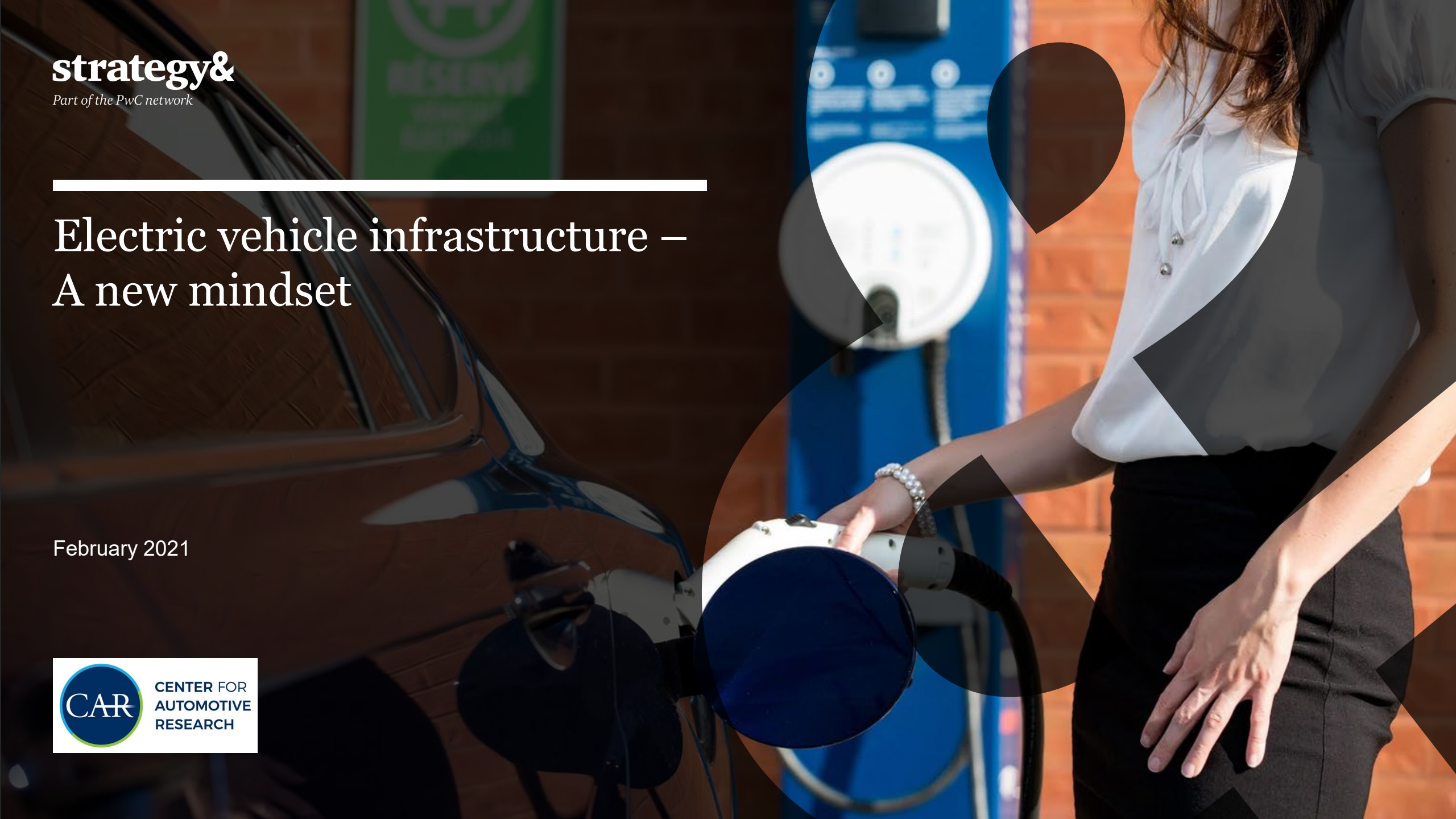

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Electric vehicle infrastructure – A new mindset

