

17 March 2011

Federal Fleet Electrification Roundtable

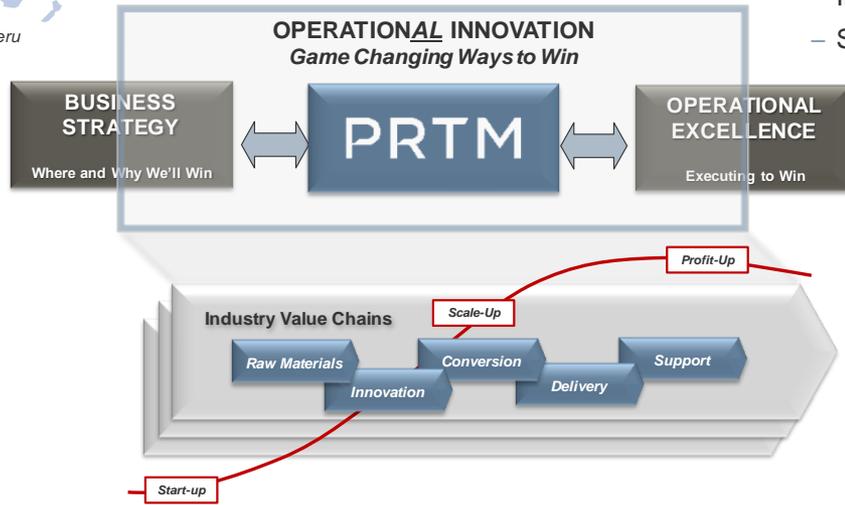
xEV Total Cost of Ownership

PRTM - Operational Strategy with a Global Reach and Industry Depth

- More than 32 years of operational strategy and innovation experience
- More than 600 consultants worldwide
- 18 offices worldwide
- Over 1,200 clients and 6,000 projects
- 90% level of repeat business



- Major commercial and government sectors:
 - Aerospace and Defense
 - **Automotive**
 - Chemicals and Process Industries
 - Communications and Media
 - Consumer Goods and Retail
 - Electronics and Computing
 - **Energy and Utilities**
 - Financial Services
 - **Government**
 - Life Sciences and Healthcare
 - Industrial Products
 - Software

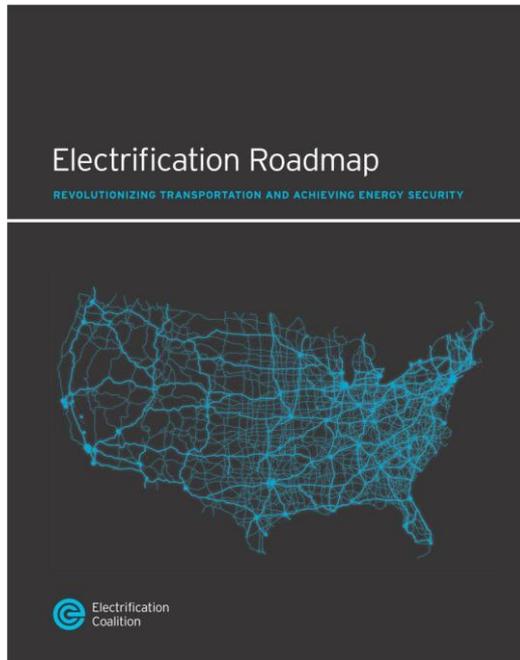


- Strategy
- Execution
- Performance

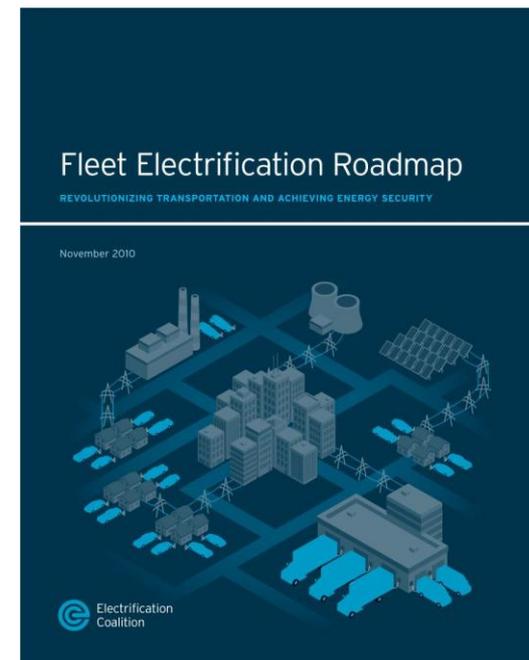


Among Our Work in eMobility, We Have Collaborated with the Electrification Coalition on Two Roadmaps

November 15, 2009



November 15, 2010



PRTM provided the technical support, including industry analyses, technology roadmaps/assessments and modeling of scenarios. Full reports available at www.prtm.com

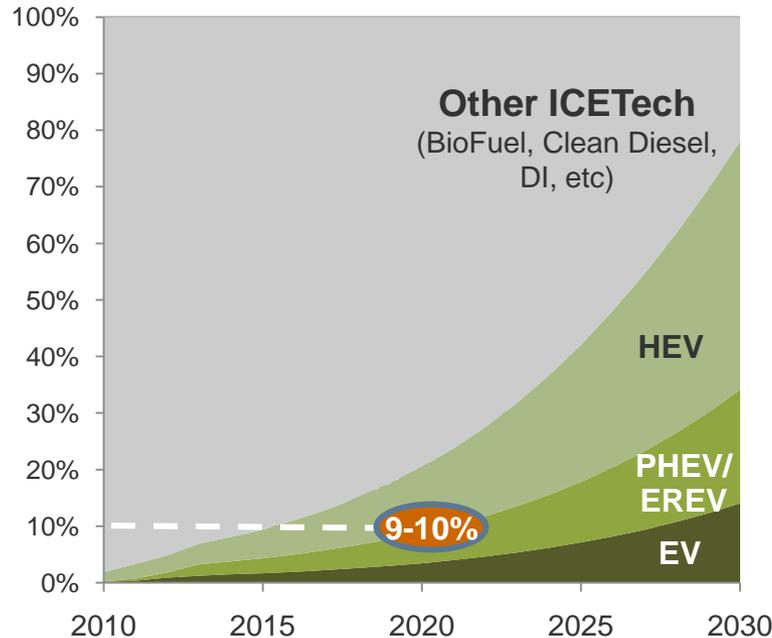
Multiple Drivers Are Aligning That Will Drive an Overall Shift Toward Vehicle Electrification

Megatrends and Drivers...



...Will Cause Electrification of the Vehicle Propulsion...

