ELECTRIC VEHICLE ADOPTION FORECASTING

TUCSON ELECTRIC POWER

DECEMBER 19, 2019

IRP MEETING

TEP
Tucson Electric Power

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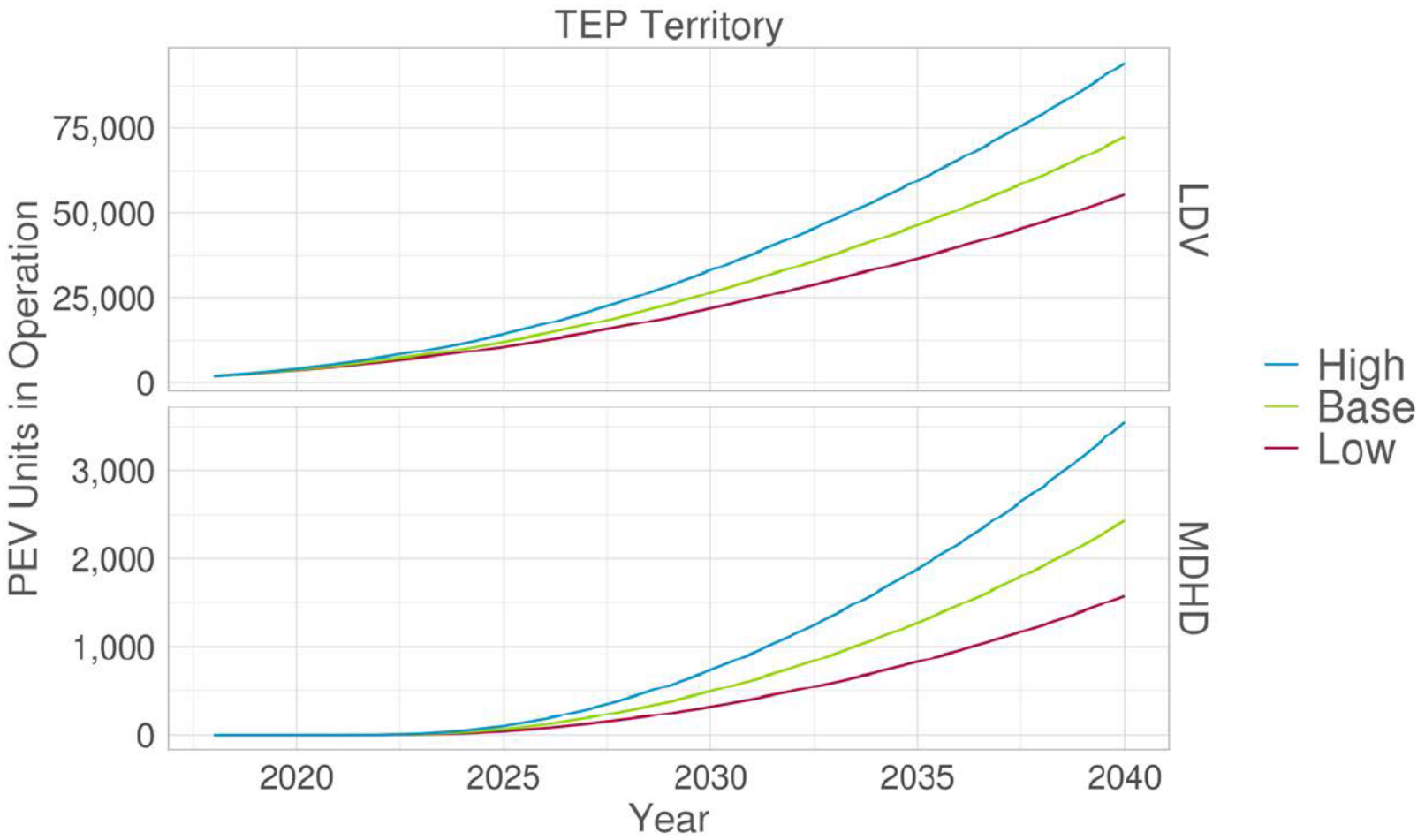
EV ADOPTION – TEP TERRITORY POPULATION



- Navigant estimates the number of ***light-duty plug-in electric vehicles (EVs)*** in TEP's territory will increase to about ***72,000 by 2040*** under the ***Base scenario*** (i.e., if the current market trajectory persists).
- Navigant estimates ***medium- and heavy-duty EVs*** to reach nearly ***2,500 by 2040*** under the ***Base scenario***.

* Scenarios in this study represent a range of poss ble outcomes under business-as-usual conditions (i.e., without assuming transformational policy / market interventions or technology changes).
Source: Navigant Analysis

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NAVIGANT'S VEHICLE ANALYTICS & SIMULATION TOOL (VAST™) ANALYSIS FOR TEP