February 2021

CAR CENTER FOR AUTOMOTIVE RESEARCH

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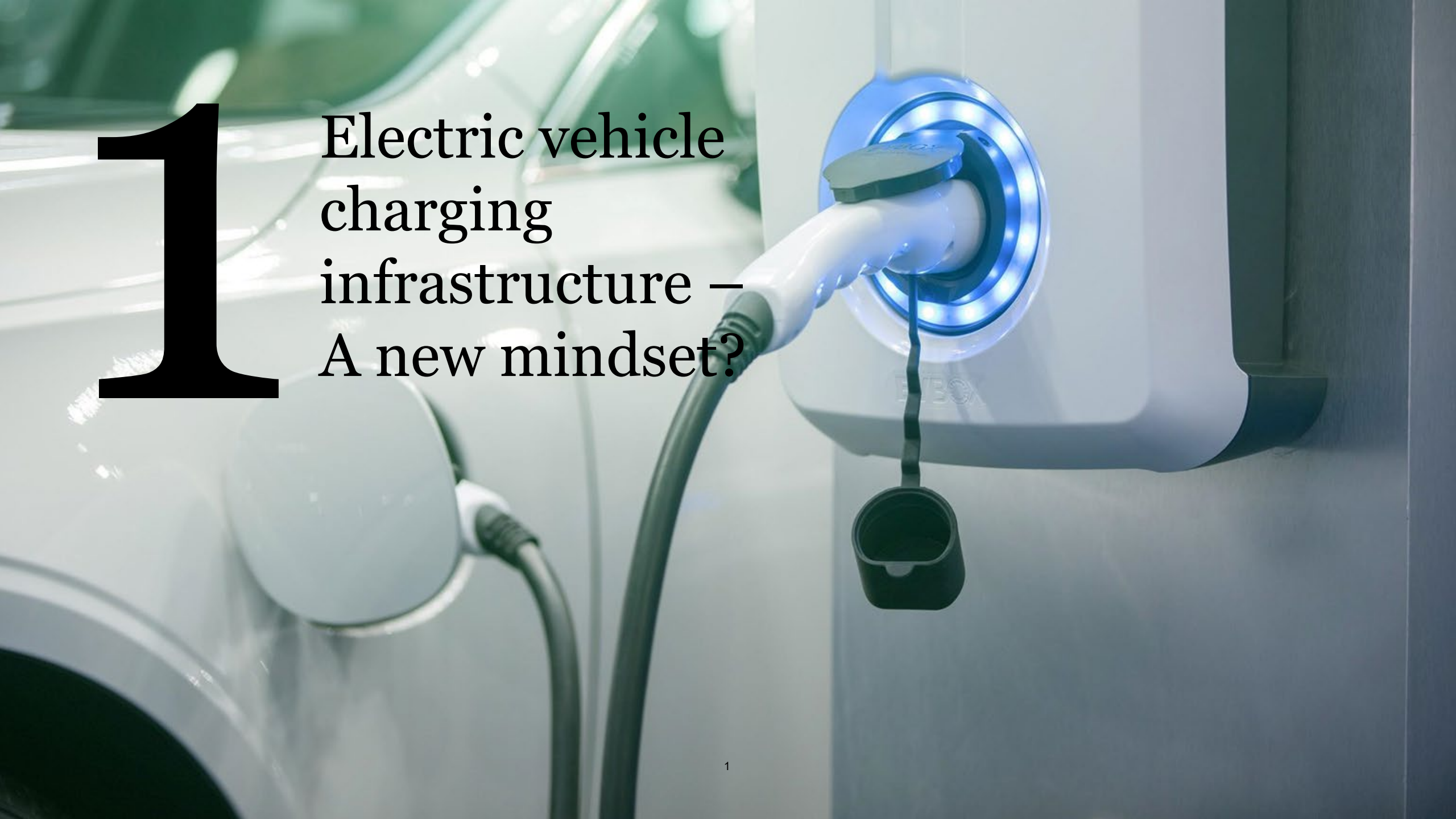
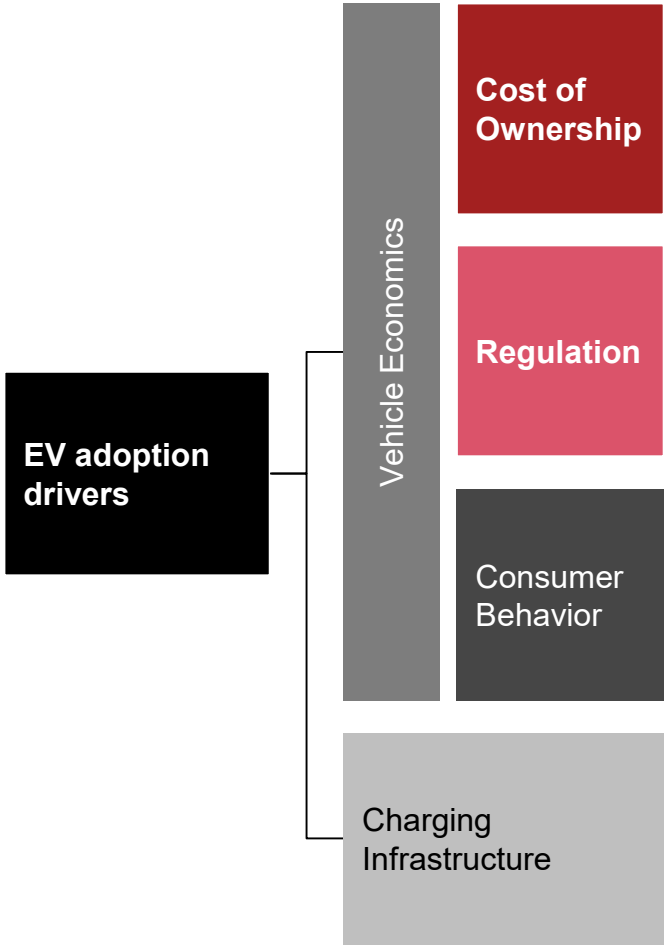


