Impact of Climate Change – Not Business as Usual

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Presented at the California Energy Commission (CEC) Integrated Energy Policy Report Workshop on "Trends in Sources of Crude Oil"

June 25, 2014

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Focus of Talk

- Need to get off petroleum
- Is it feasible?
- Technology pathways for vehicles and fuels
- Transition timing
- Summary

Drivers to Get Off Petroleum

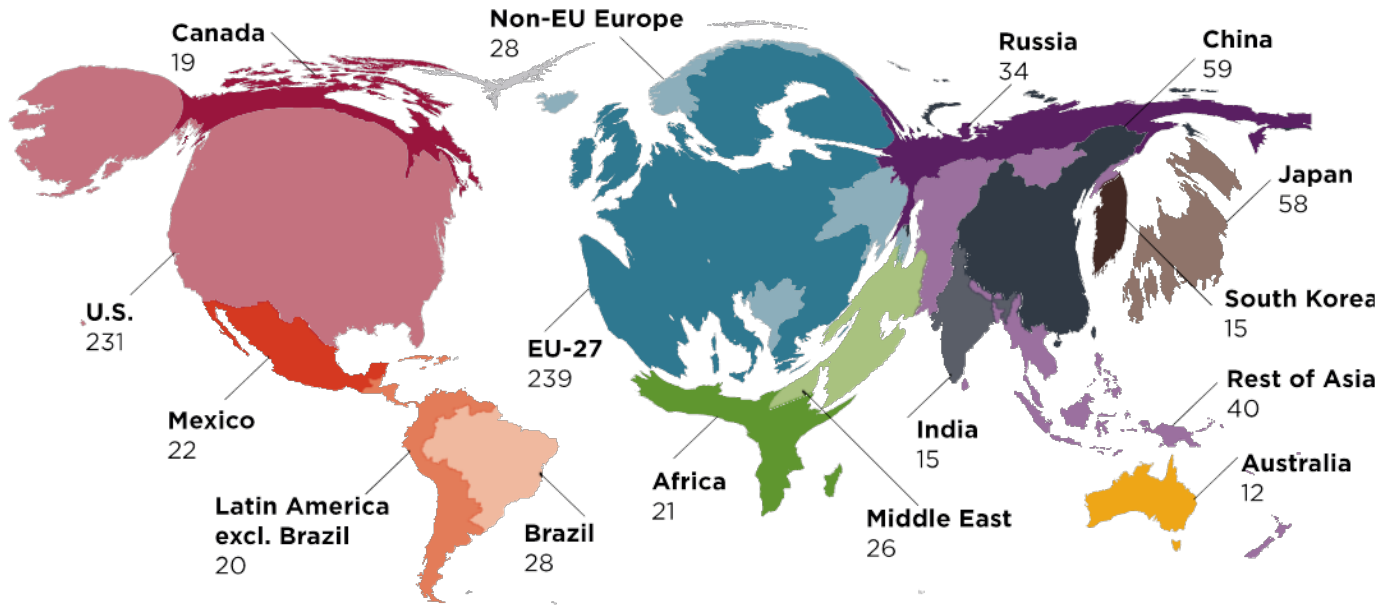
- Climate
- Air pollution
- AB32 and likely successor
- Obama Carbon Pollution Standards
- Increasing costs of petroleum

Consumption of Oil and Gas

- California is major consumer of oil and gas
- Demand increasing globally as shown on next slides