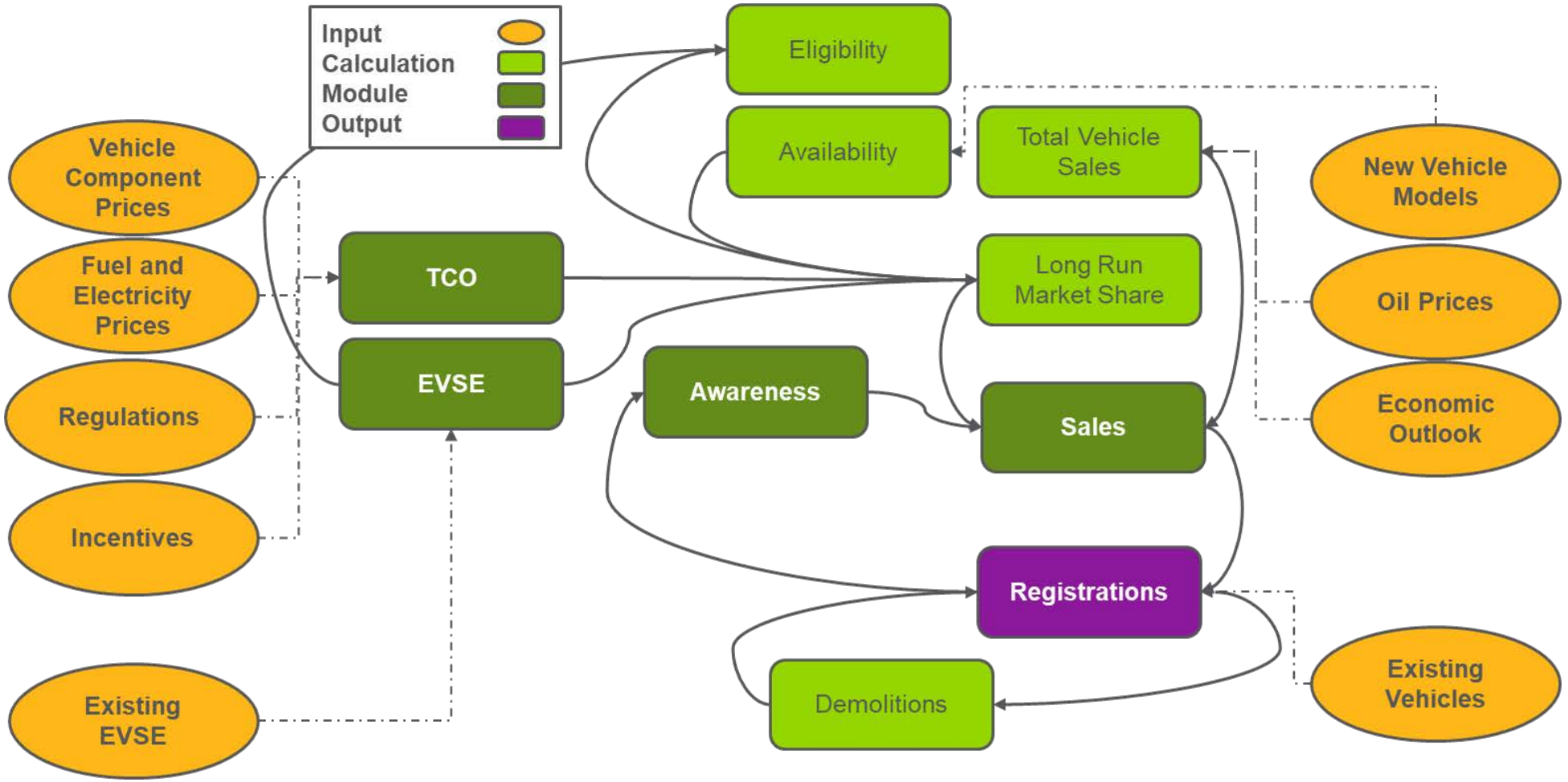
TODAY'S FOCUS

KEY INPUTS

- Baseline vehicle **registrations** and **charging infrastructure**
- Historic vehicle **sales** and projected vehicle **availability**
- Gasoline, battery, component price, and **TEP electricity rate** forecasts
- State, national, and utility **incentives**
- **Demographic** data (income, educational attainment)

	METHODS	KEY OUTPUTS
Adoption *How many vehicles are on the road by type and location?*	**VAST™ Adoption Module:** Systems dynamics model that forecasts the penetration of plug-in electric vehicles (EVs) by duty, powertrain, vehicle class, ownership type (individual/fleet), and geography (state/territory/census tract).	Vehicle **registrations** and **sales** from 2019-2038 High, Base, and Low adoption **scenarios**
Charging Infrastructure *What charging infrastructure is required to support these vehicles?*	**VAST™ Charging Infrastructure Module:** Network optimization model that forecasts the number and location of chargers needed to meet future EV demand by use case and technology type.	# of **charging ports** by charger type in TEP territory by year and census tract
Energy / Demand *What load impacts are associated with forecasted vehicle charging?*	**VAST™ Energy / Demand Module:** Heuristic model that calculates the energy and demand needs associated with EVs in a given geographic area, given driving patterns, fuel efficiency, and rate structures.	Annual **energy and load** impacts for the territory and by census tract

NAVIGANT'S VEHICLE ANALYTICS & SIMULATION TOOL (VAST™) ADOPTION MODULE



- Navigant's VAST™ Adoption module draws upon refined inputs and economic logic to produce granular forests for EV market growth.
- Trends in vehicle sales/availability, stock turnover, and consumer behavior are driving factors.

TCO = Total cost of ownership. EVSE = Electric vehicle supply equipment. Source: Navigant

EV ADOPTION SCENARIO DRIVERS

Drivers	Description	Low Scenario	High Scenario
Incentive	Dollar per EV tax incentive	No change	**Description:** Additional “cash on the hood” incentive **Magnitude:** $2,000 per vehicle **Timing:** Throughout forecast
Battery Costs	Battery pack costs (dollars per kwh)	**Description:** Slower battery cost decrease vs. Base, leading to increased operation cost of EVs **Magnitude:** Based on Navigant Research high battery cost forecast **Timing:** Throughout forecast	**Description:** Higher battery cost decrease vs. Base, leading to decreased operation cost of EVs **Magnitude:** Based on Navigant Research low battery cost forecast **Timing:** Throughout forecast
Gas Prices	Gasoline prices (cents per gallon)	**Description:** Gasoline prices decrease vs. Base, leading to decreased operation cost of ICEVs **Magnitude:** 25% decrease vs. Base **Timing:** Throughout forecast	**Description:** Gasoline prices increase vs. Base, leading to increased operation cost of ICEVs **Magnitude:** 75% increase vs. Base **Timing:** Throughout forecast
Marketing and Awareness	Influences customer familiarity (i.e., public awareness) and a prerequisite for adoption	**Description:** Consumer awareness below projected levels **Magnitude:** Roughly one-third decrease vs. Base **Timing:** Throughout forecast	**Description:** Consumer awareness increases above projected levels due to marketing or other public awareness change **Magnitude:** Roughly one-third increase vs. Base **Timing:** Throughout forecast

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Source: Navigant

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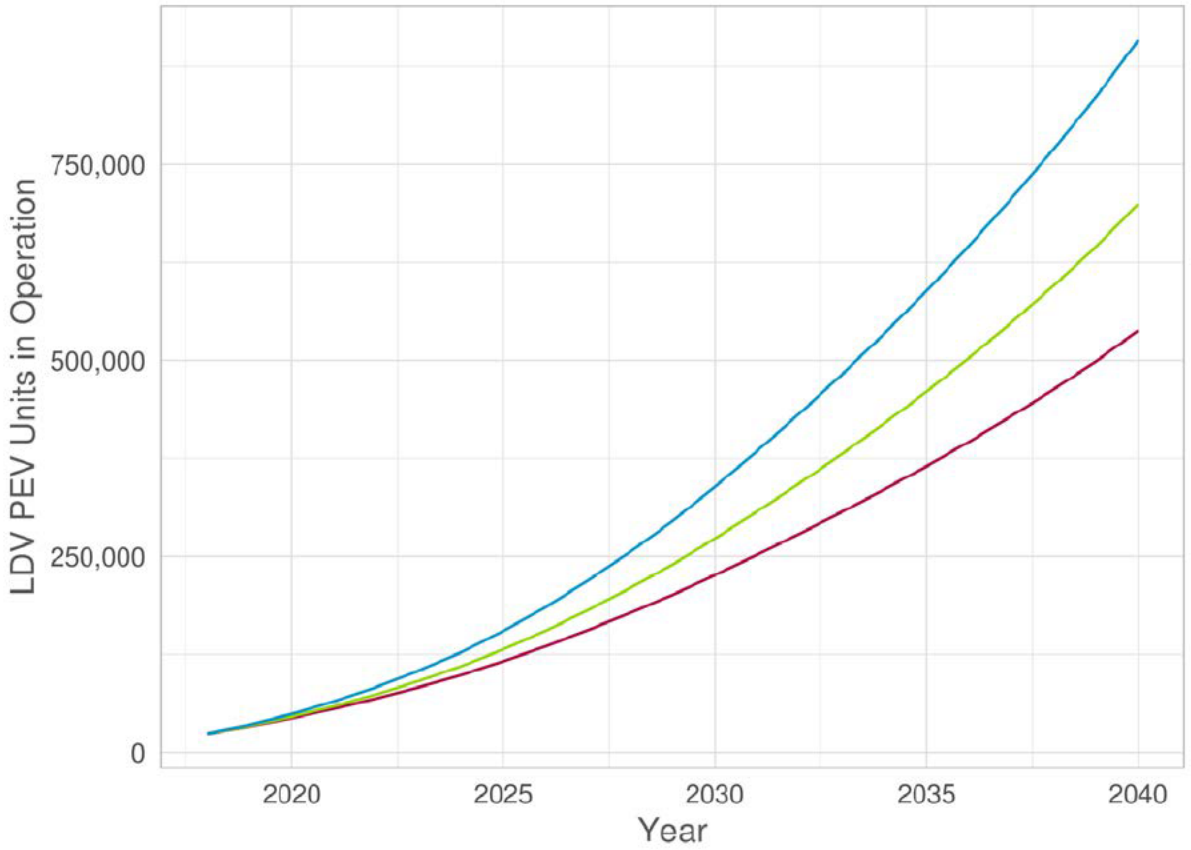
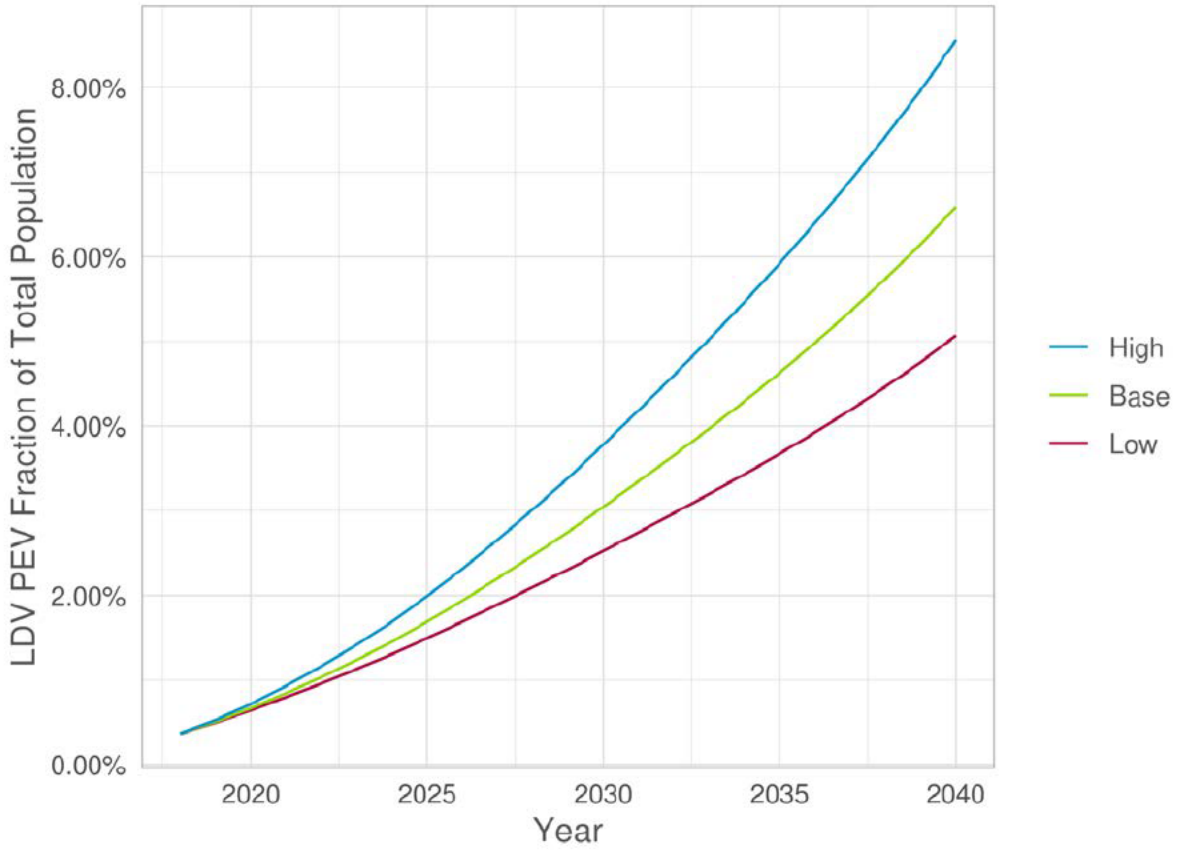
LIGHT-DUTY EV ADOPTION – STATE-WIDE ARIZONA POPULATION