1 Electric vehicle charging infrastructure – A new mindset?

Electric vehicle (EV) adoption is driven by vehicle economics and the availability of charging infrastructure



- Most consumers evaluate three-year EV total cost of ownership (TCO) parity with conventional internal combustion engines (ICE)
- TCO parity without incentives will likely be the tipping point for large BEV/PHEV[1] adoption

- Regulations impact economics to an extent (e.g., fuel economy standards, EV incentives, ICE bans)
- Historically, headline-grabbing regulations (e.g., ICE bans) get watered down as deadlines approach
- Given TCO parity and sufficient infrastructure availability, regulations can be implemented quickly to accelerate EV adoption

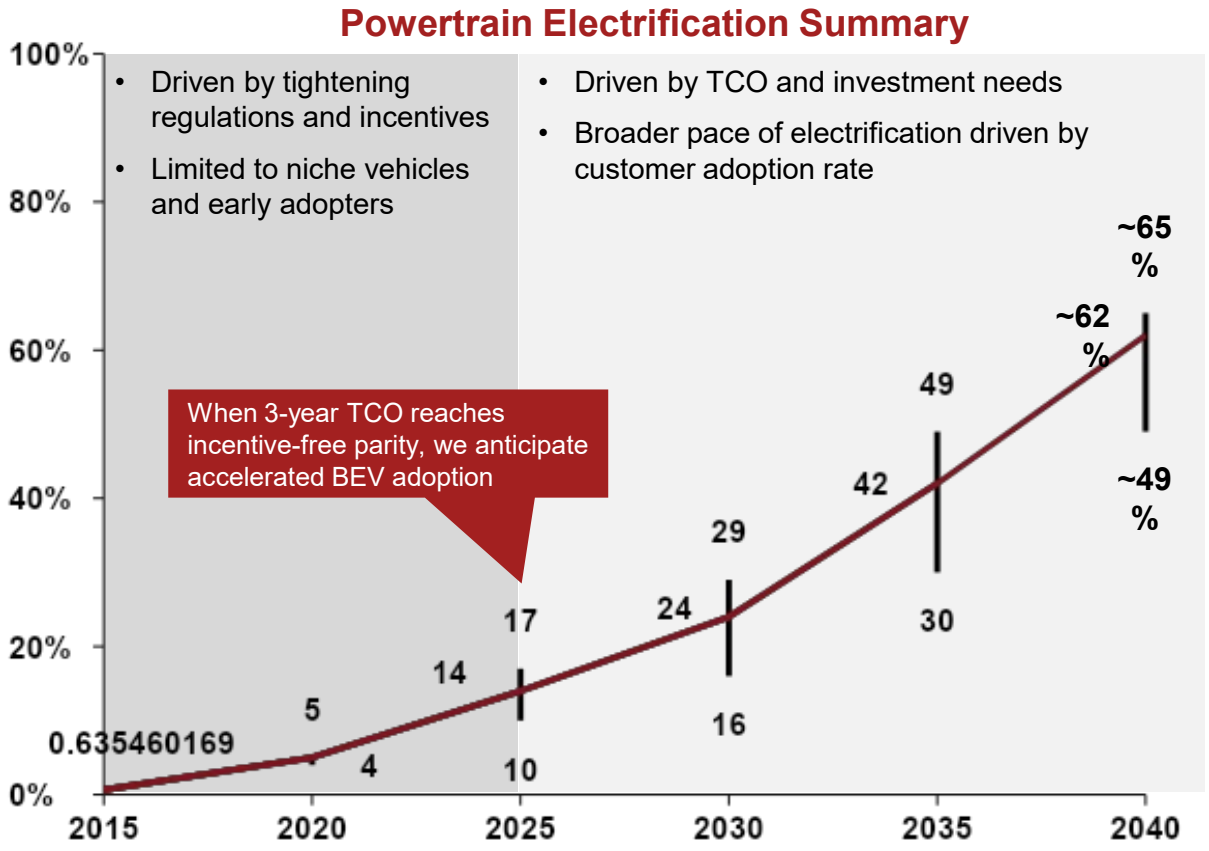
- Changes in demand patterns and consumer preferences will likely continue to shape TCO economics
- EV range/range anxiety, familiarity with charging providers and their networks, and access to more 'away-from-home' charging use cases will likely each impact EV adoption