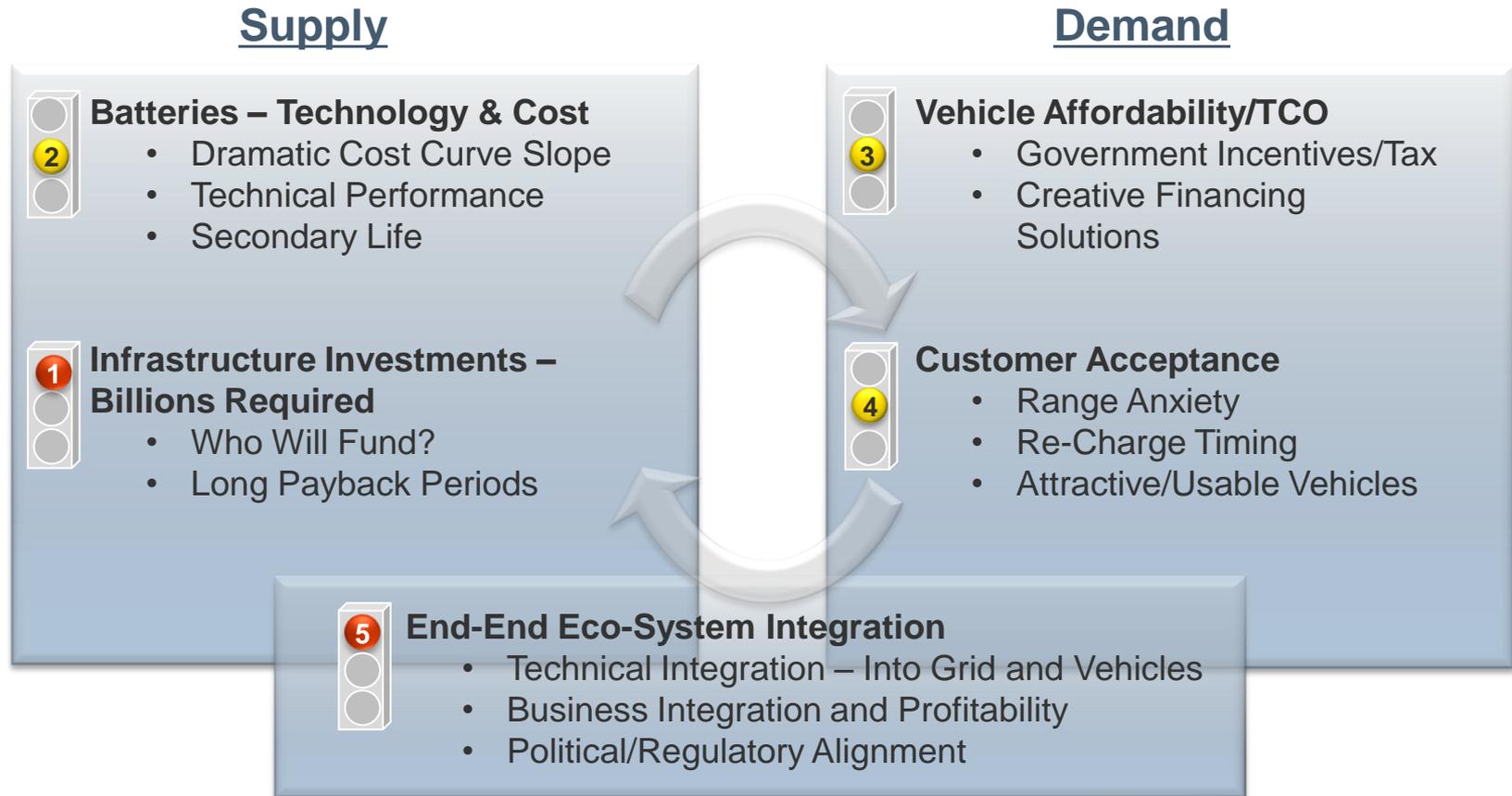
Global New Sales Penetration (%)



- *Not A Silver Bullet, But Will Become Integral Part of Powertrain Portfolio*
- *Reaching “Tipping Point” for Wider Adoption*

Sources: PRTM Research, OICA (International Organization of Motor Vehicle Manufacturers), various analyst reports, interviews

Adoption and Growth in Electric Vehicle Depends on Addressing Five Key Barriers



- High Risk/ Barrier – Partial/No Solutions
- Moderate Risks- Only Partial Solutions
- Moderate Risk – Plans in Place

Fleet Electrification Outlook

Total Cost of Ownership (TCO) to Drive Fleet Vehicle Purchase Decisions

- HEV Reaching Crossover vs. ICE Today for Fleets
- EV / PHEV TCO Parity Begins 2016+ on Current Trajectory

Electrification TCO Drivers in Fleet Applications

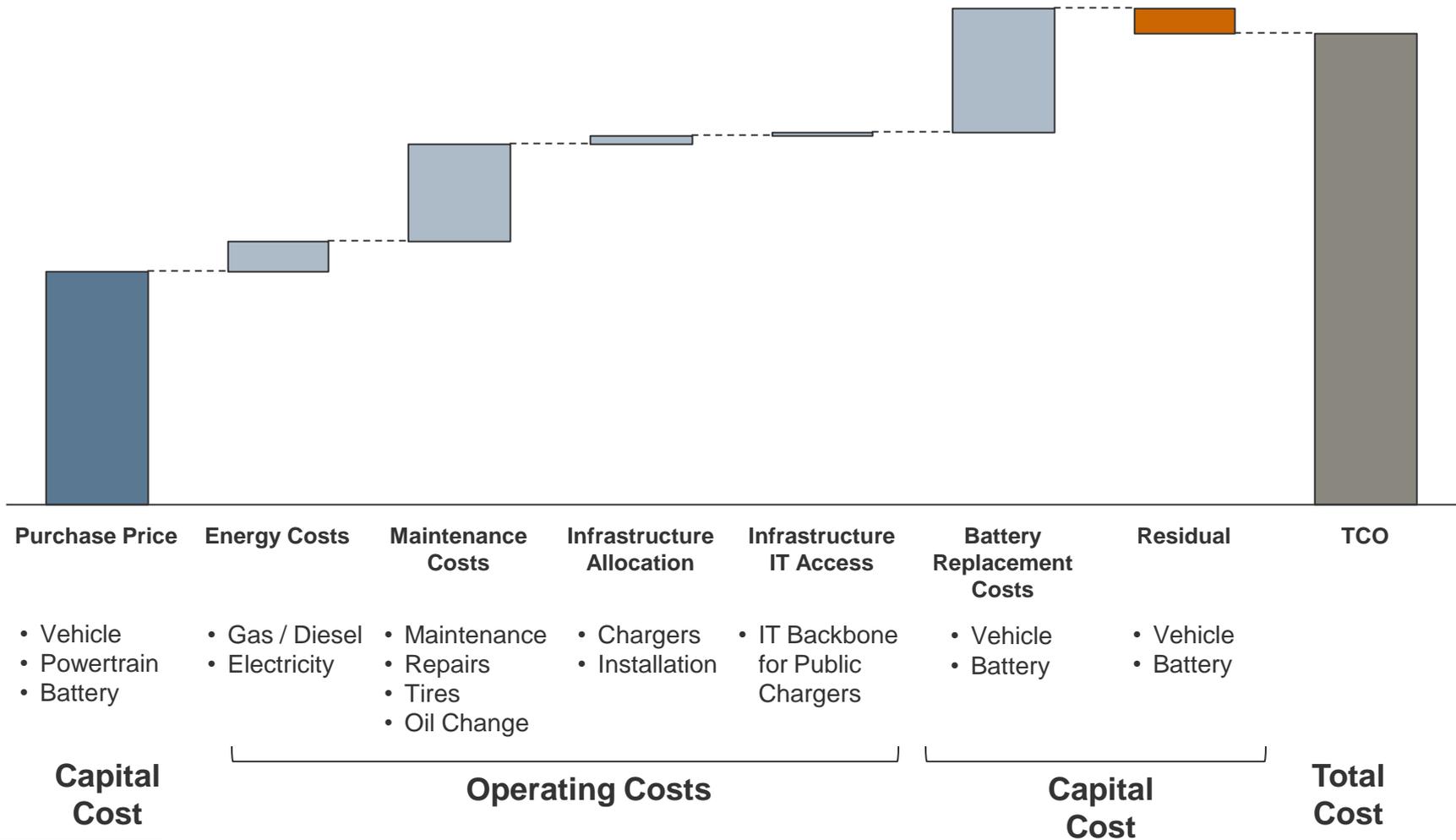
- Fleet Operating Characteristics Vary Widely Between Fleet Segments
 - Daily Driving Distance and Patterns
 - Vehicle Requirements
- EV Component Cost Decreases with ICE Component Cost Increases
- Petroleum Cost Increases Greater than Electricity Cost Increases