Arizona is forecasted to have 700,000 light-duty EVs in operation by 2040 under the Base case (~6.5% of the light-duty vehicle population), as market turnover replaces conventional vehicles with EVs.

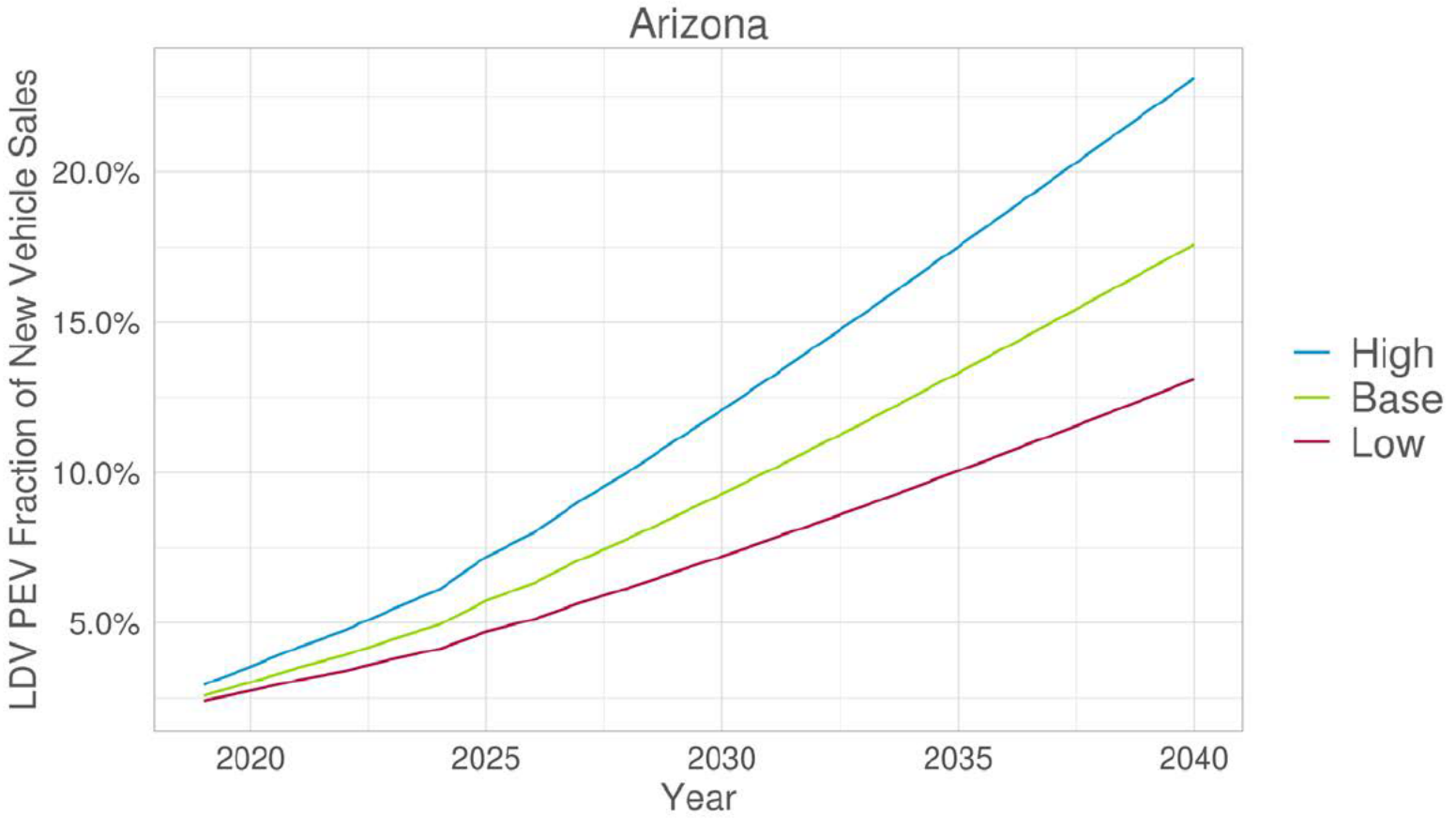




Source: Navigant Analysis. See appendix for further information on EV Adoption output.

LIGHT-DUTY EV ADOPTION – STATE-WIDE ARIZONA SALES

EVs are forecasted to reach 17.5% of light-duty vehicles sales state-wide by 2040 under the Base case.