- Availability of EV charging infrastructure decreases consumer range anxiety
- Charger speed, utilization, and capital investment requirements dictate which charging use cases (e.g., public highway, work charging) are economical

1) BEV = Battery electric vehicle, PHEV = Plug-in Hybrid Electric Vehicles

Once TCO parity is reached, EVs could become up to 65% of new vehicle market share

Global EV penetration



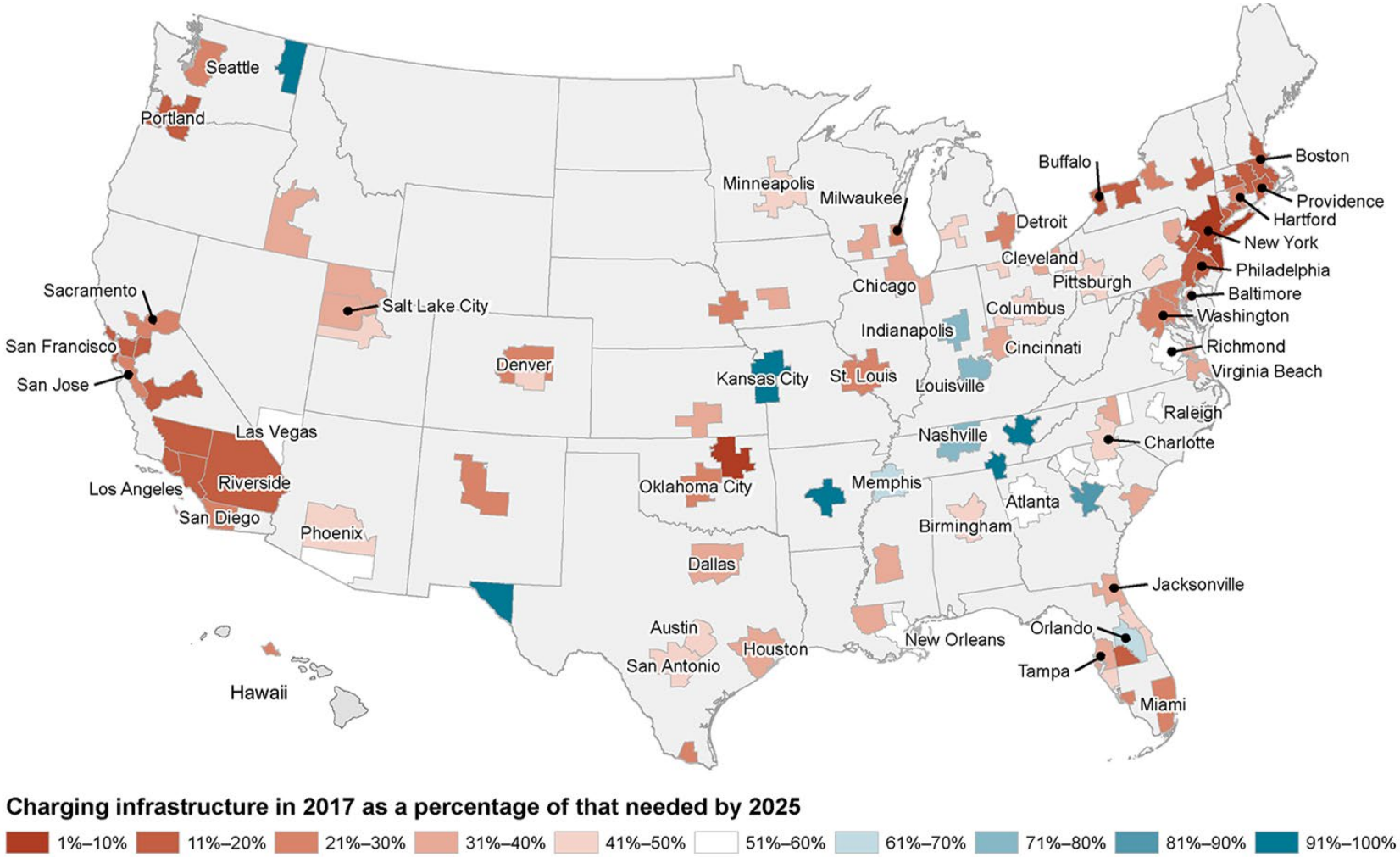
Discussion

- The US ICE/BEV tipping point (i.e., TCO parity) could occur by 2024 - 2026
- US will have 12%-15% EV penetration of new vehicles by 2030...
- ...while there will be significantly higher penetration in EU and China in that timeframe
- In the US, auto OEMs are introducing over 70 EV nameplates by 2027

