KPMG

Vehicles Advice
Energy

Infrastructure Victoria

Key Findings – August 2018

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Overview

Purpose

Assess the impact of automated and zero emissions vehicles (ZEV) uptake on electricity generation and networks in Victoria by 2046 under seven scenarios, and consider potential infrastructure responses

Modelling approach

Simple representation to help aid the understanding of the potential relationships between ZEV uptake, daily charging profile, demand and the required generation and network responses under the seven different scenarios

Findings

High levels of ZEV uptake will require significant investments in generation and networks capacity by 2046, but this can be mitigated to some extent by managing ZEV charging patterns and putting in place policy arrangements which best captures the benefits of ZEVs

Structure of the presentation

1 Overview of methodology for KPMG's Electricity Market Model

2 Summary of modelling results across scenarios and presentation of detail findings using Electric Avenue scenario

3 Factors which will drive infrastructure responses and key points

KPMG's Electricity Market Model

Model Framework

Distance and electrical demand Conversion of kilometres driven to electricity daily demand for cars and freight vehicles	**Demand impacts** Contribution to peak demand by mapping daily ZEV demand profiles (based on charging behaviour and infrastructure of different types of vehicles) onto system demand profiles	

Modelled electricity demand

Generation capacity impact Generation capacity required to meet forecast consumption and maximum demand, including from ZEVs, and associated NPV cost	**Network capacity impact** Costs for DNSPs to serve forecast demand, including from ZEVs, from 2018-2046 Spatial analysis of localised impacts	**Emissions** Emissions produced (noting that all new capacity is "zero emissions" by design)

Limitations

- The model is a simple representation to help aid the understanding of the relationship between ZEV uptake and generation / network responses.
- The model is not a complete simulation of the highly complex NEM system, and it does not, for example, predict economically driven new entry and retirements.
- The model does not encompass very detailed or granular load studies of flows or network capabilities.

Key assumptions

- Linear uptake of ZEVs until 2046
- Demand and costs forecasts and current / expected (e.g. VRET) supply from AEMO
- Limited retirements (only Yallourn 2032)
- Wind and solar to meet total consumption (50/50), batteries and pumped hydro (50/50) to meet maximum demand
- Network long term marginal costs from DNSPs

Calculating contribution to peak demand

In calculating the contribution to peak demand, we have recognised the need to account for differences in :

- Type of vehicle use (which impacts the volume and time of charging);
- Type of charging rate (different charging types consume varying levels of energy)
- Charging profile (whether any influencers alter how a vehicle is charged).