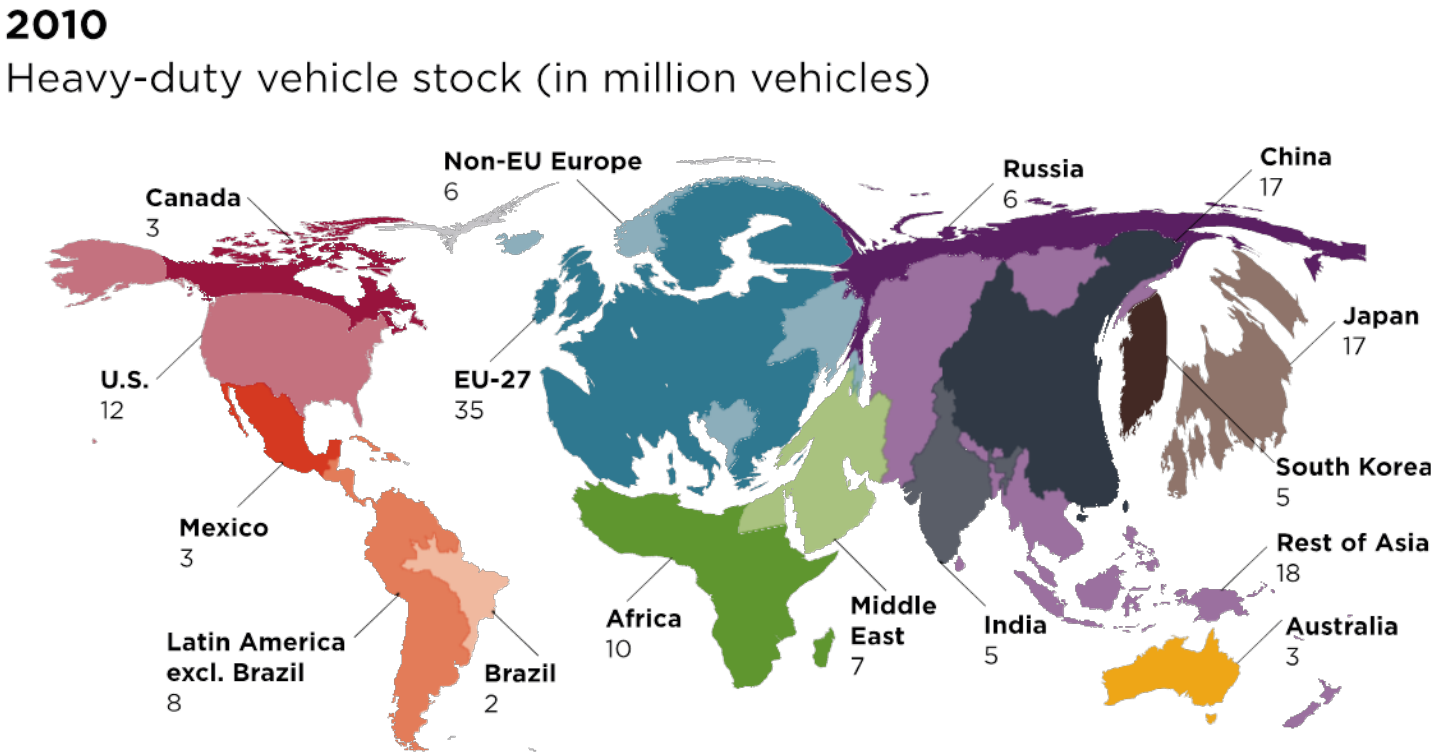
Global Car Fleet– Cars & Vans

Number of cars and vans on the road in 2010



Global Car Fleet– HDVs

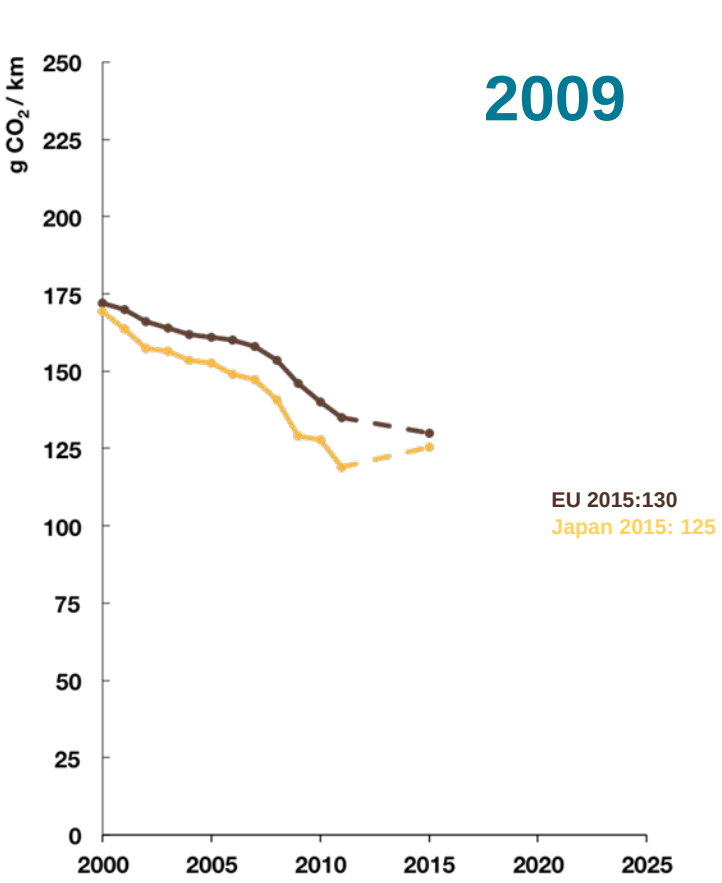
Number of HDVs on the road in 2010