Range of Fleet Vehicle Configurations Likely to be Needed

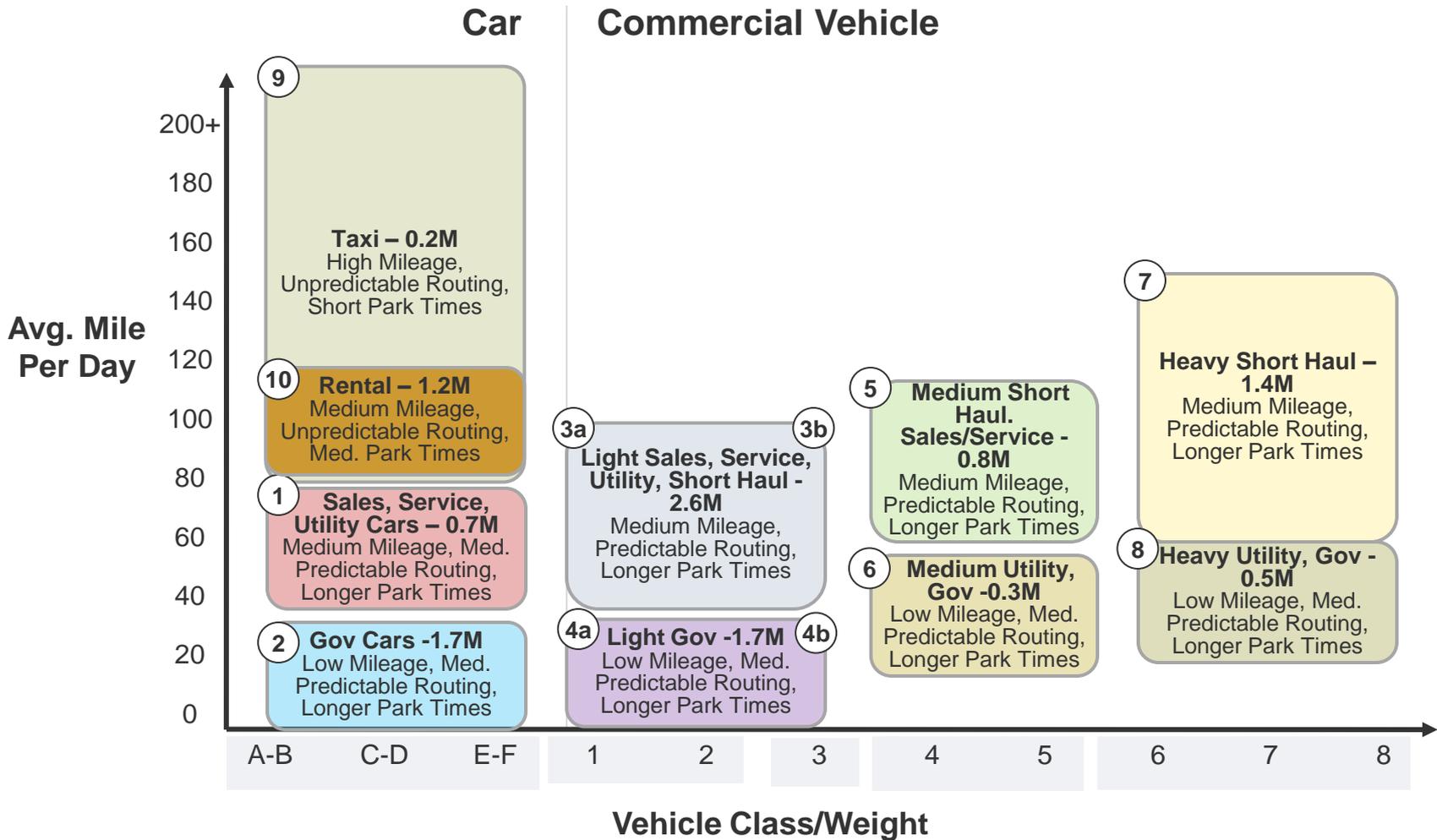
- Different Battery Size Options

xEV Total Cost of Ownership for Needs to be Evaluated Differently Than With Conventional Vehicles

Total Cost of Ownership

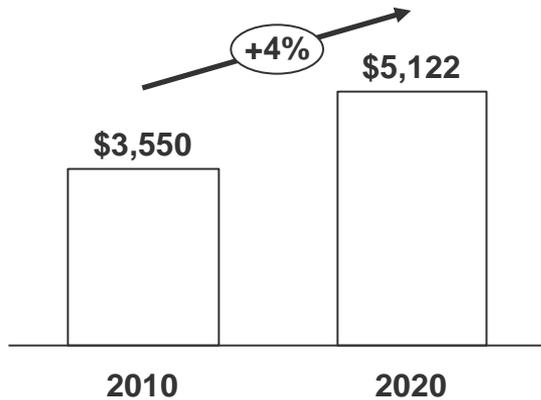


Operating and Vehicle Requirements of Different Fleet Segments Will Have Significant Impact on TCO



Diverging Costs of xEV and ICE Component Costs Will be a Key Driver in TCO...