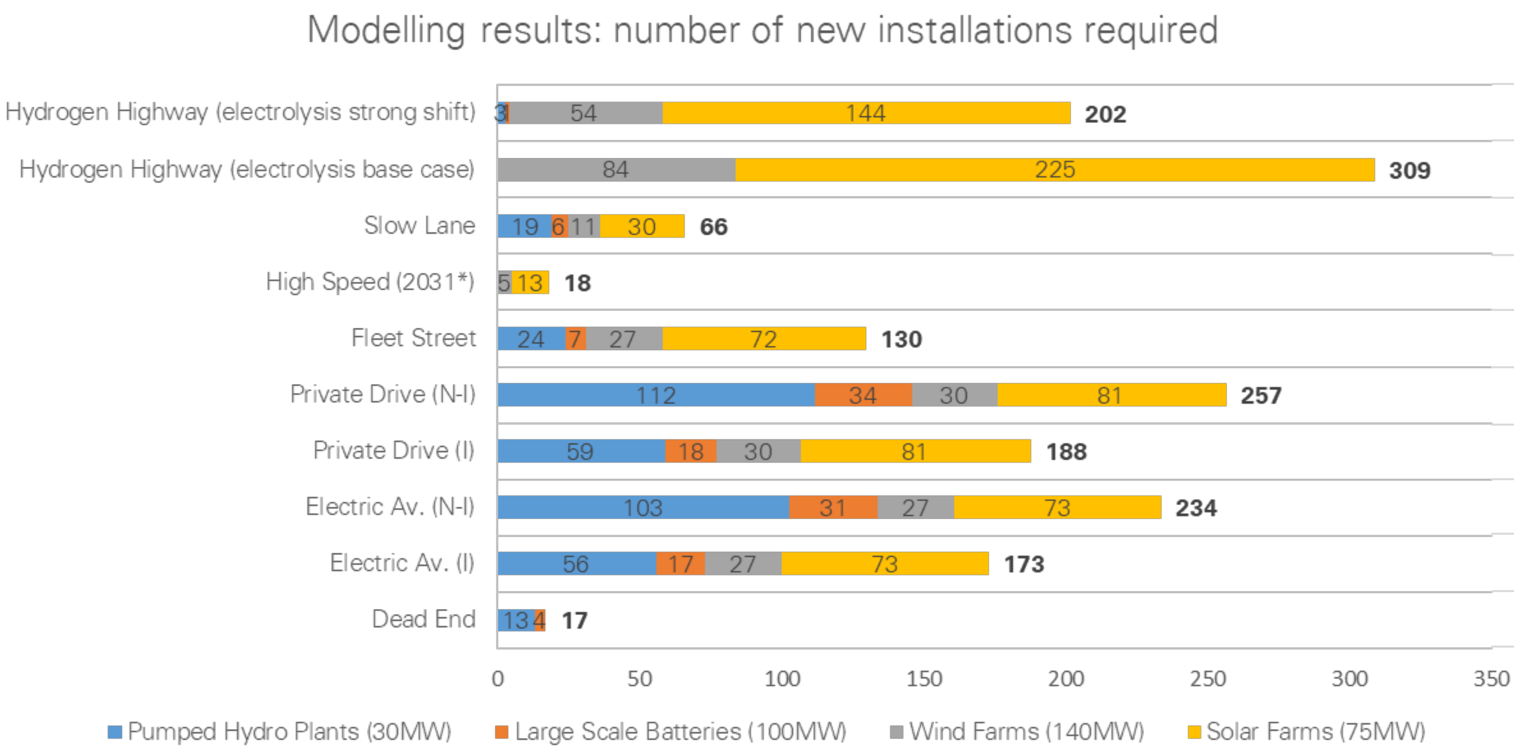
	Type of vehicle use	Type of charging rate	Charging profile
1	Residential	Type 1	Incentivised
2	Residential	Type 2	Non-incentivised
3	Residential	Type 1	Non-incentivised
4	Residential	Type 2	Incentivised
5	Out of home	Type 3	Out of home profile
6	Commercial	Type 2	Incentivised
7	Commercial	Type 2	Non-incentivised
8	Shared	Type 2	Shared profile
9	Shared	Type 3	Commercial incentivised

Our model calculates a contribution to peak demand for each of the nine patterns above. Then for each scenario, we sum the relevant charging patterns (out of the nine possible patterns).

Summary of modelling results

The chart below highlights the extent of new generation that would need to be installed meet the modelled requirements under the various scenarios. New generation is need to serve both the increase in maximum demand (dispatchable) and increase in electricity consumption (non-dispatchable)

As of July 2018, there is 11,098 MW of total generation capacity installed in Victoria, indicating the significant need for new generation investment under wide spread uptake ZEVs in Victoria.



Scenario	Dispatchable generation (MW)	Non-dispatchable generation (MW)
Hydrogen Highway (electrolysis strong shift)	166	18,313
Hydrogen Highway (electrolysis base case)	0	28,529
Slow Lane	1,121	3,808
High Speed (2031*)	0	1,636
Fleet Street	1,451	9,198
Private Drive (N-I)	6,719	10,279
Private Drive (I)	3,519	10,279
Electric Av. (N-I)	6,205	9,308
Electric Av. (I)	3,331	9,308
Dead End	800	0