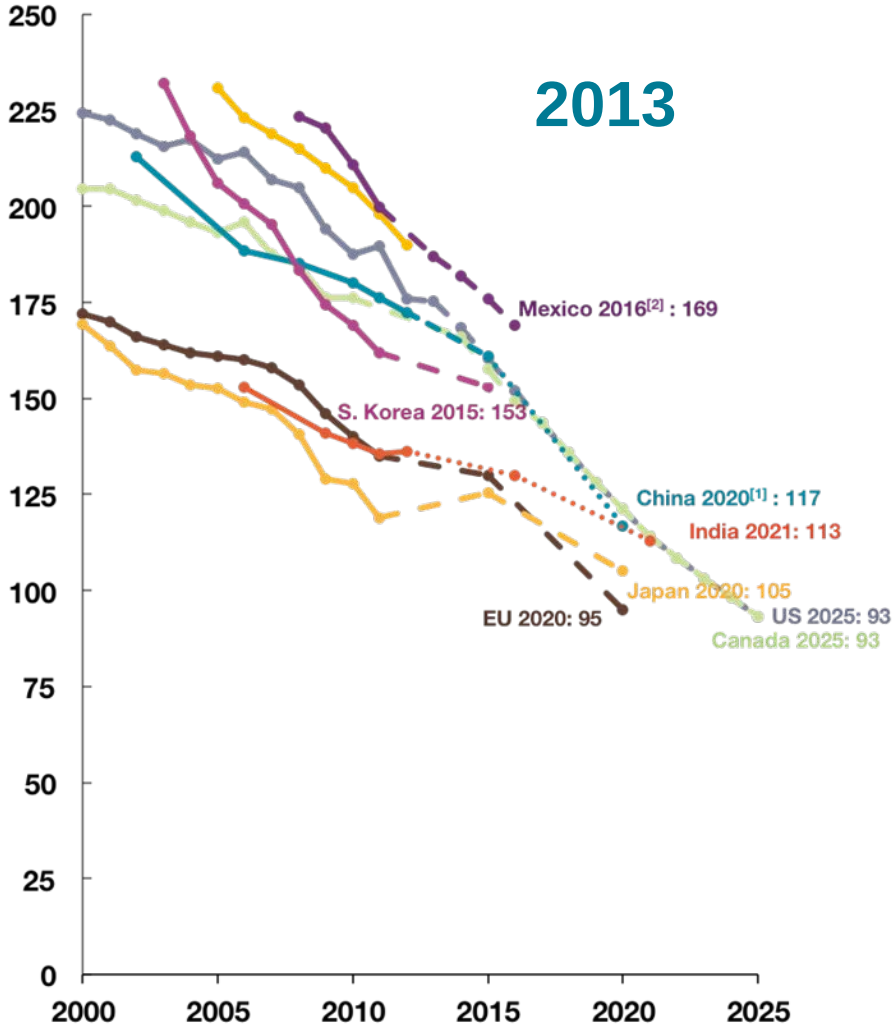


Fuel Economy Standards Offset by Growth in Developing World

- Fuel economy standards are impacting consumption– together with lower car ownership (e.g. Europe)
- However, developing world still showing strong growth

