

Electric Vehicle Technology and Policy

TRB Executive Committee Meeting

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Woods Hole, Massachusetts

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Chair – TRB ADC80 Alt. Vehicle Fuels and Techs. Committee

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Transportation Sustainability
RESEARCH CENTER



Key Points

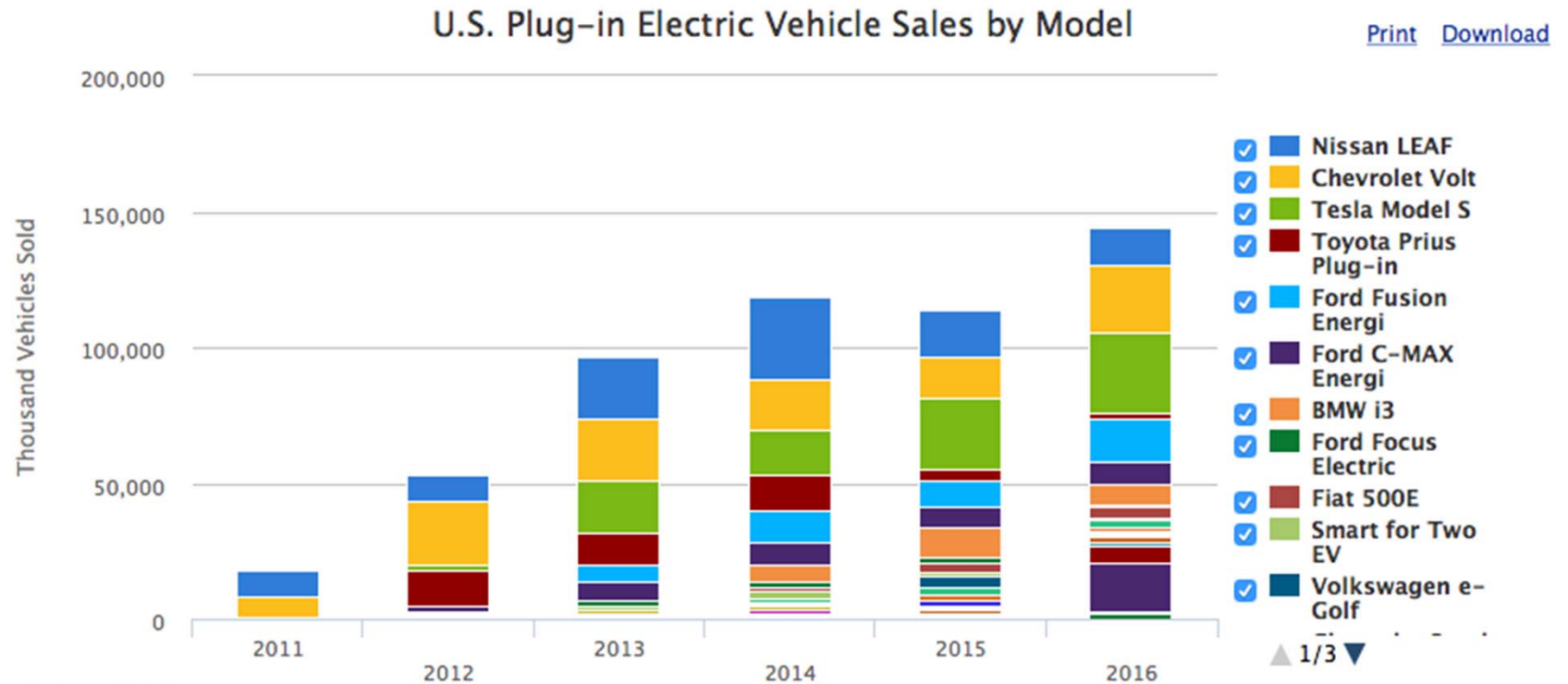
- Electric Vehicle (EV) and Battery Technologies are Progressing Rapidly
- Vehicle Charging Infrastructure is a Key Issue but With Innovative New Approaches
- “Vehicle-Grid Integration” (VGI) Offers Potential for Reduced EV Charging Costs as Well as Improved Grid Operations
- EVs Are Making Inroads in Medium/Heavy Duty Markets as Well as Light-Duty Markets
- Synergies Between EVs and Connected/Autonomous Vehicles
 - DOE SMART Mobility Program
 - How should EV charging infrastructure be considered for a future with fewer privately-owned vehicles?
- Hydrogen and Fuel Cell Technologies Also Becoming Interesting

TSRC – Early PHEV Research History

- 2010-11 Toyota-sponsored project included 10 conventional hybrid Priuses and 10 plug-in hybrid Priuses