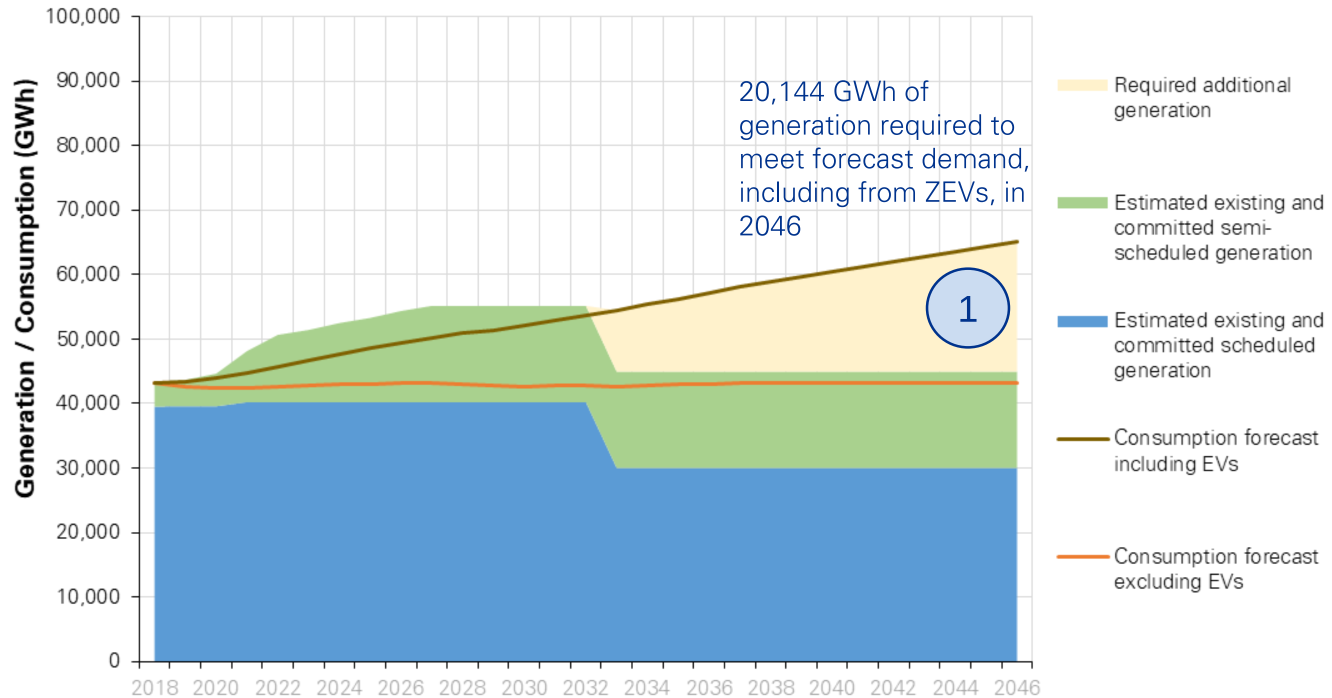
Electric Avenue: Generation and consumption

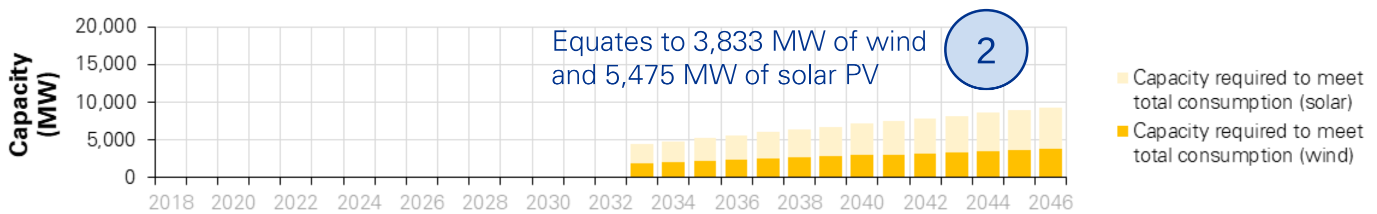
ZEVs:

- 3.9 million privately owned ZEVs (3.5 million cars and 0.4 million freight)
- Total annual consumption of ZEVs of 21,999 GWh by 2046

Key assumptions:

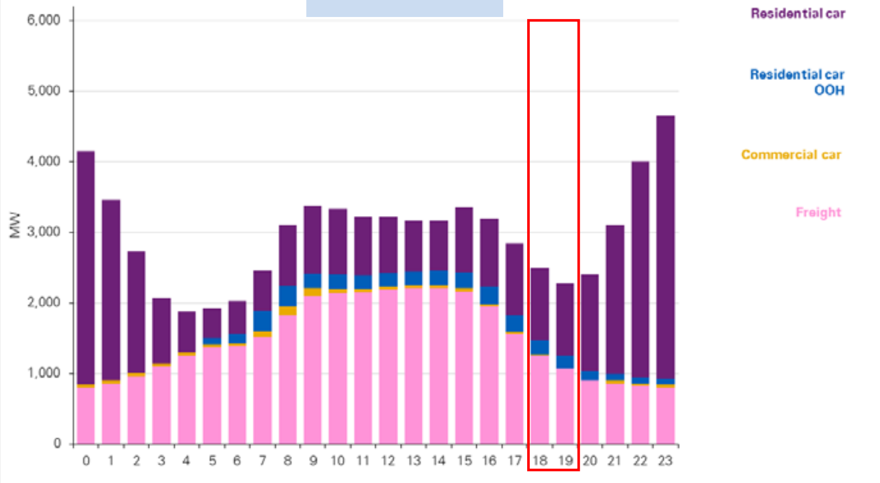
- Current generation remains constant, except Yallourn retires in 2032
- Renewable capacity through VRET given
- New generation 50/50 solar (21% capacity factor) and wind (30% capacity factor)
- No contribution from storage technologies installed to meet maximum demand