Notes: Global penetration calculated using China EU and U.S. EV penetration; 3-year total cost of ownership; Incentives phase out in 2020+
Source: Battery expert Interviews, Strategy& analysis

External estimates suggest significant EV infrastructure investment is needed just to meet 2025 projections

Charging Infrastructure Needs to Meet 2025 Demand



1. International Council on Clean Transportation – EV Charging Infrastructure Gap, 2019

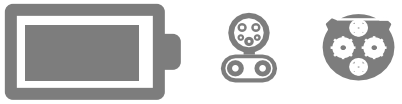
Sources: International Council on Clean Transportation (ICCT)

Charging infrastructure technology trades off charge time, power/Range, and cost

"At Home" -- Residential Charging

~80% of the charging

"Away from Home" -- Commercial Charging

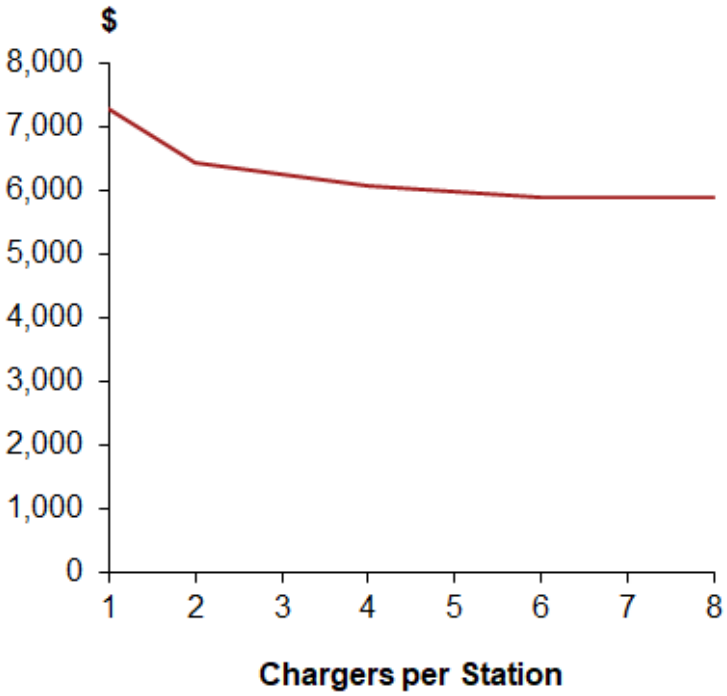
	Level 1	Level 2	Level 3[1]	Level 4[1]
				
Use Cases	Overnight charging	At work, overnight	Short stops, highway corridors	Short stops, highway corridors
Power Level	120 Volts-AC	200-240 Volts-AC	200-500 Volts-DC	480+ Volts-DC
Charge Time[2]	~20 hours	~5-6 hours	~30 minutes	~20 mins
Range/Hour	~5 miles	~25 miles	~100+ miles	100+ miles
US Plug Types[3]	NEMA 5-15 (Standard electrical outlet)	SAE J1772 (i.e., 'J-Plug')	SAE J1772 Combo (CCS – Combo Charging System), CHAdeMO[4]	Dual SAE J1772 Combo CCS1, single CHAdeMO, single SAE J1772 Combo CCS1
Capital Investment[5]	No investment needed	$2,000 - $7,500	~$75,000	~$125,000
Annual Operating Cost/charger	-	~$4000	~$13,000	~$28000

1) Not all vehicles are compatible with Level 3 or 4 charging; 2) Estimated charging time for an example BEV from empty to full; 3) Excludes some suppliers that makes adapters to fit either SAE or CHAdeMO plugs; 4) CHAdeMO stands for 'Charge de Move', or move using charge; 5) Includes est. cost of EVSE hardware, site preparation, interconnection, etc.
Sources: Utility Dive, NREL, Idaho National Laboratory, Semaconnect, ClipperCreek, Charge Hub, Strategy& analysis