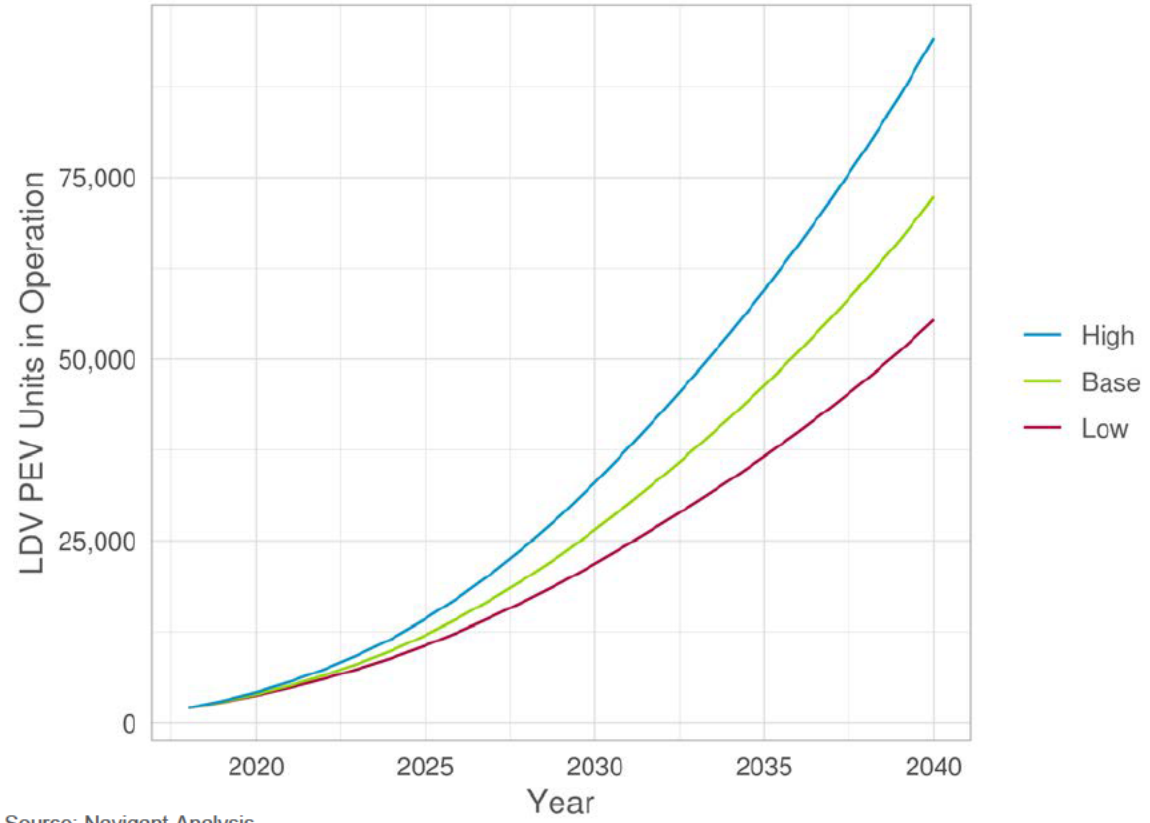
Main Drivers

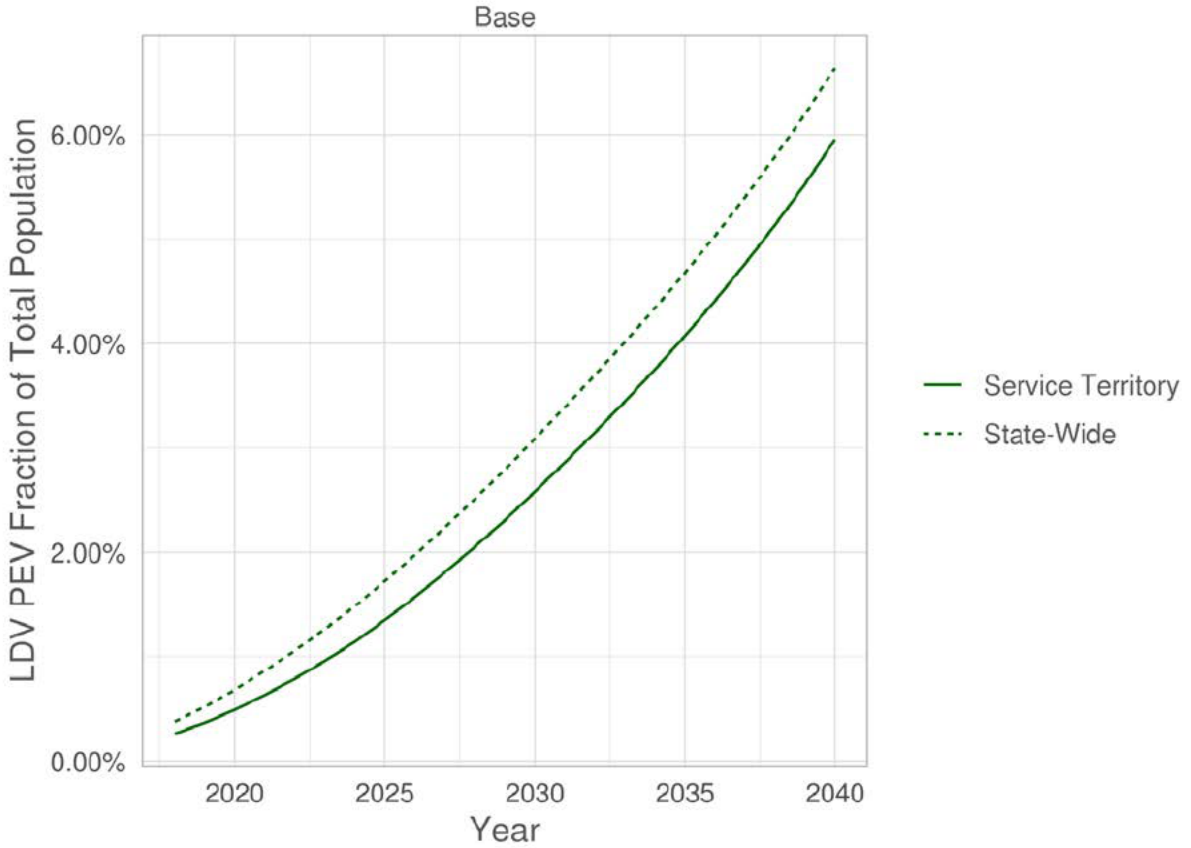
- Increased availability of EV models, especially in the SUV and light-truck segments in the next decade
- Increased access to public charging, expending eligibility for customers without garage charging
- Reduced costs due to battery improvements and better fuel efficiency
- Increased awareness due to word of mouth and marketing effects

Source: Navigant Analysis

LIGHT-DUTY EV ADOPTION – TEP TERRITORY POPULATION

TEP's territory is forecasted to have 72,000 light-duty EVs in operation in by 2040 under the Base case (~6% market penetration), slightly lower than the rest of the state due to historic adoption trends and demographics such as income and education levels.