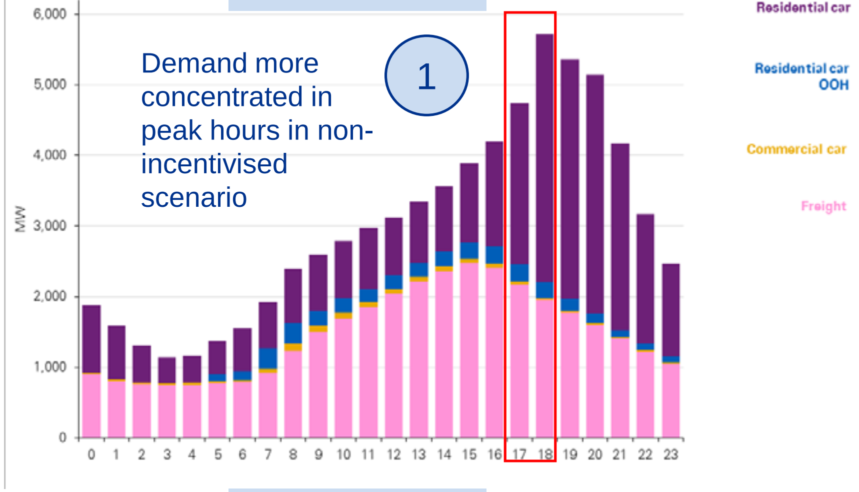


Electric Avenue: Maximum Demand

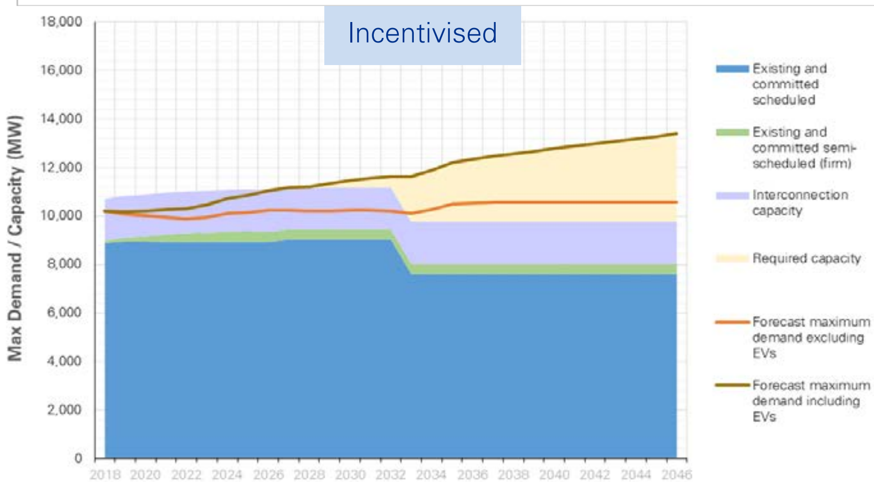
Incentivised



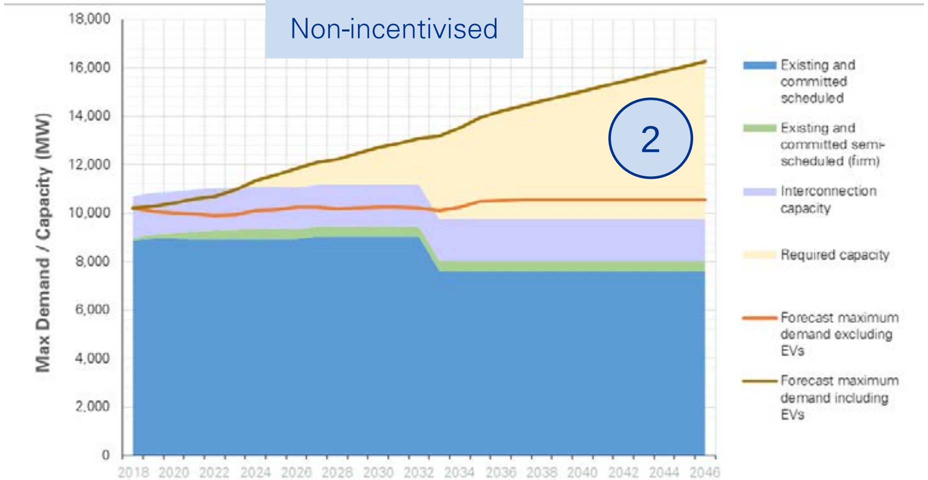
Non-incentivised



Incentivised



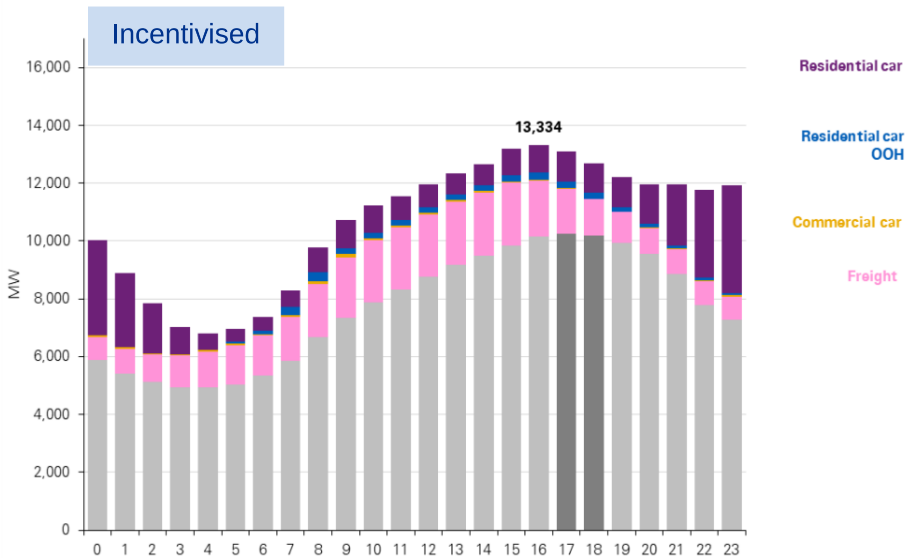
Non-incentivised

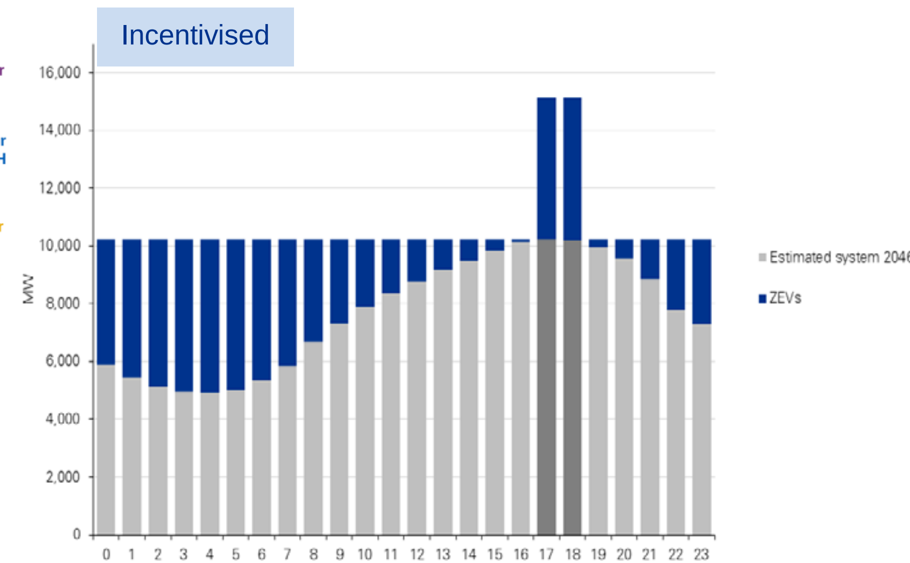


Electric Avenue Incentivised : Impacts on Maximum Demand

1 Significant demand from ZEVs has the potential to shift the peak

2 Maximum demand increases regardless of charging profile due to large ZEV uptake. Cannot absorb extra demand within current load profile