EVs Are (Finally) Starting to Scale



Last updated: May 2017
Printed on: February 1

Source: hybridcars.com

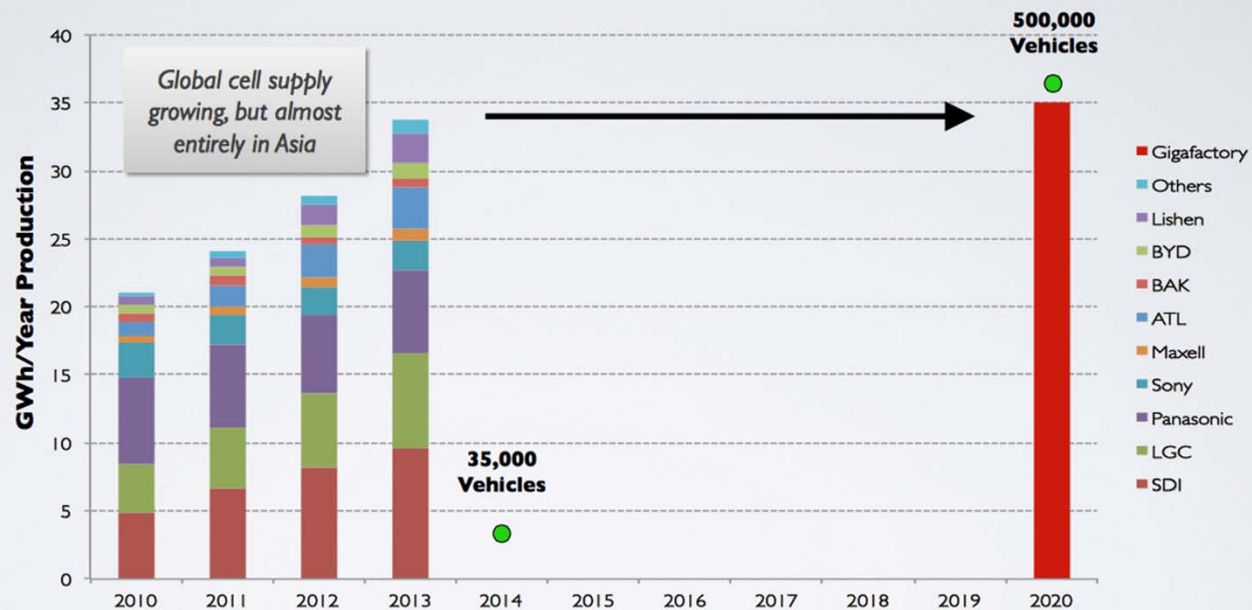
Tesla Gigafactory

Tesla Gigafactory – Concept Drawing – 10 million square feet!



Gigafactory Battery Production

Planned 2020 Gigafactory Production Exceeds 2013 Global Production



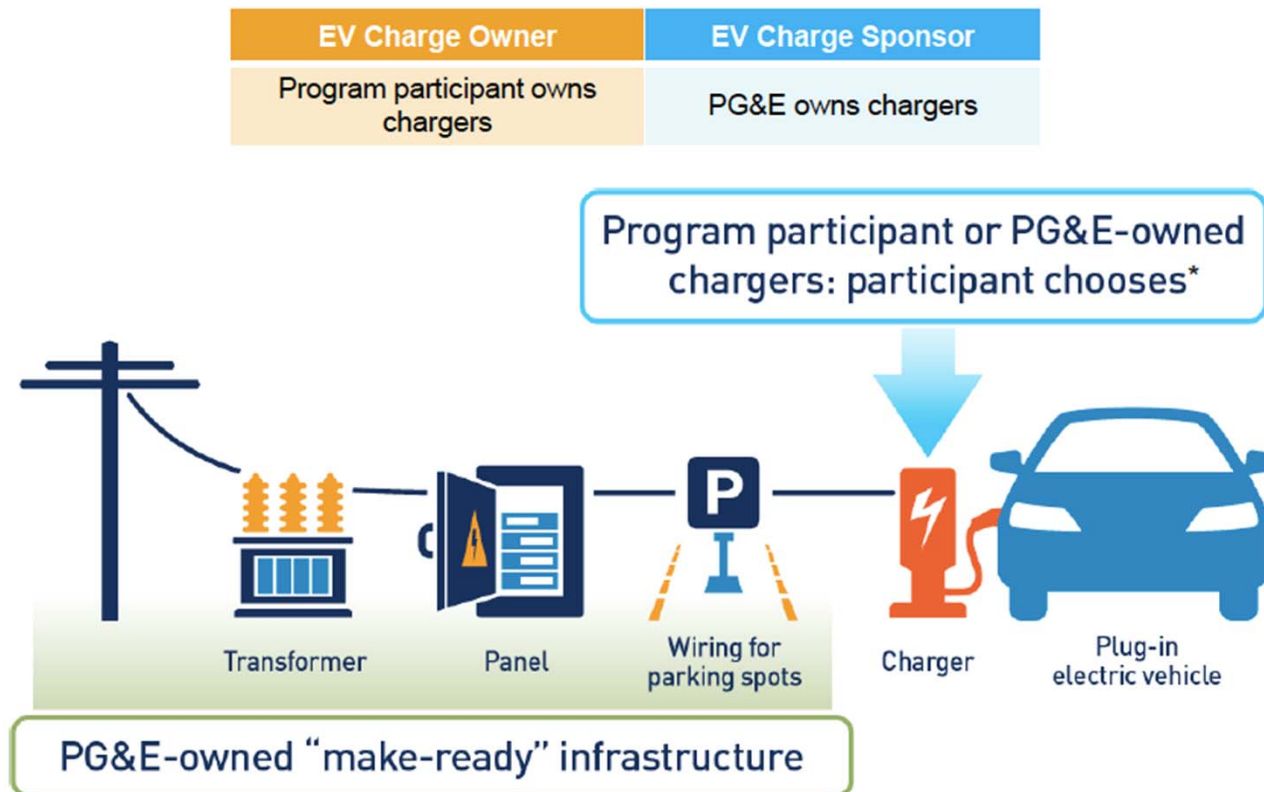
Battery pack cost/kWh reduced >30% by Gen III volume ramp in 2017