EV charging stations may reach minimum efficient scale at 4-6 charger points across all level types

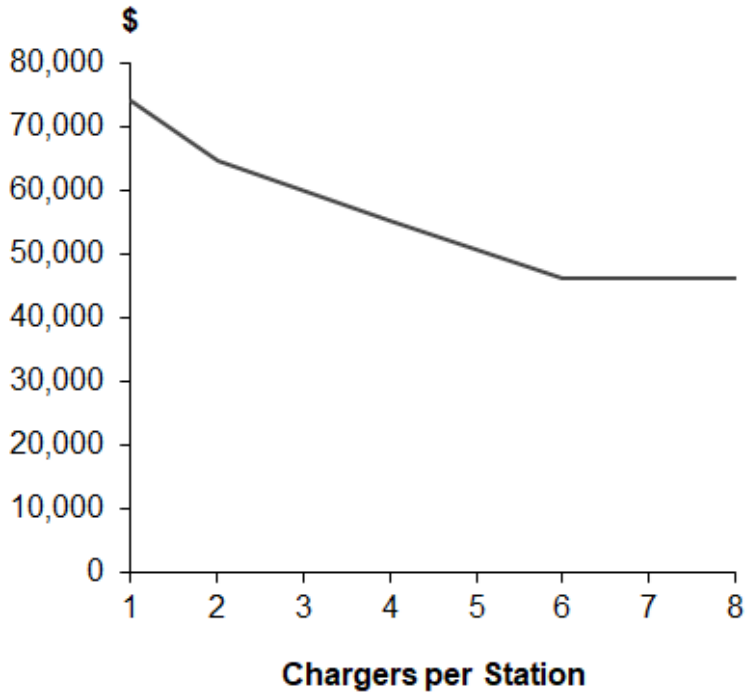
Capital expenditures per charger by level and station format ($ per charger)

Level 2 - Capex per Charger



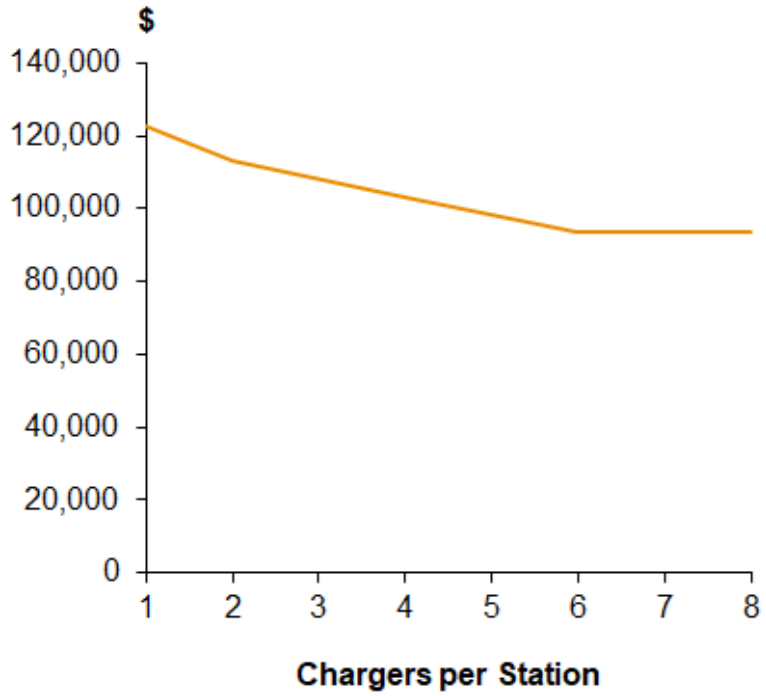
Capex / Charger @ 6 Chargers per Station = ~$6,000
Capex / KW = ~$1,200