System demand estimated based on peak day in summer 2018 to date and AEMO forecast (grey, with darker grey indicating current peak period)

Electric Avenue: Distribution Network Impacts

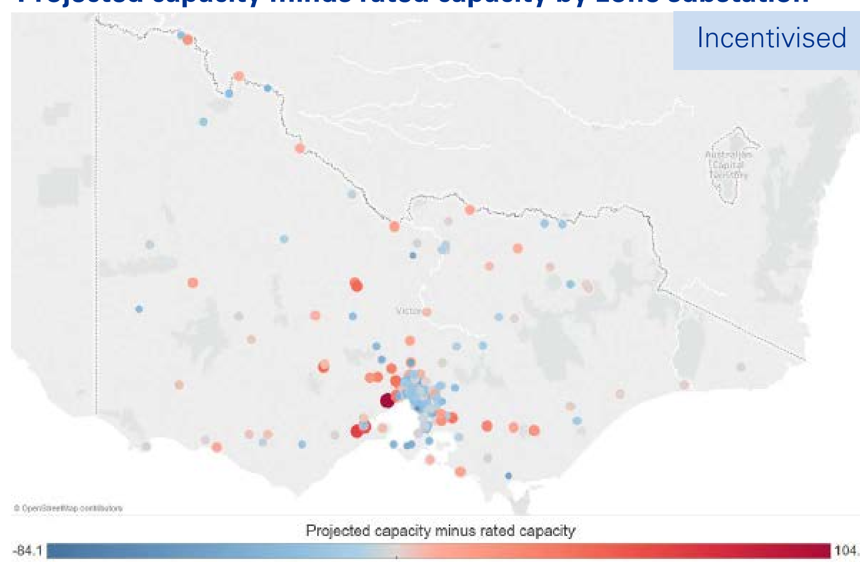
DNSP	Peak hours	Additional demand (MW) by 2046	# zone substations (ZS)	#ZS projected MD < current rated capacity	# ZS projected MD > current rated capacity (ex. 0-10%)	#ZS projected MD > current rated capacity (ex. 10%+)
Ausnet	2 - 6 pm	1,029	52	24	**16**	**12**
CitiPower	10 am – 6 pm	226	37	31	**4**	**2**
Jemena	3 – 9 pm	539	30	18	**3**	**9**
Powercor	3 – 9 pm	1,315	58	23	**13**	**22**
United Energy	3 – 9 pm	752	47	42	**5**	**0**