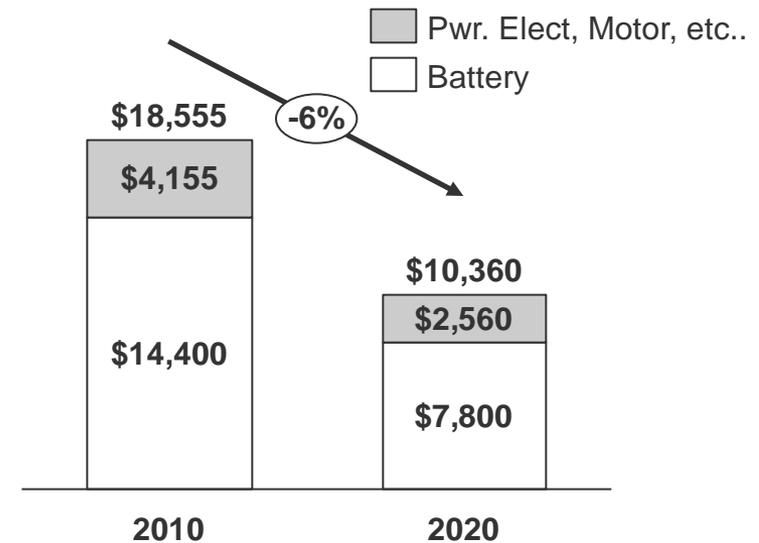
ICE Powertrain Component Costs
2010-2020 (C-Class Vehicle Example)



3-4% YOY Cost Increase for Emissions / Fuel Economy Technology

- Gas Direct Injection
- Engine Boosting
- Start / Stop
- Diesel After-treatment
- 6 Speed AT

EV Component Costs 2010-2020
(C-Class Vehicle Example)

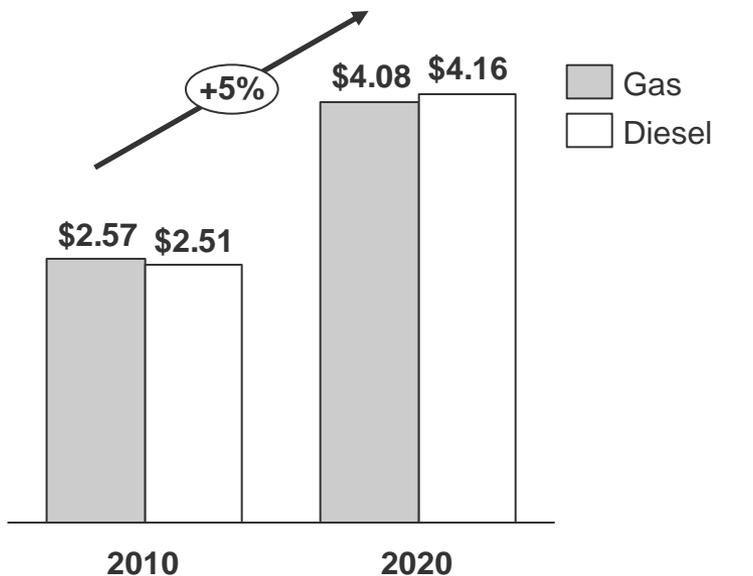


5-6% YOY Cost Decrease in Battery, Power Electronics, and Motor

- Production Scale
- Production Learning Curve
- Supply Chain Optimization
- Material Advances (Cathode / Anode, Pwr. Semiconductor, etc..)

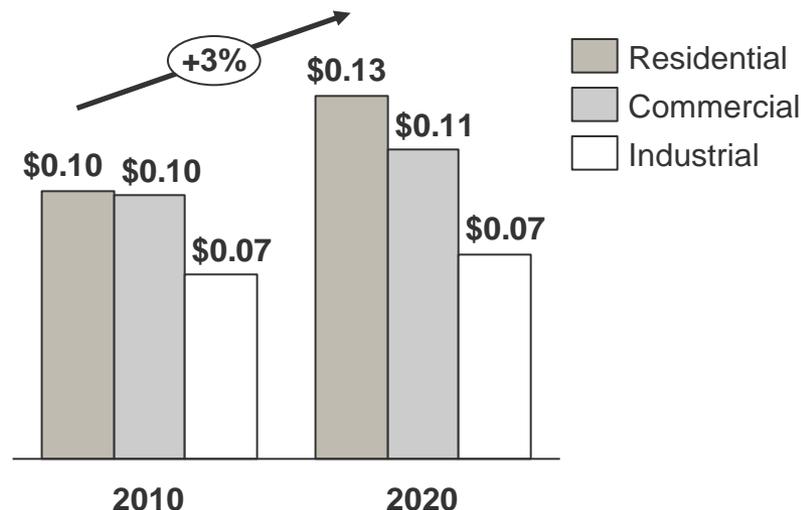
...Likewise, Diverging Energy Cost Trends Between Petroleum and Electricity Will Also Play a Key Role

Gas / Diesel Fuel Cost Trends (\$ / Gal)



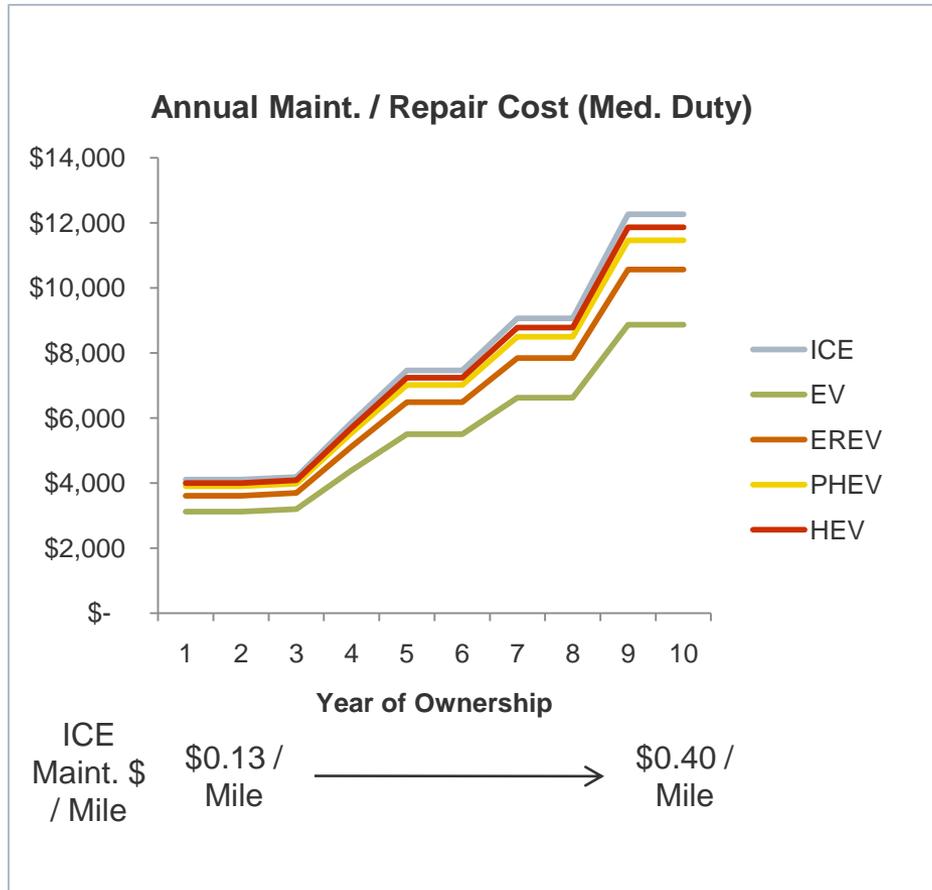
~5% YOY Gas / Diesel Price Increases
2010-2020