Level 3 - Capex per Charger



Capex / Charger @ 6 Chargers per Station = ~$49,000
Capex / KW = ~$600

Level 4 - Capex per Charger



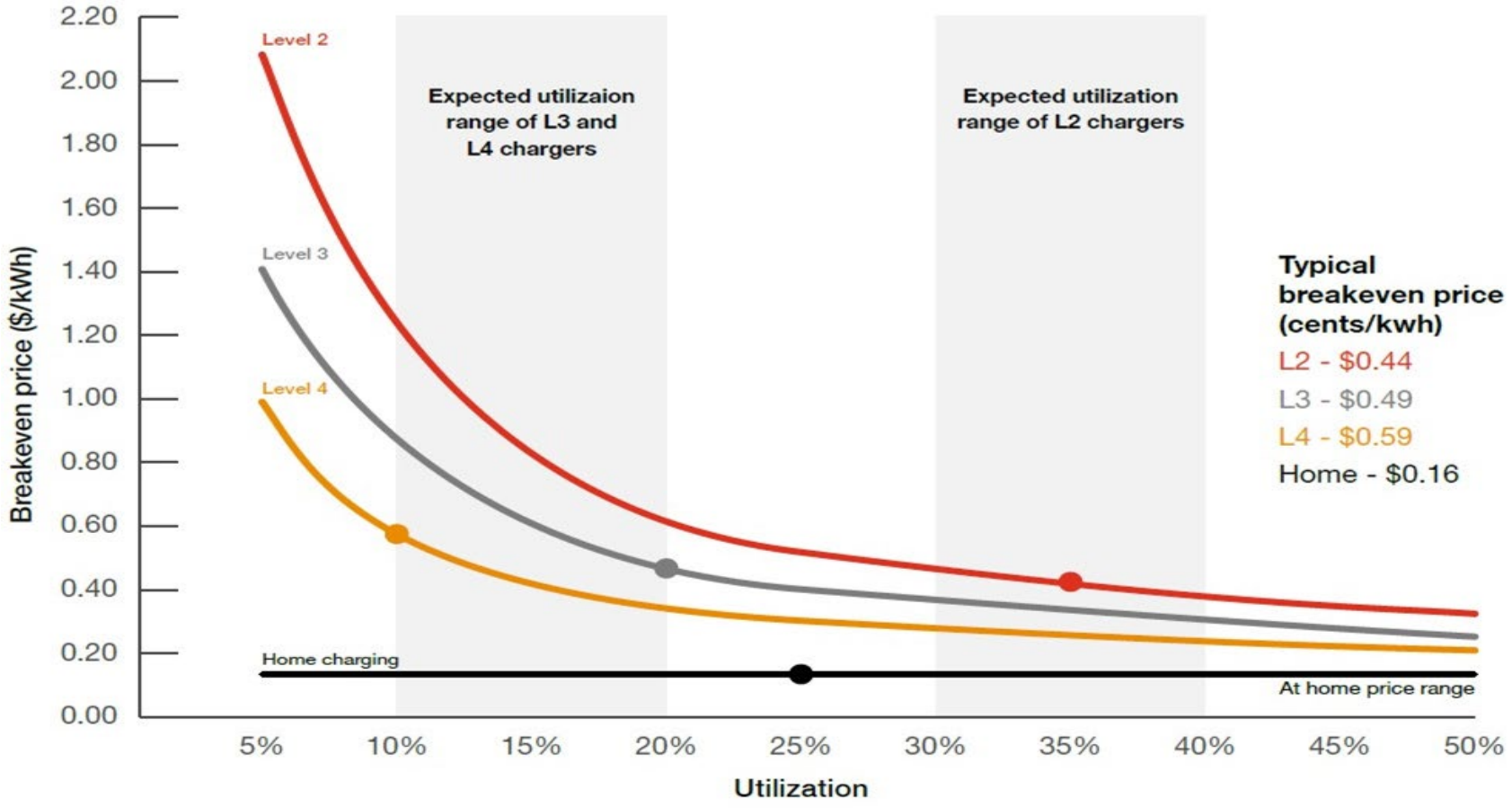
Capex / Charger @ 6 Chargers per Station = ~$96,000
Capex / KW = ~$800

Sources: International Council of Clean Transportation, EV expert interviews, Strategy& analysis

Expected utilization will likely be the critical factor in breakeven pricing for positive charging economics

Charging Economics: Breakeven Price by Charger Type[1]