Source: IIT Takeshita 2013

Electricity Charging Infrastructure is Key Issue for EVs

- But Lots of New EV Charger Programs Through Utilities Like PG&E, VW Electrify America, State Energy Offices, and Local Air Districts



Evolving Utility Grids Enable Innovative Solutions for Load Control Like VGI

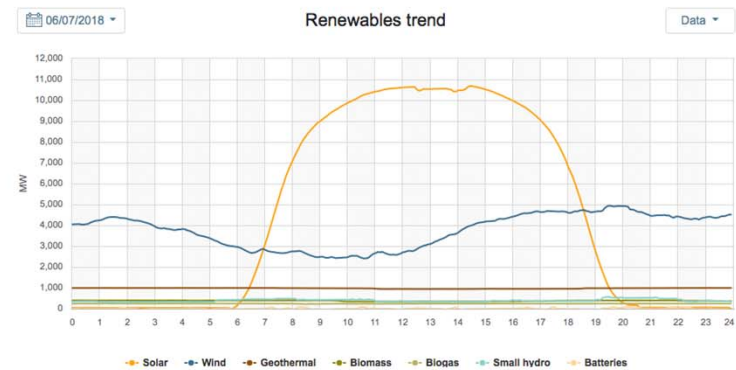
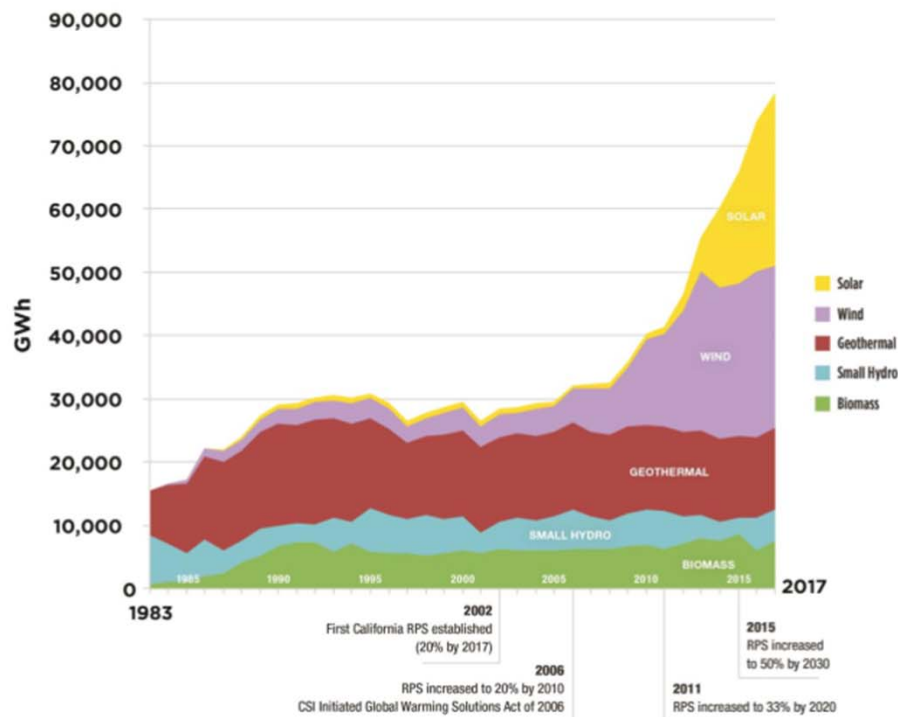
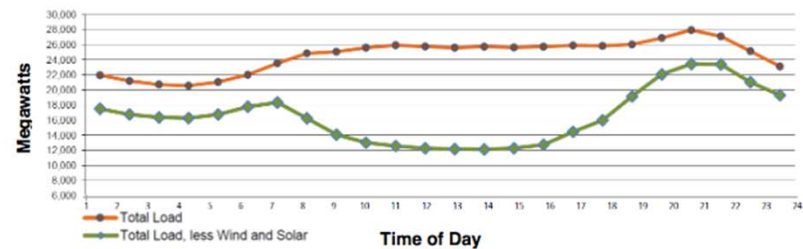