Electricity Price Trends (\$ / kWh)



3% YOY Electricity Price Increase
2010-2020

EV Maintenance and Repair Costs Likely to be an Area of Significant Savings for EVs

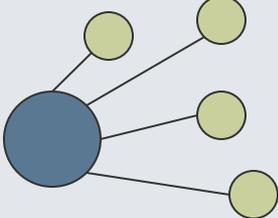
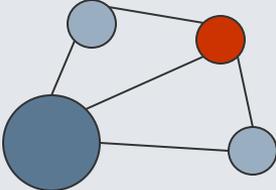
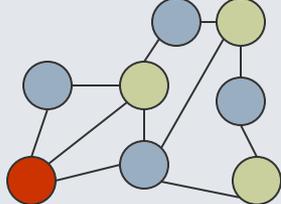
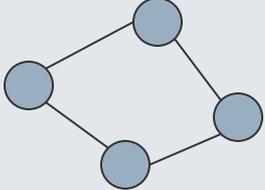


Maintenance Costs ~33% of ICE TCO Cost

EV Maintenance Costs Expected to be ~30% Lower than ICE

- Fewer Overall Parts
- Fewer Moving Parts
- Less Complicated Fluid Systems

Charging Infrastructure Requirements and Cost Will Vary Significantly Between Fleet Segments

	Single Depot	Company Car Commuter	Regular Delivery	Sales Force	Multiple Sites
					
	Increasing Cost 				
Description	<ul style="list-style-type: none"> Single home lot for all fleet vehicles Fleet has short, regular, and defined routes eliminating need for extraneous charging 	<ul style="list-style-type: none"> Fleet has primary day-time location Fleet is parked overnight at home 	<ul style="list-style-type: none"> Fleet has regular, defined routes Fleet has specific dwell points ideal for topping off 	<ul style="list-style-type: none"> Fleet has multiple locations with no central depot Fleet is parked overnight at home 	<ul style="list-style-type: none"> Fleet has multiple locations with no central depot
Key Challenges	<ul style="list-style-type: none"> Range anxiety 	<ul style="list-style-type: none"> Investment in at-will employees' residence Charger utilization vs. Investment 	<ul style="list-style-type: none"> Changes in route structure Intermittent events 	<ul style="list-style-type: none"> Complexity Investment in at-will employees' residence 	<ul style="list-style-type: none"> Charger utilization vs. Investment
Characterized By	<ul style="list-style-type: none"> Single large bank of charge stations at central depot 	<ul style="list-style-type: none"> Primary bank of charge stations at primary day-time lot Individual home chargers at private residences 	<ul style="list-style-type: none"> Primary bank of charge stations at central depot Extended infrastructure of public & fast charging stations 	<ul style="list-style-type: none"> Multiple public chargers per location Individual home chargers at private residences Sporadic fast charging 	<ul style="list-style-type: none"> Multiple public chargers per location



= Central charger depot bank



= Public charger



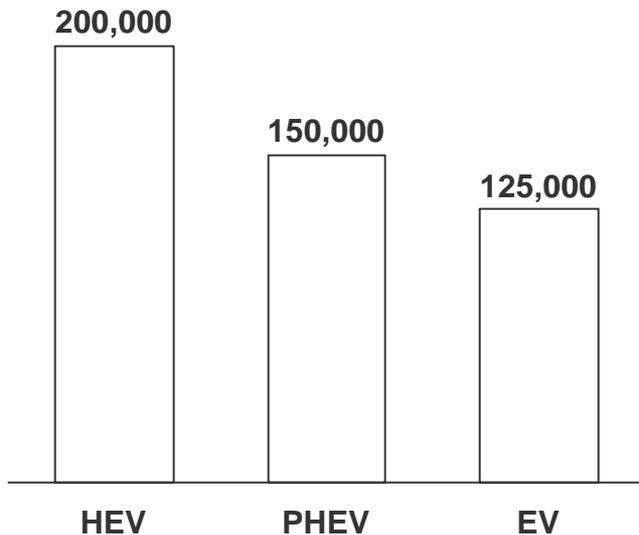
= Fast charger



= Home charger

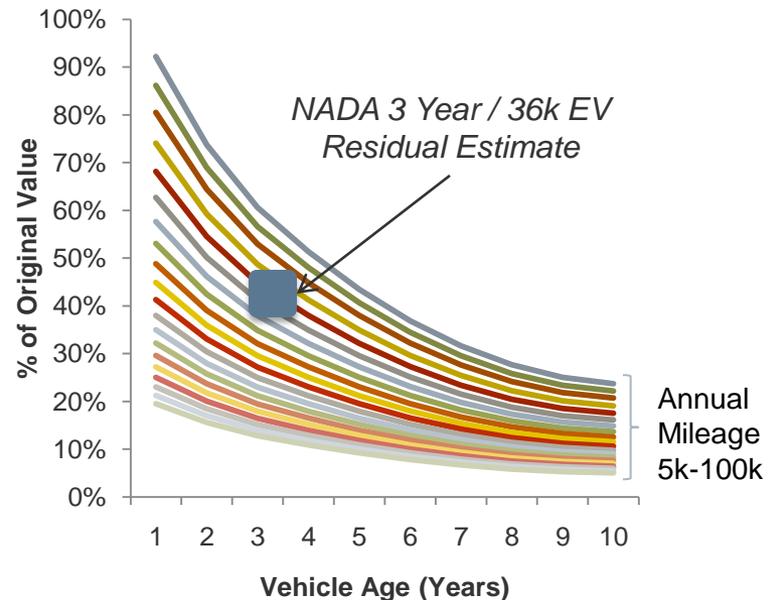
Battery Replacement and Residual Value Also Play a Key Role in the xEV Total Cost of Ownership