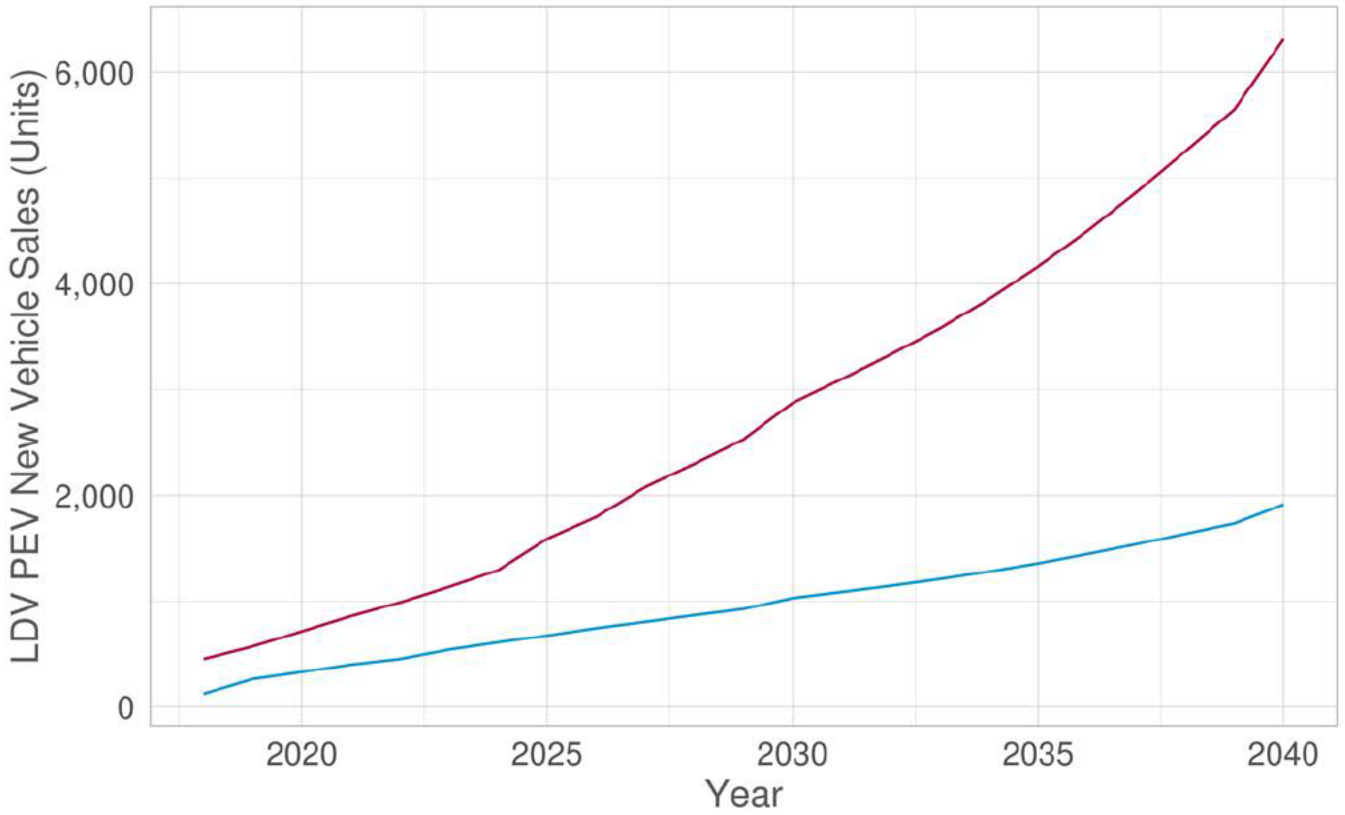




Source: Navigant Analysis

LIGHT-DUTY EV ADOPTION – TEP TERRITORY SALES

Battery electric vehicle (BEV) technology is expected to dominate EV adoption, as most automakers are pulling back on plug-in hybrid electric vehicle (PHEV) production.

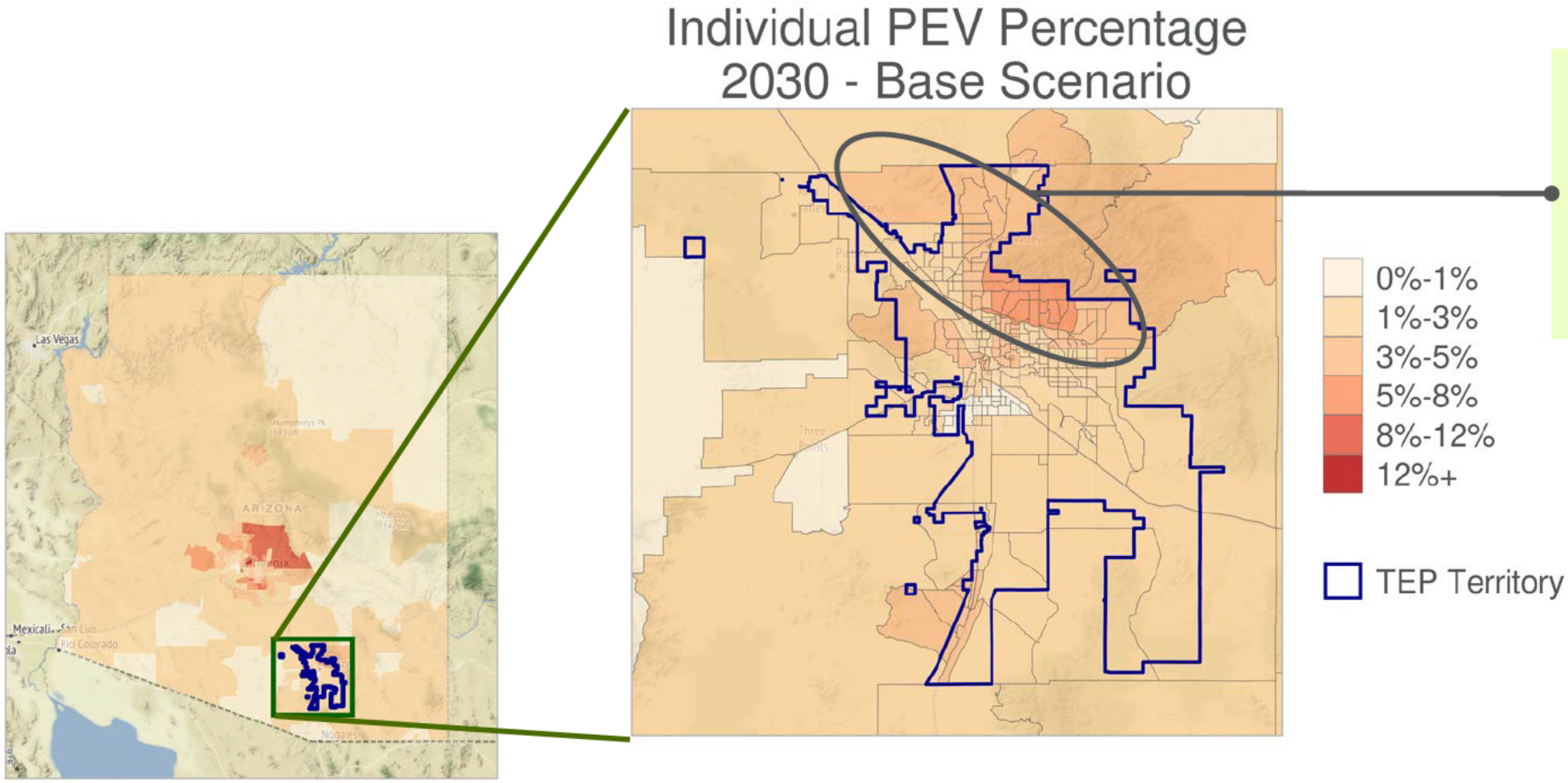


Most automakers have publicly announced that they are moving away from offering PHEV options, focusing solely on BEV technology.

Greater access to public charging over time also facilitates BEV adoption.