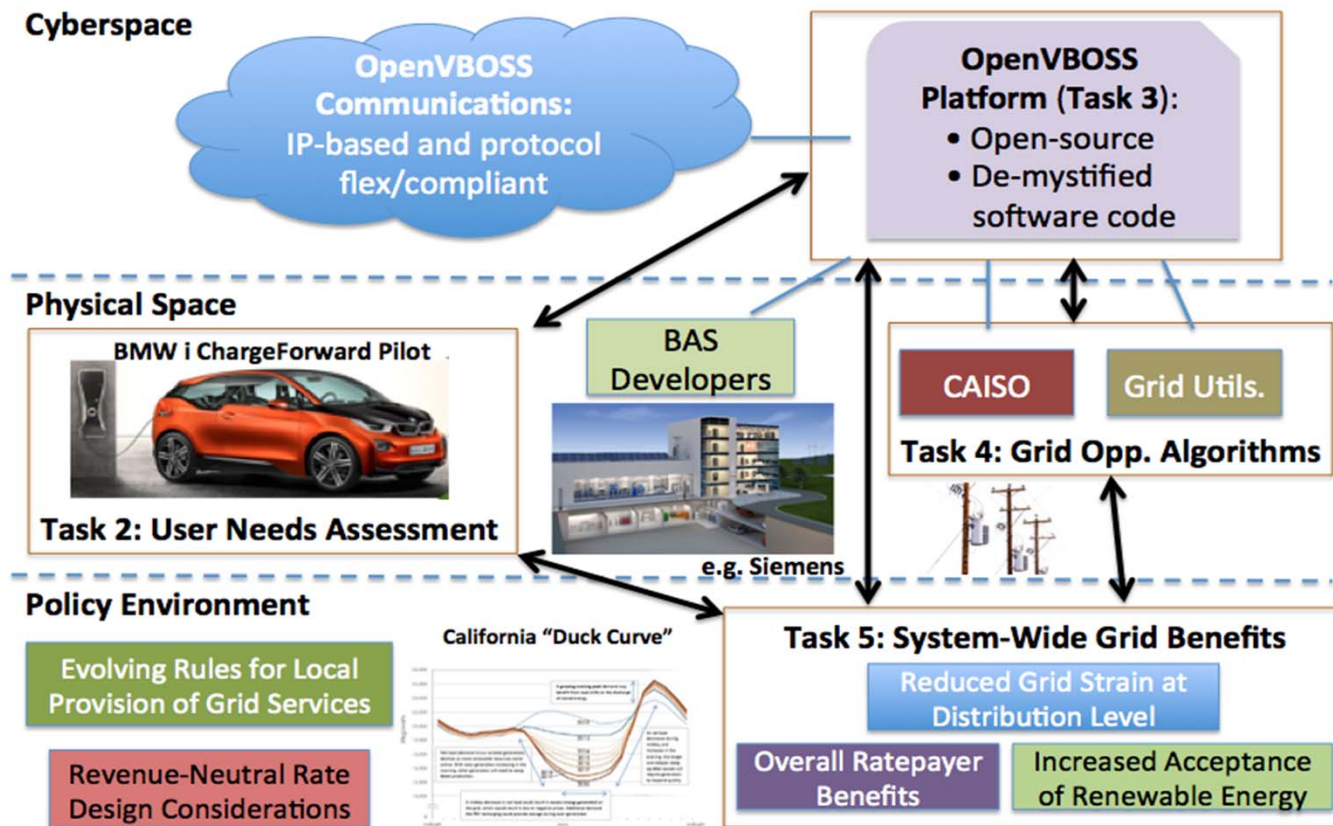
Figure 7: Average Hourly Net Load in California ISO on 5/16/17^{viii}