1. Cost to network is based on LRMCs per MW per annum multiplied by additional maximum demand in relevant peak hours (linearly increasing from 2018 to 2046). Model then calculates the NPV of the annual LRMC amounts over the modelling horizon.

2. Spatial analysis considers each DNSP's zone substations, their expected maximum demand in 2046, and whether their expected maximum demand exceeds current rated capacity by 0-10% (low exceedence) or 10%+ (high exceedence).

Results likely to under-estimate impacts on networks costs

Projected capacity minus rated capacity by zone substation



Key findings from modelling results

Key observations	Key sensitivities
• High levels of ZEV uptake will require significant investment in both generation capacity and networks by 2046 to accommodate up to 50% increase in consumption. • This can be mitigated to by managing ZEV charging patterns, for example: o Incentivising or controlling charging to occur outside of peak hours o Encouraging charging in early morning and late afternoon o Co-ordinating of out of home super fast charging (Type 3) • The estimated investment is higher under the private ownerships compared to the shared fleet scenarios. Expectation that the shared fleet operator will be able to better manage charging in order to avoid peak periods. • The network capacity impacts in particular will be variable and subject to local conditions, and our model is likely to underestimate the full costs as some types of network impacts have not been estimated	• Government policy and market design arrangements • Timing of retirement of existing generation • Snowy 2.0 adding significant new capacity • Increase in uptake of demand side participation • Increase for wind and solar PV in capacity factors and/or contribution to peak demand • Interconnection availability • Development of new technologies • Local conditions across networks • Ability to capture flexibility benefits of ZEVs as a discretionary load and/or as battery storage • New capacity may not be located in Victoria

Factors influencing infrastructure responses

Key policy and regulatory questions to be resolved

Generation	• Potential supply constraints on the development of technology types (e.g., land) • Will ZEV uptake lead to greater demand side participation • Reliability of renewable generation sources
Transmission	• Timing and availability of transmission capacity to transport electricity from new renewable generation locations
Distribution	• Diversity in the local impacts of BEV charging • Access and connection arrangements and managing super fast charging or shared depots • Uncertainties in the regulatory cost recovery framework • Transition to a distribution system operator role • Tariffs for EV charging
Charging	• Interoperability (ability for various systems to work together) and standards • Is charging a sale of electricity under legislation? • Flexibility in metering arrangements • Ownership models for charging infrastructure • Locations, including for out of home charging and common end-of-trip sites (planning and construction)
H_2 Hydrogen Economy	• Preferred production method • Approaches for distribution of hydrogen from production to pump • Ownership models across supply chain, distribution, and retail and whether ring fencing is required. • Safety and technical regulation

Concluding thoughts

- High levels of ZEV uptake will require very significant investment in both generation capacity and networks by 2046.
- This can be mitigated to some extent by managing charging patterns, and also by capturing the full benefits of the flexibility and storage potential of the fleet
- However, the mobility requirements, load unpredictability of driving patterns and charging behaviour, plus challenges in coordination will all set challenges in capturing such benefits.
- Location will also be important as some of the benefits from V2G such as ancillary services and grid support will only be material in certain areas.
- Both the generation and network capacity impacts modelled are highly uncertain and will be influenced by a range of factors relating to policy, retirements and technological developments.
- There are key policy and regulatory questions which need to be addressed to ensure the appropriate infrastructure is in place to accommodate ZEV uptake, noting that the different uptake scenarios (or combinations of scenarios) will pose different challenges.