Cars CO_2 regulation in the world's key markets in 2009 and 2013





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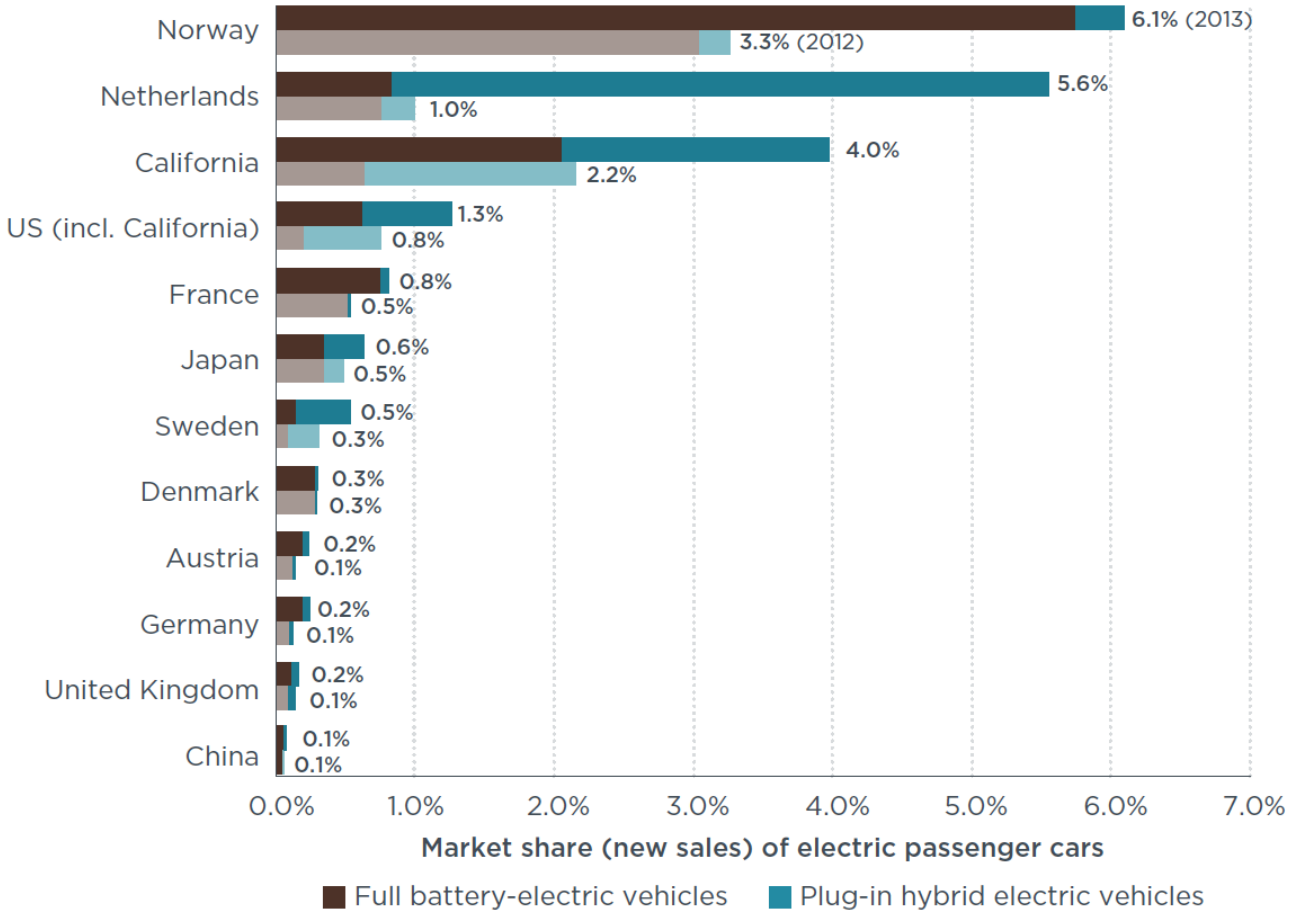
Some countries are quickly transitioning to low-carbon vehicles…