Source: http://content.aiso.com/green/renewrpt/20170516_DailyRenewablesWatch.pdf

XBOS-V Project – Task Overview

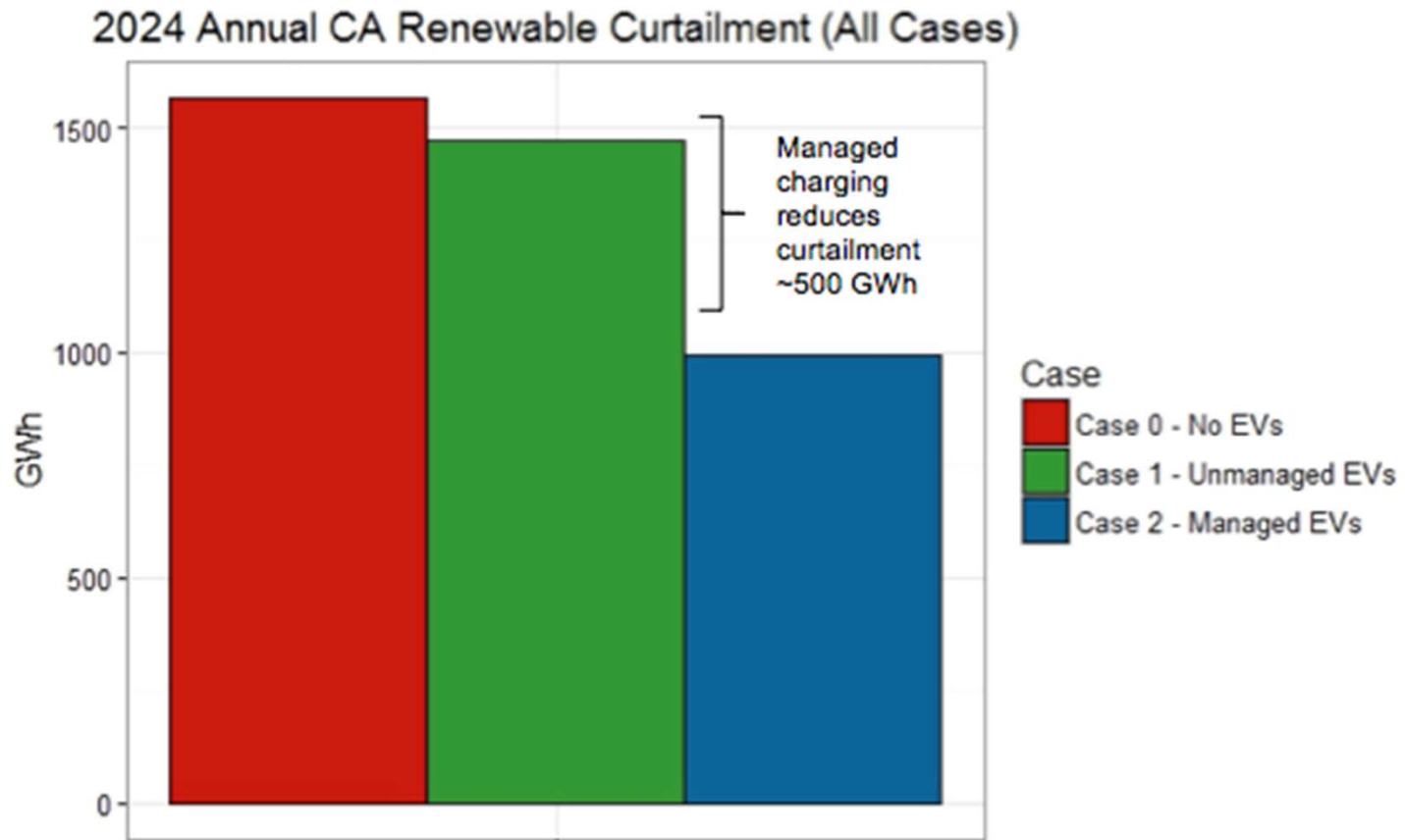
UC Berkeley OpenVBOSS Project – Cyber-Physical Space



Vehicle-Grid Integration – Recent Findings

Future California Grid and EV Scenario Using PLEXOS Modeling

Important Implications for Where and When EVs Should be Enabled to Charge



Source: Julia Szinai, UC Berkeley/LBNL, 2017 (CEC EPIC 15-013 project)