Source: Navigant Analysis

INDIVIDUAL EV ADOPTION – TEP TERRITORY POPULATION

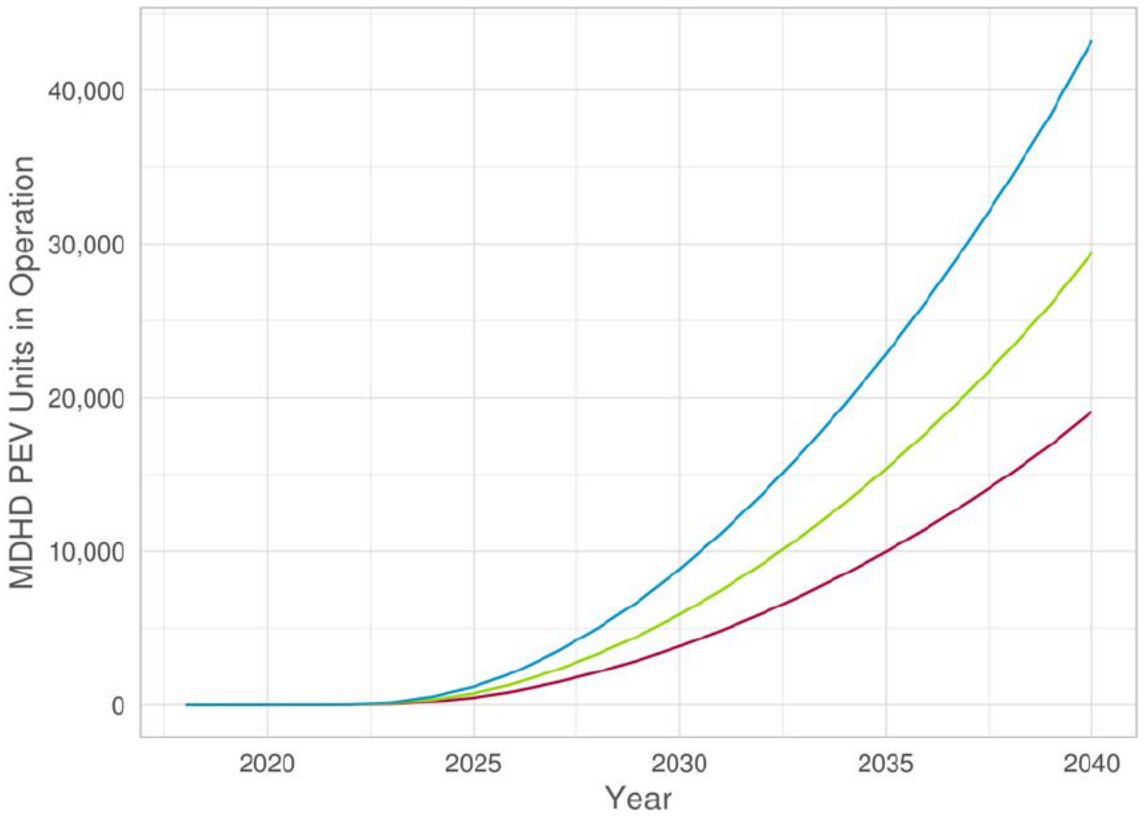


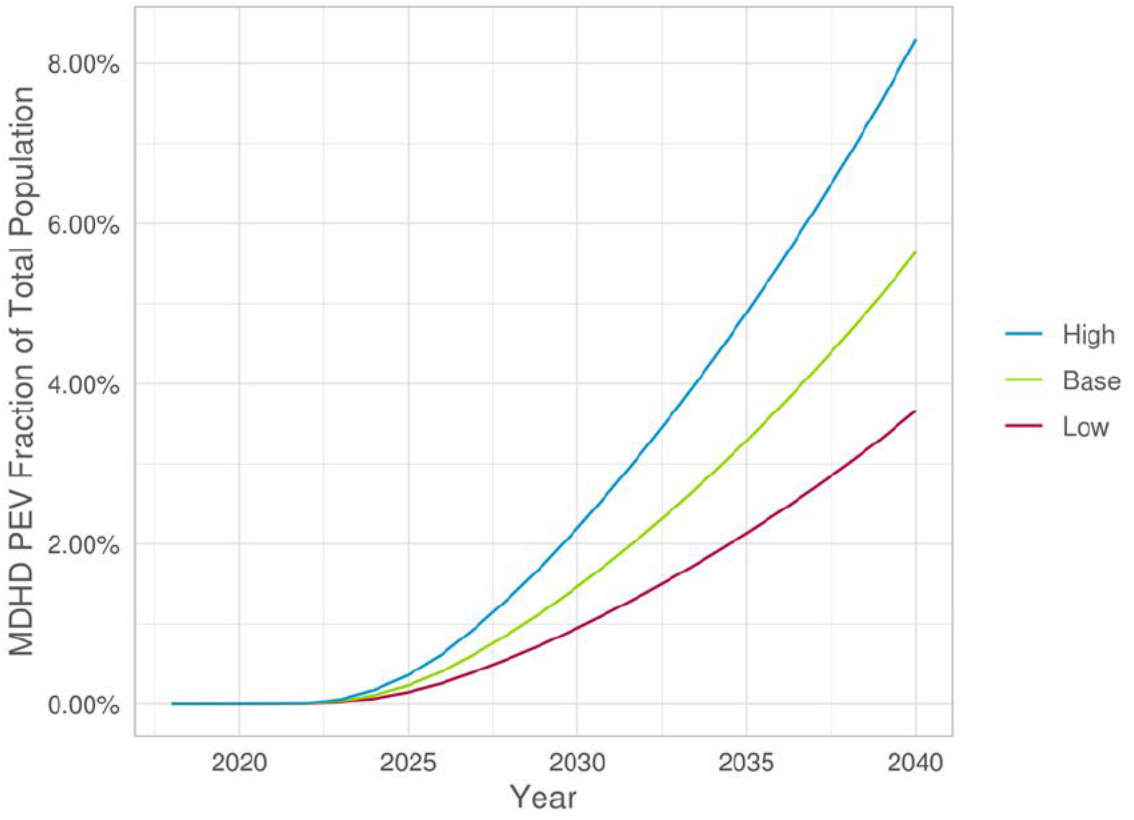
Individual EV adoption is forecasted to be higher in **higher-income neighborhoods**, such as Catalina Foothills and Oro Valley

Source: Navigant Analysis

MEDIUM- AND HEAVY-DUTY EV ADOPTION – STATE-WIDE ARIZONA

Medium- and heavy-duty EV adoption is expected to accelerate in the late 2020s, as more models become available—reaching 6% of total medium- and heavy-duty vehicle Base case population in Arizona by 2040.