Appendix A: Scenario definitions

	Description	Automated vehicles	Vehicles on demand	Zero emissions vehicles
Dead End	This is the no change, 'business as usual' scenario. None of the technologies are taken up by 2046. The fleet is entirely composed of traditional CDVs which are privately owned. This forms a reference scenario in that it is similar to existing fleet composition and ownership models.	✗	✗	✗
Private Drive	All vehicles are automated, but are privately owned (i.e. no vehicles on demand). The AVs are zero emission – they are powered by electricity, not fossil fuels.	✓	✗	✓
Fleet Street	All vehicles are automated, and operate as on-demand vehicles. This means that all car travel is undertaken via a fleet of shared, on-demand automated taxis. All vehicles are automated and are powered by electricity, not fossil fuels.	✓	✓	✓
High Speed	This scenario is the same as the Fleet Street scenario described above, but a full shift to automated, electric vehicles as an on-demand service occurs by 2031 instead of 2046.	✓	✓	✓
Slow Lane	Half of the population uses a vehicle on demand model (like the Fleet Street scenario), and the other half of the population use privately owned CDVs (like the Dead End scenario).	✓ ✗	✓ ✗	✓ ✗
Hydrogen Highway	All vehicles are privately owned and automated. The cars are powered by hydrogen fuel cell vehicles rather than fossil fuels.	✓	✗	✓
Electric Avenue	The fleet is entirely composed of electricity vehicles (but vehicles are not automated) and are privately owned).	✗	✗	✓

Appendix B: Summary of modelling results

	ZEV cars in 2046	ZEV freight in 2046	Total annual consumption of ZEVs in 2046	Solar/ wind installed	Batteries / pumped hydro installed	NPV new generation installed	NPV networks requirement	Total NPV	Incremental to Dead End
	# m	# m	GWh	MW	MW	$ m	$ m	$ m	$ m
Dead End	0	0	0	0	800	319	269	588	-
Electric Av. (I)	3.52	0.39	21,999	9,308	3,331	4,918	2,028	6,946	+6,358
Electric Av. (N-I)					6,205	6,311	3,101	9,412	+8,824
Private Drive (I)	3.75	0.38	24,100	10,279	3,519	5,399	2,129	7,528	+6,940
Private Drive (N-I)					6,719	6,963	3,353	10,316	+9,728
Fleet Street	0.26	0.38	21,762	9,198	1,451	4,159	1,664	5,823	+5,235
High Speed (2031)	0.21	0.20	15,986	1,636	0	1,108	995	2,103	+2,103
Slow Lane	0.12	0.19	10,096	3,808	1,121	1,869	923	2,792	+2,204
Hydrogen Highway (electrolysis base case)	3.75	0.38	63,598	28,529	0	14,843	269	15,112	+14,524
Hydrogen Highway (electrolysis strong shift)			41,489	18,313	166	8,372	269	8,641	+8,053

Appendix C: Sensitivity Analysis

	Dispatchable capacity installed	Non-dispatchable capacity installed	NPV of generation requirement	NPV of network requirement
	MW	MW	$ m	$ m
Default settings	3,331	9,308	4,918	2,028
Absence of out of home charging	-113	0	-57	-66
Increased demand side participation	-1,024	0	-478	-27
Constrained interconnector availability	+1,555	0	+834	0
No fossil fuels in 2045	+4,855	+12,846	+3,084	0
Ramp up of existing generation	+31	-931	-355	0

The contacts at KPMG in connection with this presentation are:

Sabine Schleicher
Advisory
Partner
Tel: +61 7 3233 3233
sschleicher@kpmg.com.au

Eamonn Corrigan
Advisory
Director
Tel: +61 2 9335 8555
ecorrigan1@kpmg.com.au

kpmg.com.au

kpmg.com.au/app