Urban Bus Electrification

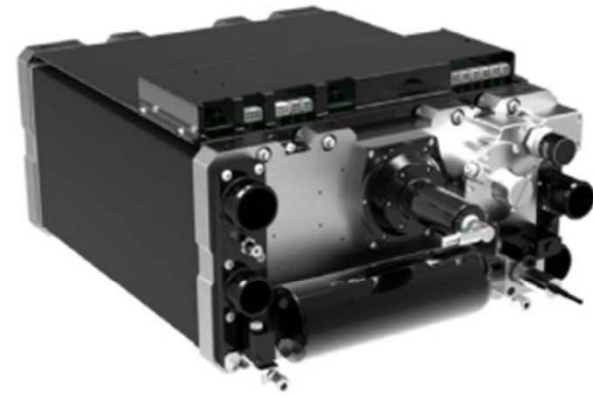


Hydrogen Fuel Cell/Battery Short Haul Trucks

Using existing ElecTruck developed in ZECT I project as a platform...



Build an extended range zero-emission truck using fuel cell technology



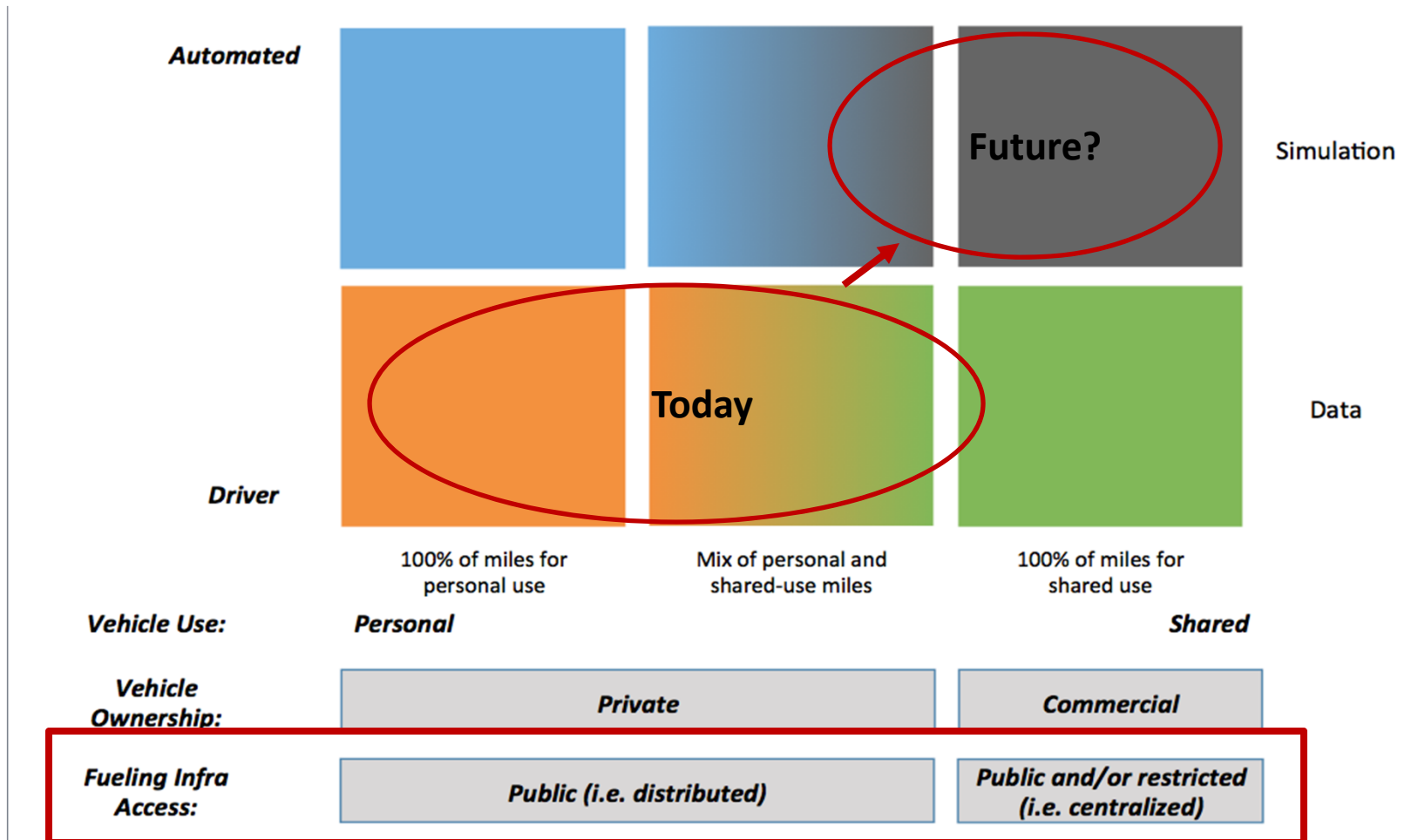
Hydrogenics HyPM™ Fuel Cell

Hydrogen Fuel Cell Trucks – Long Haul

- Major announcements in 2016 by Toyota and Nikola for Class 8 medium/long-haul trucks powered by hydrogen/FCs
- Toyota truck unveiled in Long Beach in Spring 2017
 - Currently being tested using 40 kg fuel tanks for 200 mile range
 - Incorporates Mirai LDV technology for manuf. Scale
 - New tri-generation station being built for renewable fuel
- Nikola One – FC/battery powered:
 - Nikola One is 2,000 pounds lighter than a conventional diesel semi truck
 - Lease for \$5,000-\$7,000 a month for 72 months with 1 million miles of free hydrogen fuel
 - Nikola One est. range of up to 1,200 miles and FE of 15.4 miles per gallon