Source: Navigant Analysis

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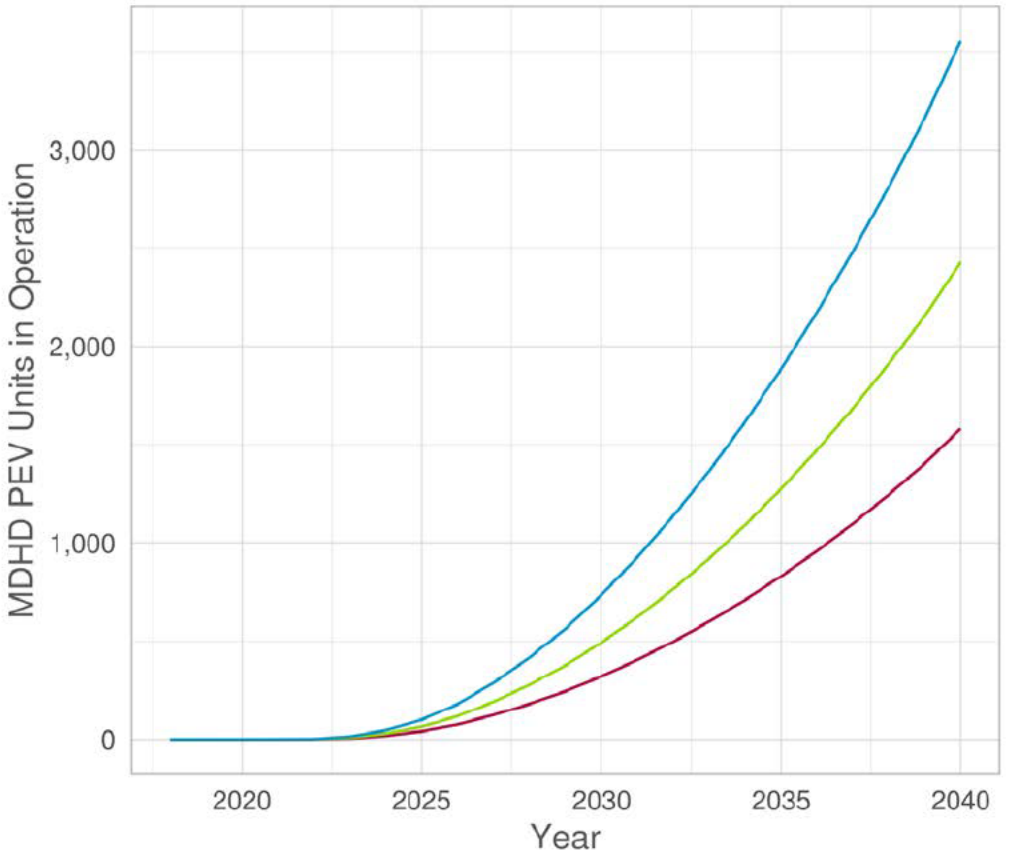
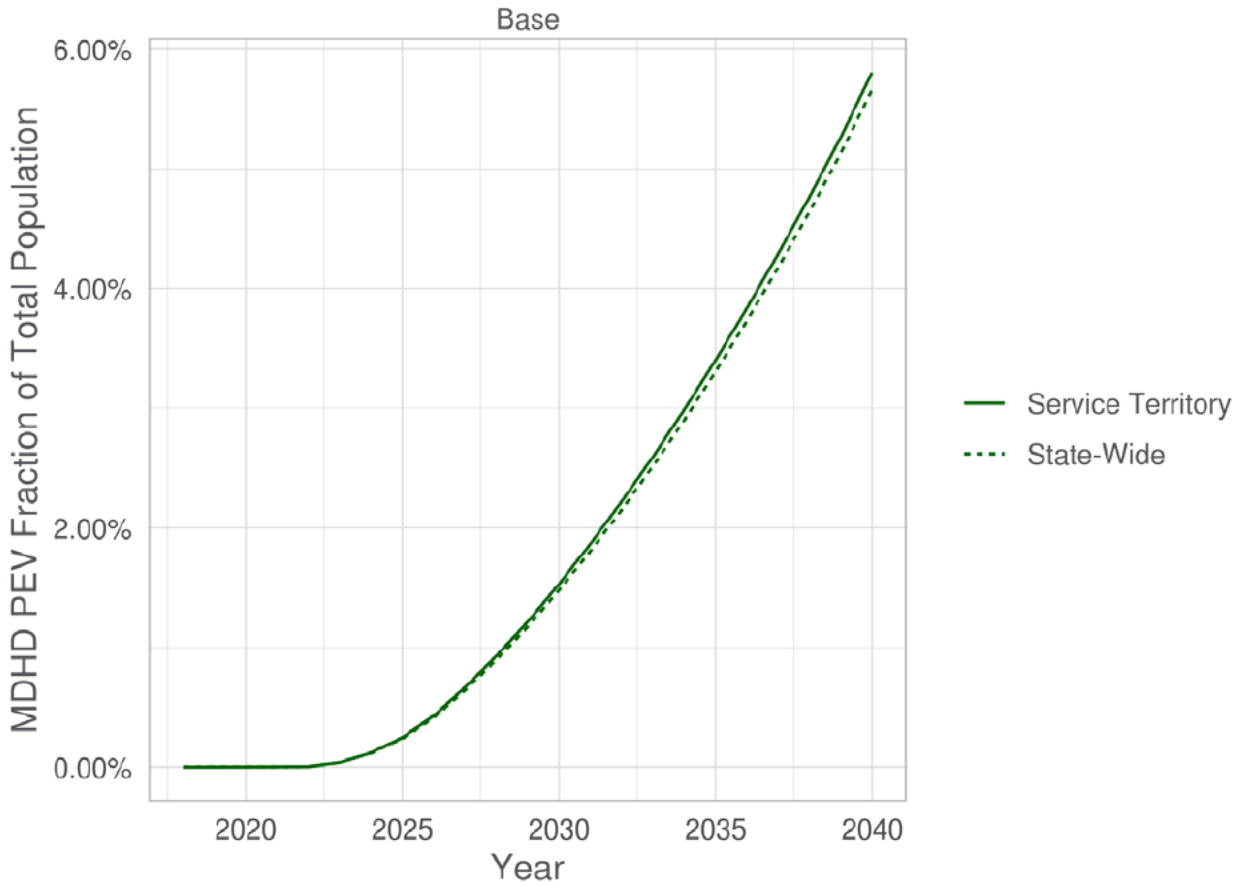
MEDIUM- AND HEAVY-DUTY EV ADOPTION – TEP TERRITORY

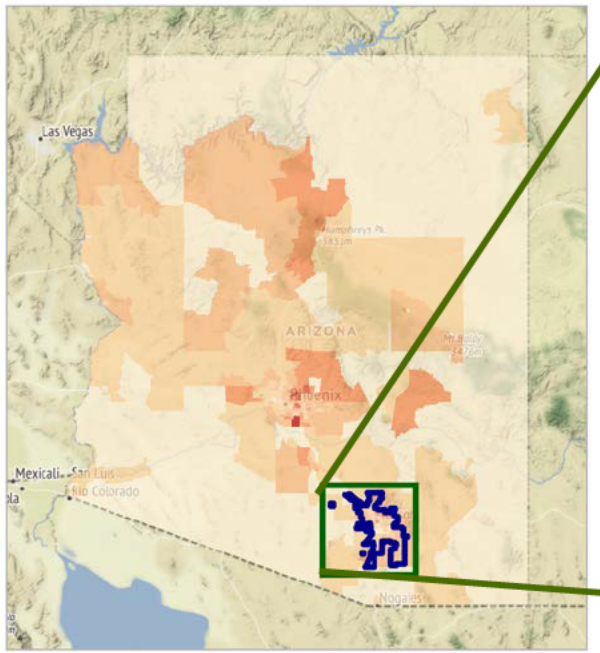
2,500 medium- and heavy-duty EVs are expected to be located in TEP's territory by 2040 under the Base case, with similar market share as the rest of the state (~6%).