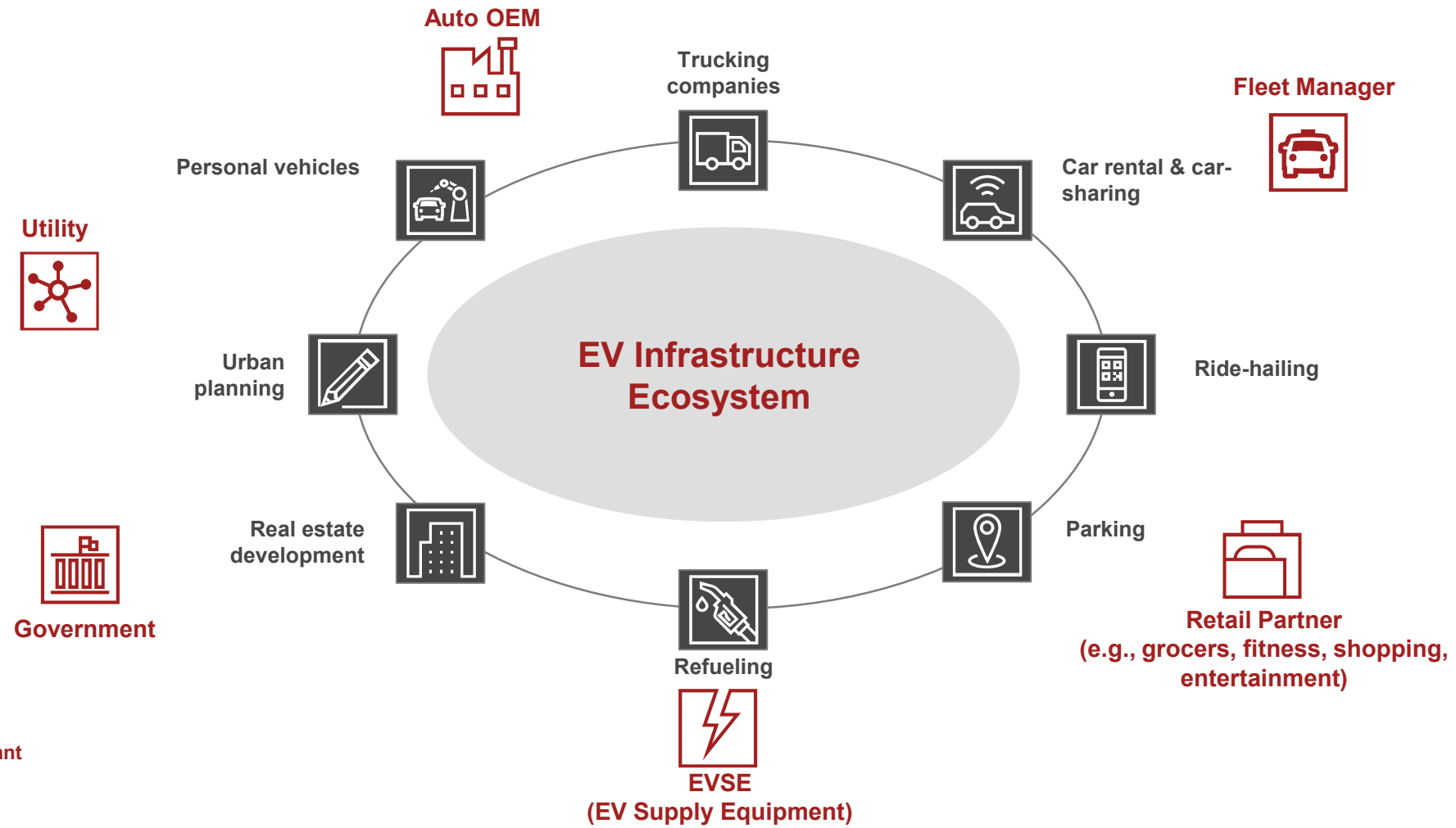
4 Charger Configuration for Various Utilization Levels



1) All-in breakeven price is selling price requested to earn a 10% return on capital invested with a wholesale power cost of $0.16 per Kwh
Sources: International Council of Clean Transportation, EV expert interviews, Strategy& analysis

A broad range of players are investing in EV infrastructure using a variety of approaches

Not exhaustive

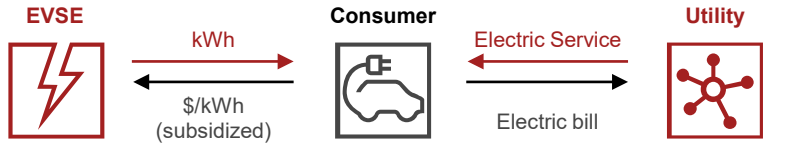


Ecosystem Participant

Ecosystem Element

EV infrastructure business models are taking shape from a variety of public or private partnerships

Example EVSE Business Models

Standalone (Own and Operate)	• EVSE company provides charging infrastructure and services • Costs are passed to consumers in charging rates	
Retail Host – Owned Channels	• Retail host utilizing EV charging to promote increased foot traffic • Subsidize EVSE investment and monetize investment via other means	
Auto OEM Subsidization	• Auto OEMs help finance EVSE investment CAPEX • Price of EV infrastructure recovered in EV car sales price	
Utility Partnership	• Incentivize EV adoption and EVSE charging infrastructure deployment • Potential to pass investment costs to customers via regulated rates	
Government Run	• Subsidize EVSE investment with tax dollars or government debt • Useful for segments that would not otherwise attract investment	

2 Panel discussion

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Thank you

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