Battery Replacement Intervals (Miles)



xEV Battery Replacement Will Vary Between Vehicle Types Due to Differences in Deep Discharge Cycles

xEV Depreciation Schedule



xEV Depreciation Profile Similar to ICE

- NADA 3/36k Residual Value Forecast for EV / PHEV (55-65% of Original Value)

Battery Expected to Follow Similar Profile to Vehicle

Medium Short Haul Shows One of the Earliest xEV Crossovers with HEV Parity in 2012 and EV Parity in 2016

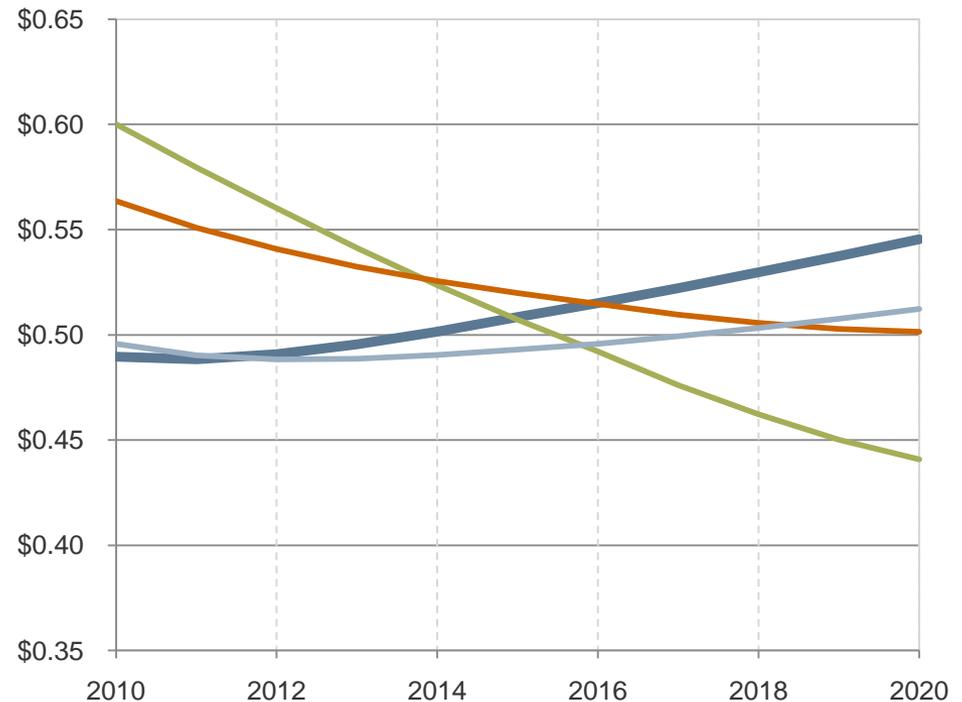
Total Lifetime Operating Cost Comparison (\$ per Mile; US, Excluding Government Incentives)

Key Assumptions

	2010	2020
Vehicle		
▪ ICE	\$45K	\$47K
▪ HEV*	\$59K	\$54K
▪ PHEV*	\$75K	\$61K
▪ EV*	\$92K	\$65K
Fuel (Diesel)	\$2.51	\$4.16
Battery (Li-ion)		
▪ HEV – 5kWh	\$1,440/kWh	\$790/kWh
▪ PHEV – 29kWh	\$790/kWh	\$430/kWh
▪ EV – 65Wh	\$720/kWh	\$390/kWh
Fuel Economy		
▪ ICE	10mpg/	13mpg
▪ HEV	13mpg/	17mpg
▪ EV	1.5m/kWh	1.8m/kWh
Vehicle Life/ Battery Replacement	~ 10 yr Ownership / 125,000mi EV Battery Replacement	

*Should-cost pricing assuming annual production > 10,000

xEV TCO
SEGMENT 5 - Medium Short Haul, Sales/Service (Base Scenario)



Looking Across Segments, HEV is Attractive Soonest With EV/PHEV Showing Opportunity 2016+

Base Case

Lowest TCO Drivetrain Technology by Year and Segment

	Seg.	Name	Mi /Yr	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020 +
Pmgr.	1	Sales, Serv., Utility	22k												
	2	Gov	9k												
	9	Taxi	36k												
	10	Rental Car Sharing	31k												
Class 1/2	3a	Sales, Serv. Util., Sh. Haul	19k												
	4a	Light Gov.	6k												
Class 3	3b	Sales, Serv. Util., Sh. Haul	23k												
	4b	Light Gov.	6k												
Class 4/5	5	Med. Short Haul	31k												
	6	Med. Utility, Gov	8k												
Class 6/7	7	Heavy Short Haul	26k												
	8	Heavy Utility, Gov	18k												

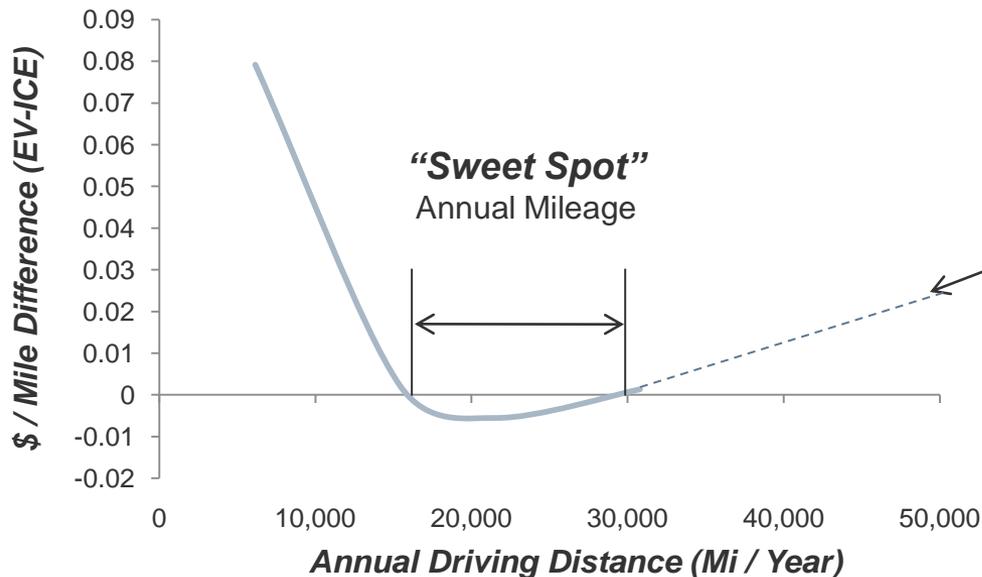
ICE

HEV

EV/EREV

TCO Will Decrease With Increased Mileage With a Natural “Sweet Spot” Emerging for Different Segments