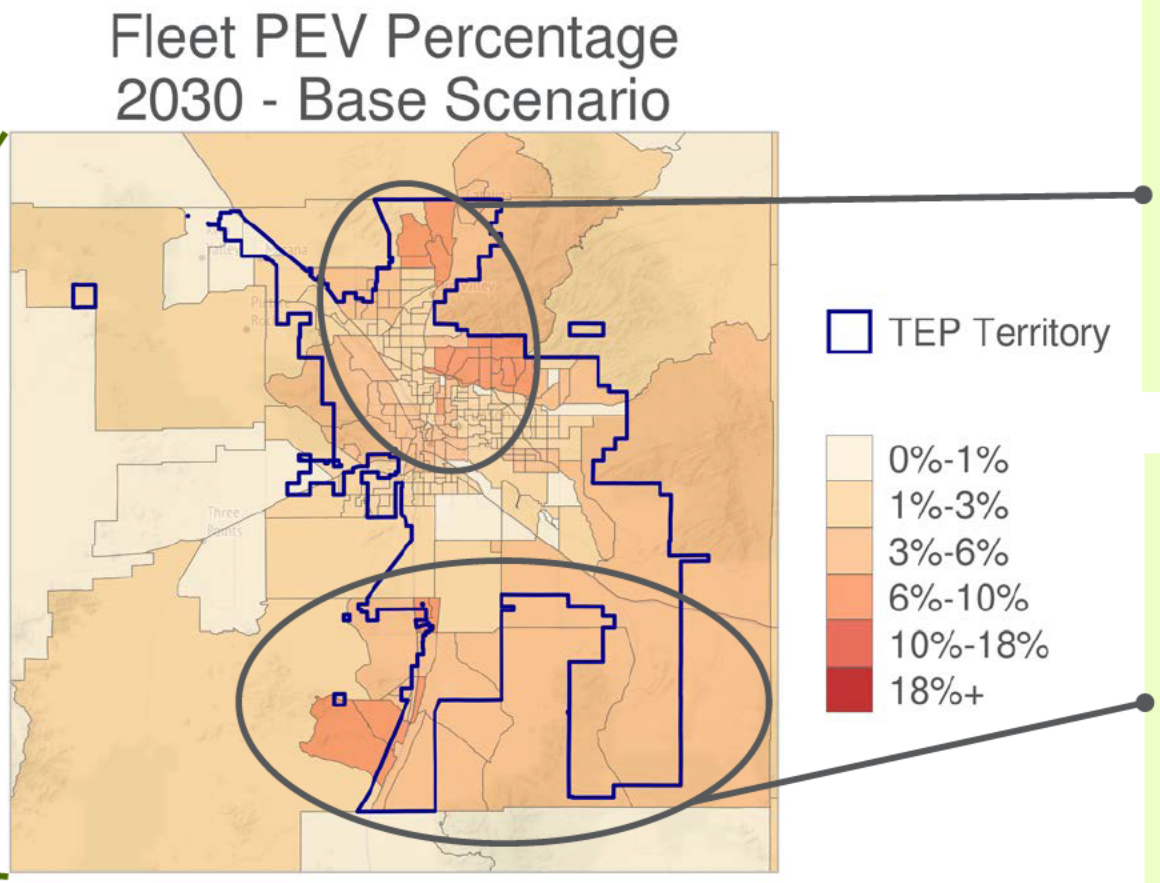




Source: Navigant Analysis

FLEET EV ADOPTION – TEP TERRITORY POPULATION





Light-duty fleet-owned EVs are expected to be concentrated in the **corporate parks** in the northern parts of the city and downtown

Medium- and heavy-duty fleet-owned EVs are expected to be concentrated in the southern part of the city around **Davis Monthan Air Force Base** and **mining** operations

Source: Navigant Analysis

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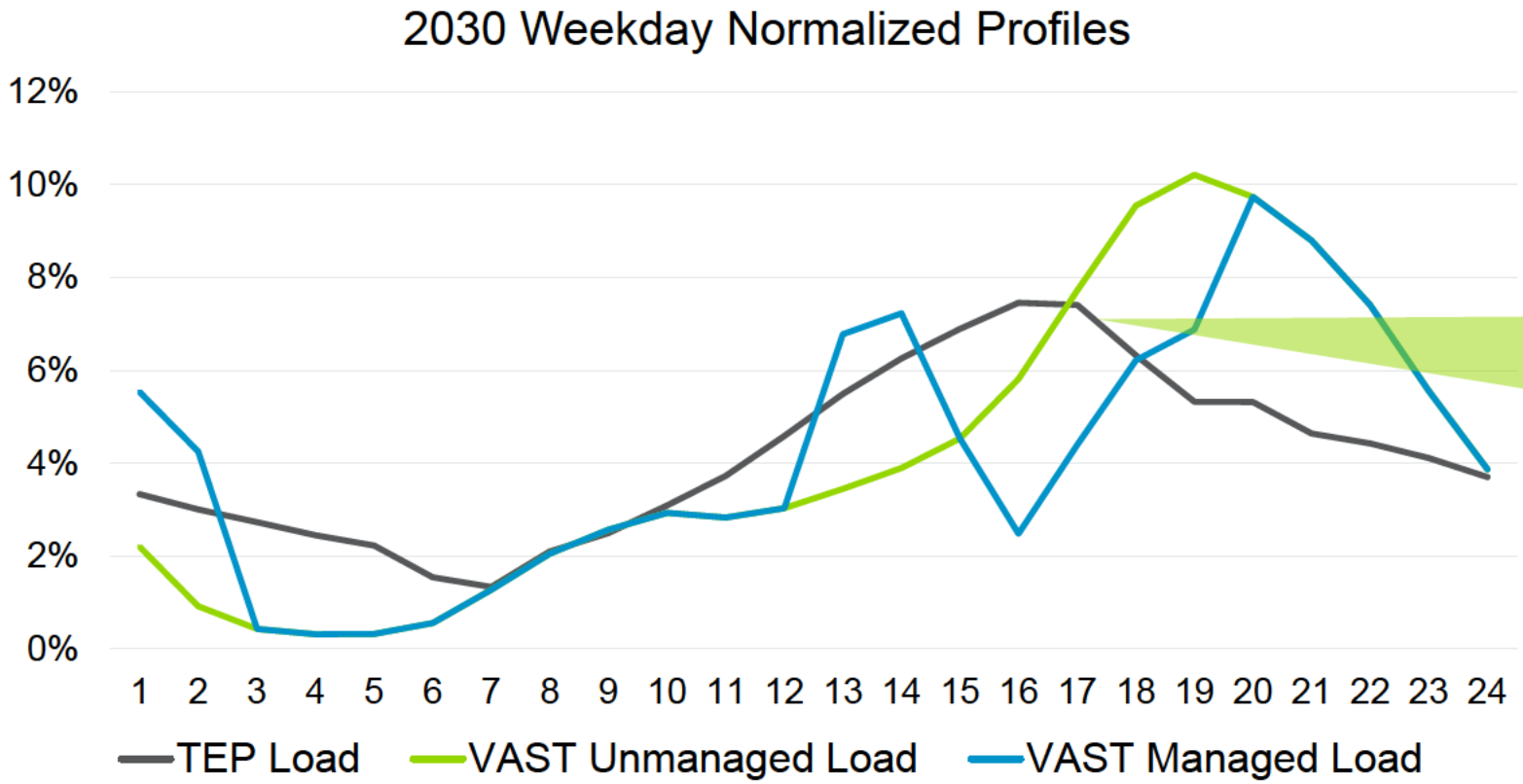
VAST™ MANAGED AND UNMANAGED CHARGING PROFILES

Unmanaged EV charging peak happens at 7pm, which overlaps with TEP's system peak (3 – 7pm). Managed charging strategies can reduce EV charging needs during this time.



Managed charging profiles significantly reduce EV charging load during the peak hours of 3pm – 7pm by shifting load to 12pm – 2pm and 12am – 2am.

Source: Navigant Analysis

DISCUSSION

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CONTACTS

BURRELL KILMER
Managing Director
burrell.kilmer@navigant.com

KEN SEIDEN
Managing Director
ken.seiden@navigant.com

DEREK JONES
Director
derek.jones@navigant.com

ROBIN MASLOWSKI
Director
robin.maslowski@navigant.com

ALEX METZ
Managing Consultant
alexandre.metz@navigant.com

LEONARDO BARLACH
Managing Consultant
leonardo.barlach@navigant.com

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