Multi-National Lab Smart Mobility Study



Hydrogen Fuel Cell Test Vehicles

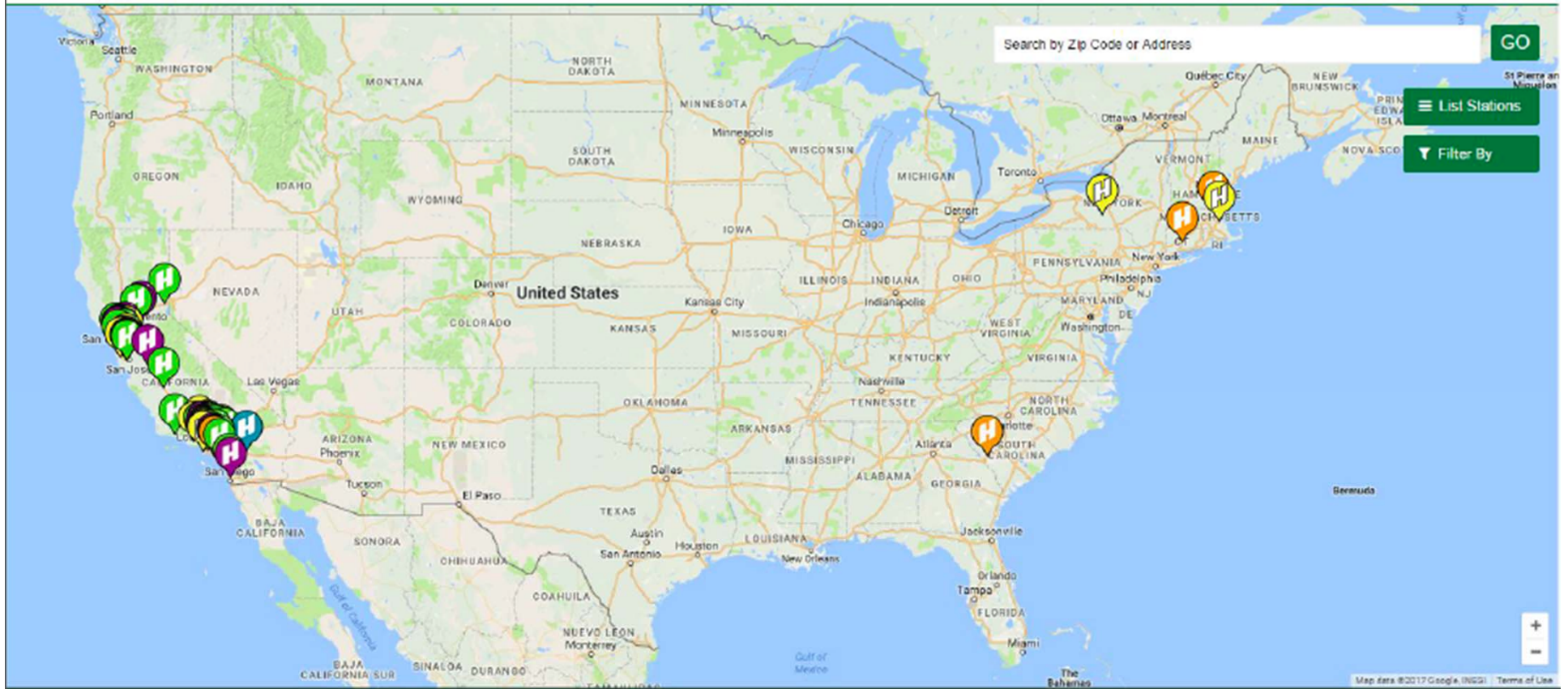


Starting to Go Nationwide

H2stationmap.com



MAP HYDROGEN STATIONS DEPLOYMENT COSTS & FINANCING STATE SUPPORT ABOUT US

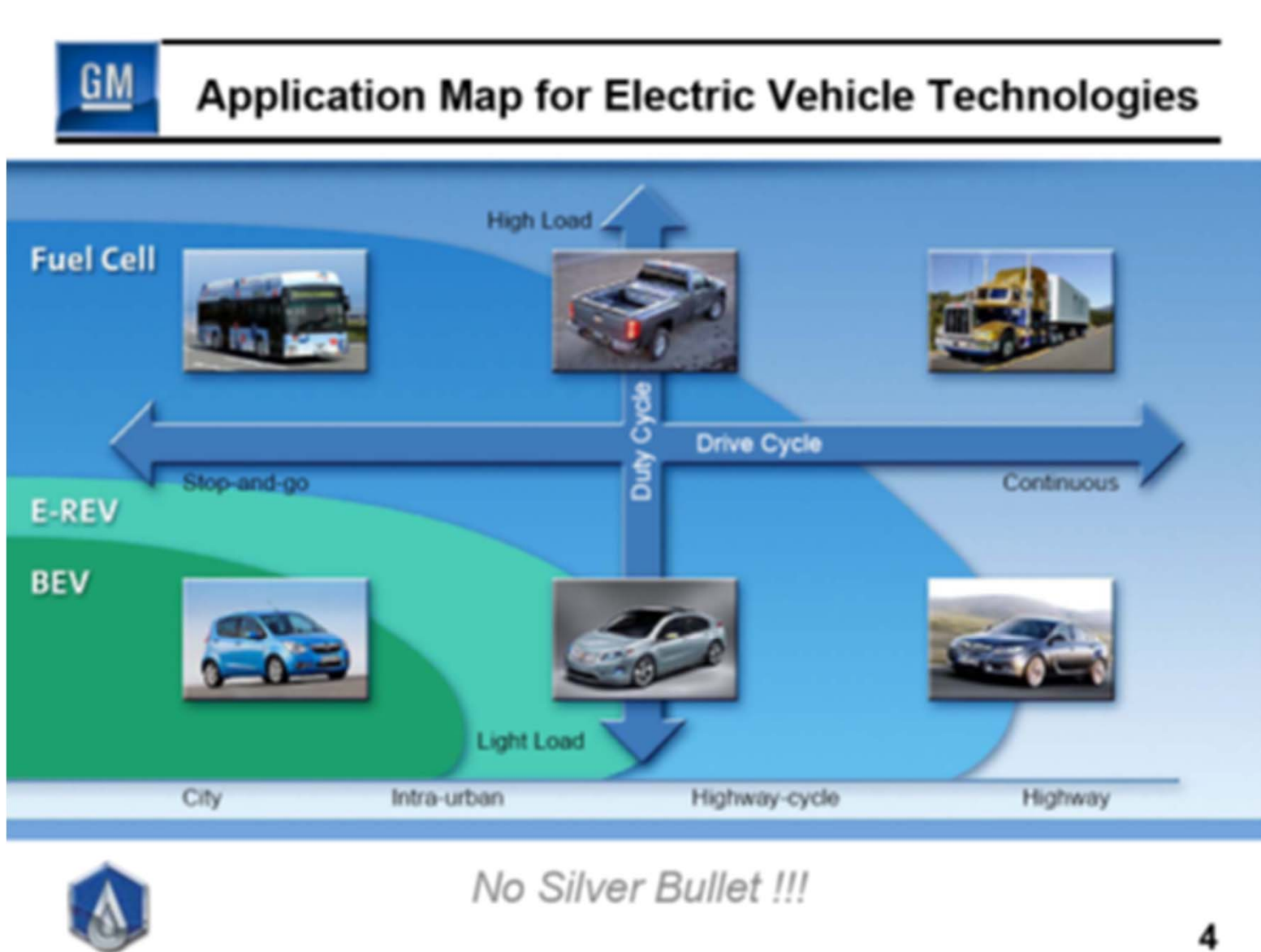


Hydrogen Station Progress



Photo: T. Lipman – Hayward, CA - 9/29/16

Application Space



Concluding Thoughts

- EV Technologies are Proliferating Around the US and the Globe
- Supportive Policies are Still Important:
 - Vehicle purchase incentives
 - Support programs for installing EV charging stations and H2 fueling stations during transition when demand may be low
 - Policies to guide co-development of CAVs with EVs, encouraging sharing to reduce overall VMT
- For States and Regions with Increasing Renewable Sources for Electricity, VGI Offers a 'Win-Win' to Reduce Grid Operating Costs and Costs to Drivers, and Help to Reduce Curtailed Power
- Hydrogen/Fuel Cell Technologies Also Coming Along and Worthy of Support for Their Zero Local Emissions



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