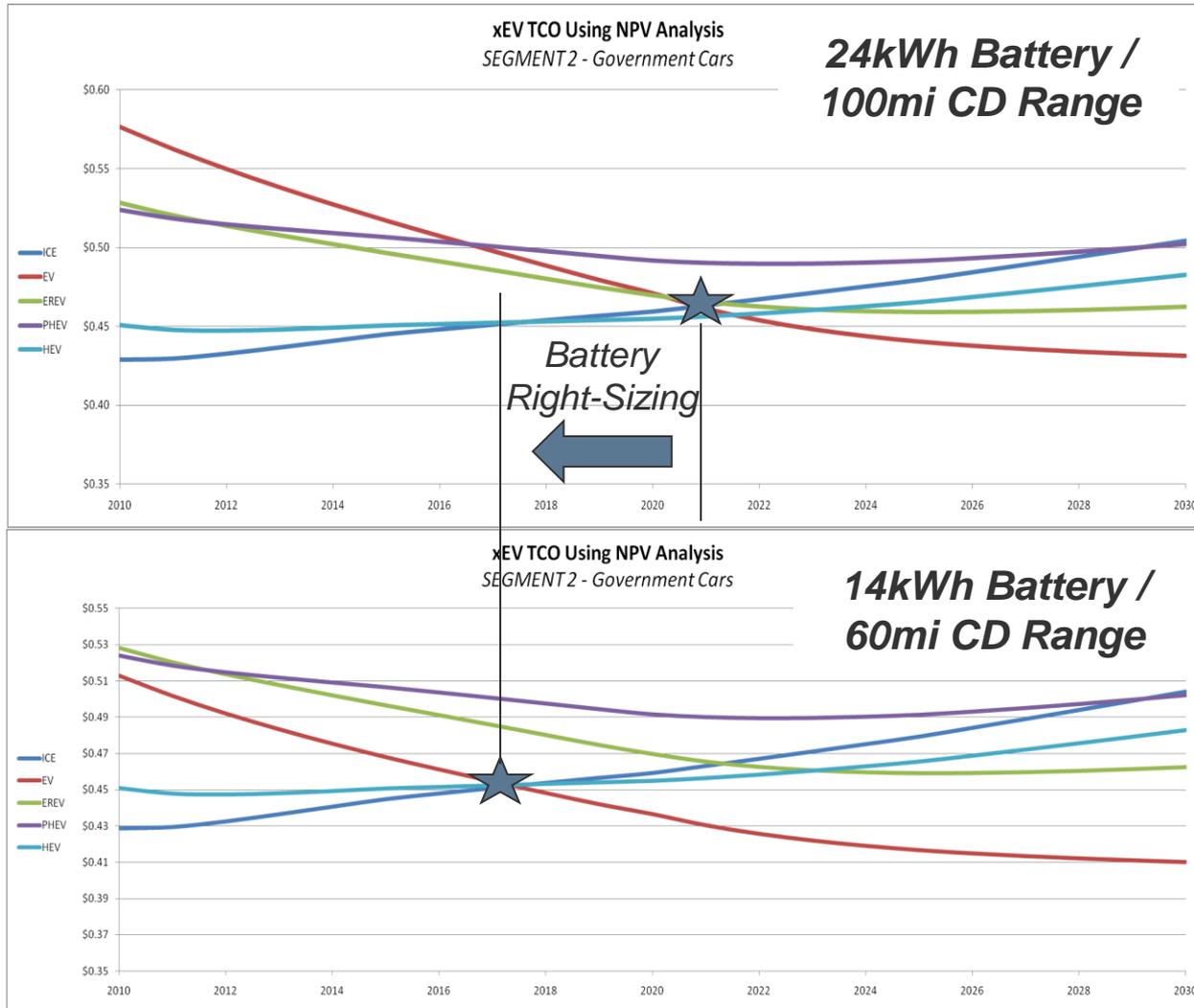
**2018 Total Cost of Ownership
(6 Years) for EV vs. ICE
Segment 1 – Sales, Svc., Utility**



Offsetting Operational Challenges:

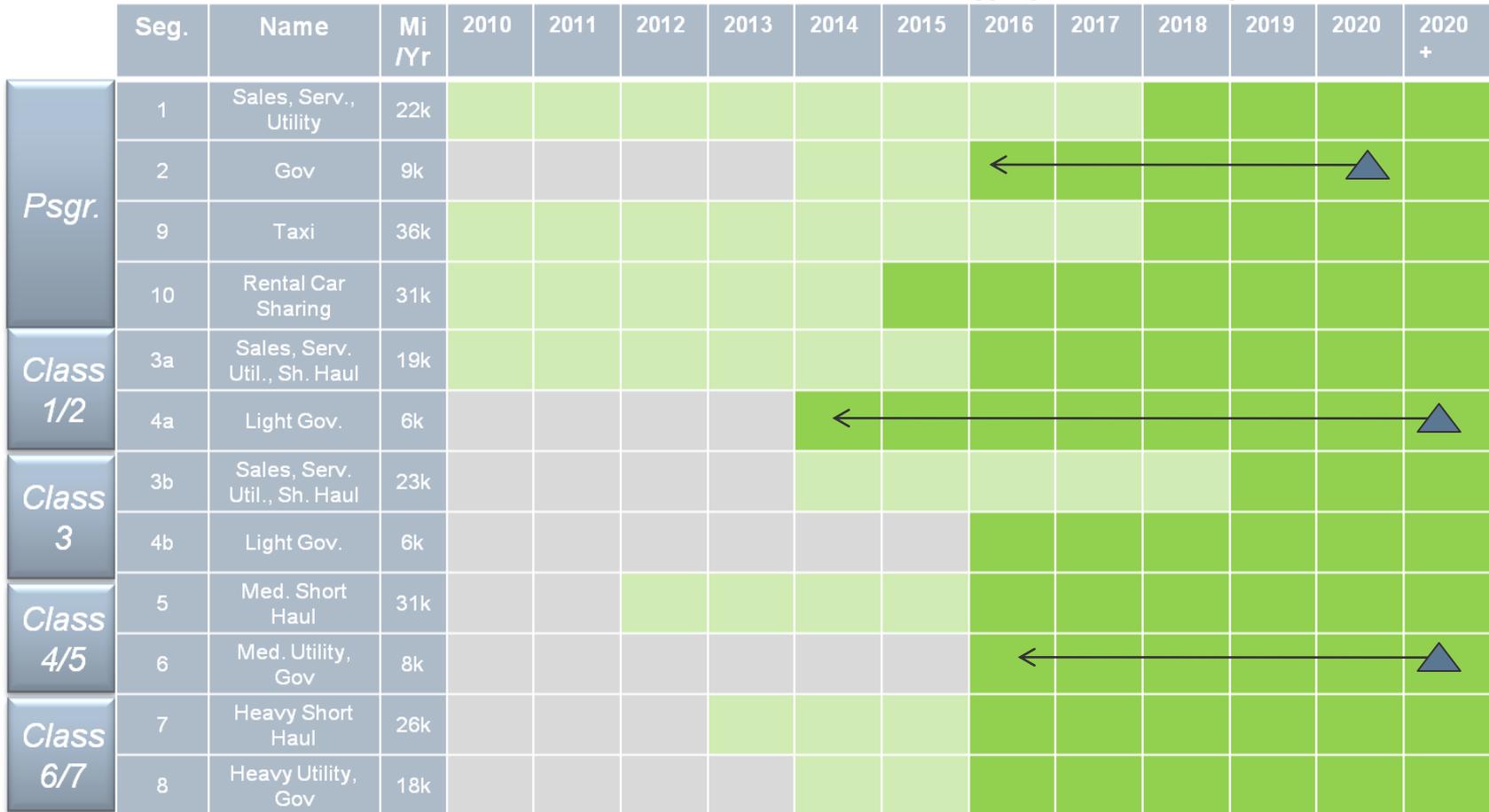
- *Dwell Time for Charging*
- *Accelerated Battery Life Degradation*
- *Battery Replacement*

