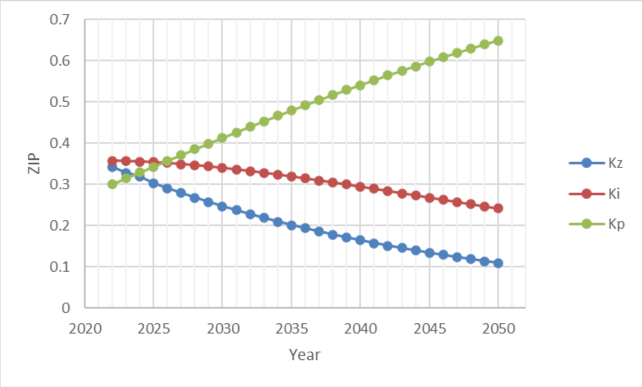
Load can now be fully model via three load aspects

- Load Growth Magnitude: How new connections are forecasted
- Load Behavior Over Time: How load demand is behaving day to day, season to season
- Load Voltage-Demand Relationship: How the instantaneous demand of MW is being modelled by load type and how this will change into the future.

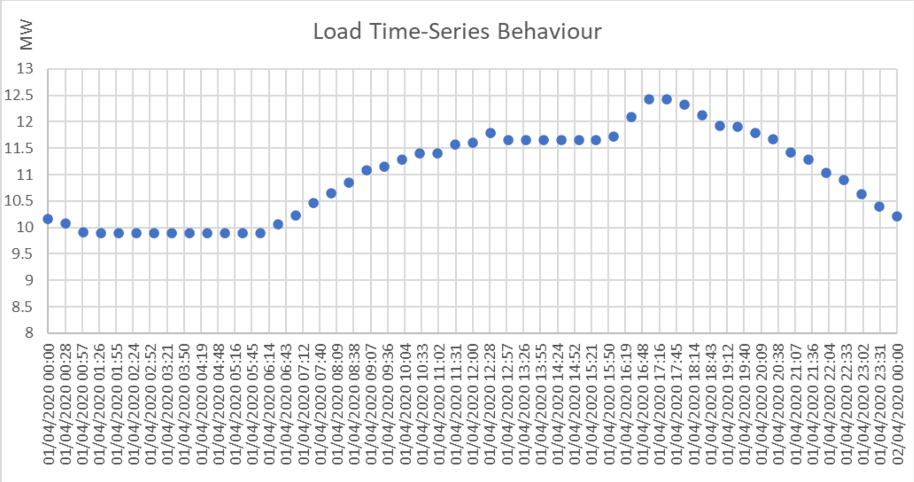
Load Growth Magnitude At Primary



Load Voltage-Demand Relationship



Load Behaviour Over Time

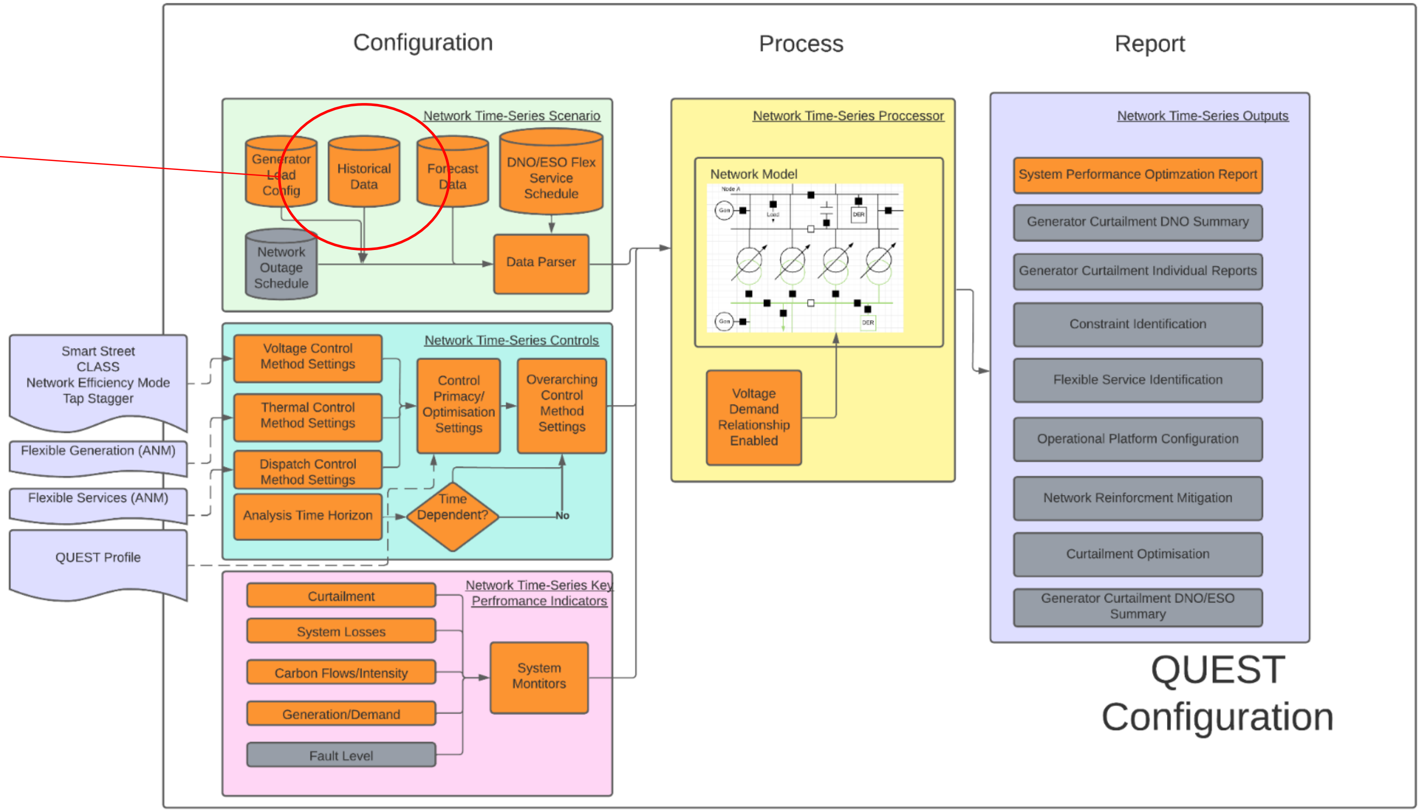


Voltage demand relationship conclusion

The Voltage Demand Relationship work allows for ENWL to more accurately incorporate load behaviour benefits from CVR methods into QUEST modelling.

By monitoring trends in the voltage relationship data. ENWL can forecast the impact of this relationship into the future.

When this is coupled with the modelling regime, ENWL can more accurately determine benefits and limitations to their operational planning assumptions in areas such as, flexibility services, network reinforcement and curtailment impacts.



	Average ENWL Network Performance April 2022			Average ENWL Network Performance April 2030		
	Before CLASS applied	After CLASS applied	Difference	Before CLASS applied	After CLASS applied	Difference
System Load (MW Average)	73.77	73.44	0.33	73.77	73.49	0.28
System Generation External (MW Average)	95.15	94.64	0.50	95.15	94.69	0.45
33kV Losses (MW Average)	0.07361	0.07247	0.00114	0.07361	0.07271	0.00090
System Carbon (kgCO2 Average)	7215.63	7181.21	34.41	7215.63	7186.54	29.09

QUESTIONS & ANSWERS

innovation@enwl.co.uk

www.enwl.co.uk/innovation-strategy

0800 195 4141

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