For Low Mileage Segments, the TCO Benefits Will be Delayed Unless New Configurations Emerge



Through Actions Such as Battery “Right Sizing”, EV/PHEV Crossover Can be Accelerated Significantly

Fleet Optimized Operations / Vehicles
Lowest TCO Drivetrain Technology by Year and Segment



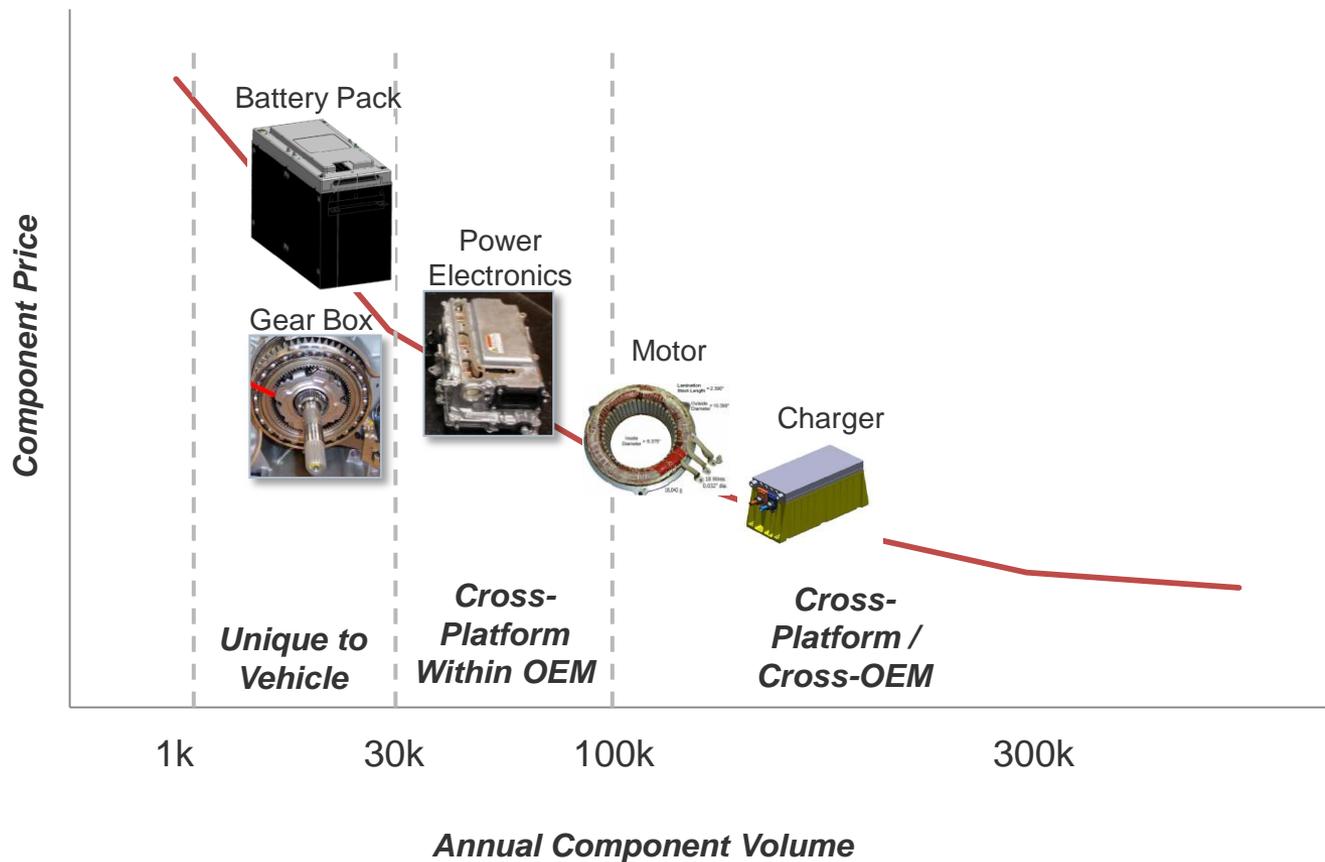
ICE HEV EV/EREV

▲ Base Case

Additional Opportunity Will Come From Cross-Platform / Cross-OEM Component Re-Use

Different Components Likely to Have Different Cross-Platform Re-Usability

xEV Component Cost vs. Volume Curve



Several Key Questions Remain to be Answered at an Industry Level on Fleet Electrification Adoption...

How Can the xEV Chicken and Egg Dilemma be Broken?

- Scale Needed to Achieve Costs
- Buyers Unlikely to Commit Before Costs Drop

Are There Cross-Operator xEV Standards That Could Drive Commonality and Scale?

- Battery Pack / Module?
- Motor / Inverter?
- Charger?

What Types of Policies Could Have the Greatest Impact on Driving Down TCO on a Sustained Basis?

...Additionally, Detailed Planning and Analysis Will be Needed at the Individual Fleet Level

1) Identify Specific Fleet Segment Candidates for Electrification

- Establish Detailed Fleet Sub-Segment Usage Profiles
- Develop Fleet Specific Total Cost of Ownership Models

2) Develop Fleet Specific Business Case

- Vehicle CAPEX and OPEX Budgeting Modifications
- Infrastructure Investment Planning

3) Identify Operating Model Changes

- Route Modifications
- Fleet Management Changes

4) Establish Long-Term xEV Phase-In Plan

- Pilot Plans
- xEV Cut-Over Plan
- Service and Maintenance Transition