Market share of electric cars in comparison to total sales in 2012/13



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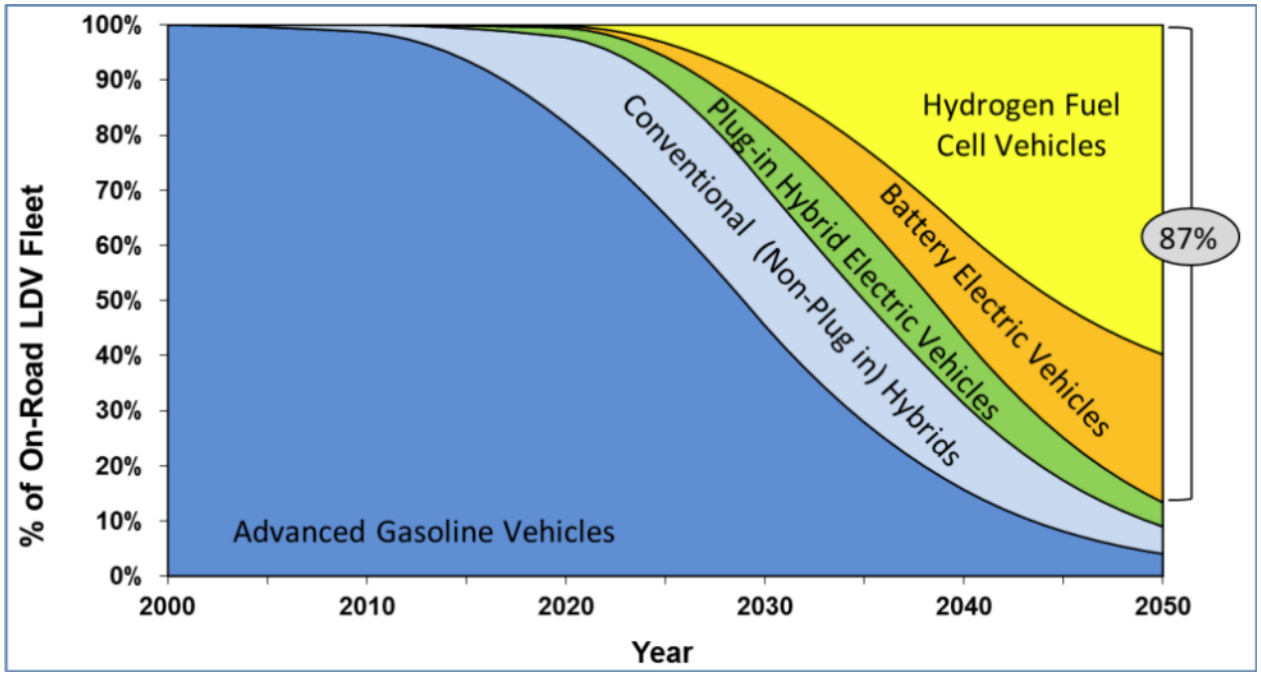
Electric Drive Penetration by 2050

LDV On-Road (all vehicles)



Source: California Air Resources Board

Scale and Duration of Needed Investment

- Net costs are incurred for about a decade
- Incentives are initially large but are generally unnecessary after 2025
- Caveats
  - Incentives need to be timed properly—not effective if technology is not ready
  - Estimates provided are for total cost, but no need for entire incremental cost to be financed or subsidized; manufacturers will absorb some portion for marketing purposes

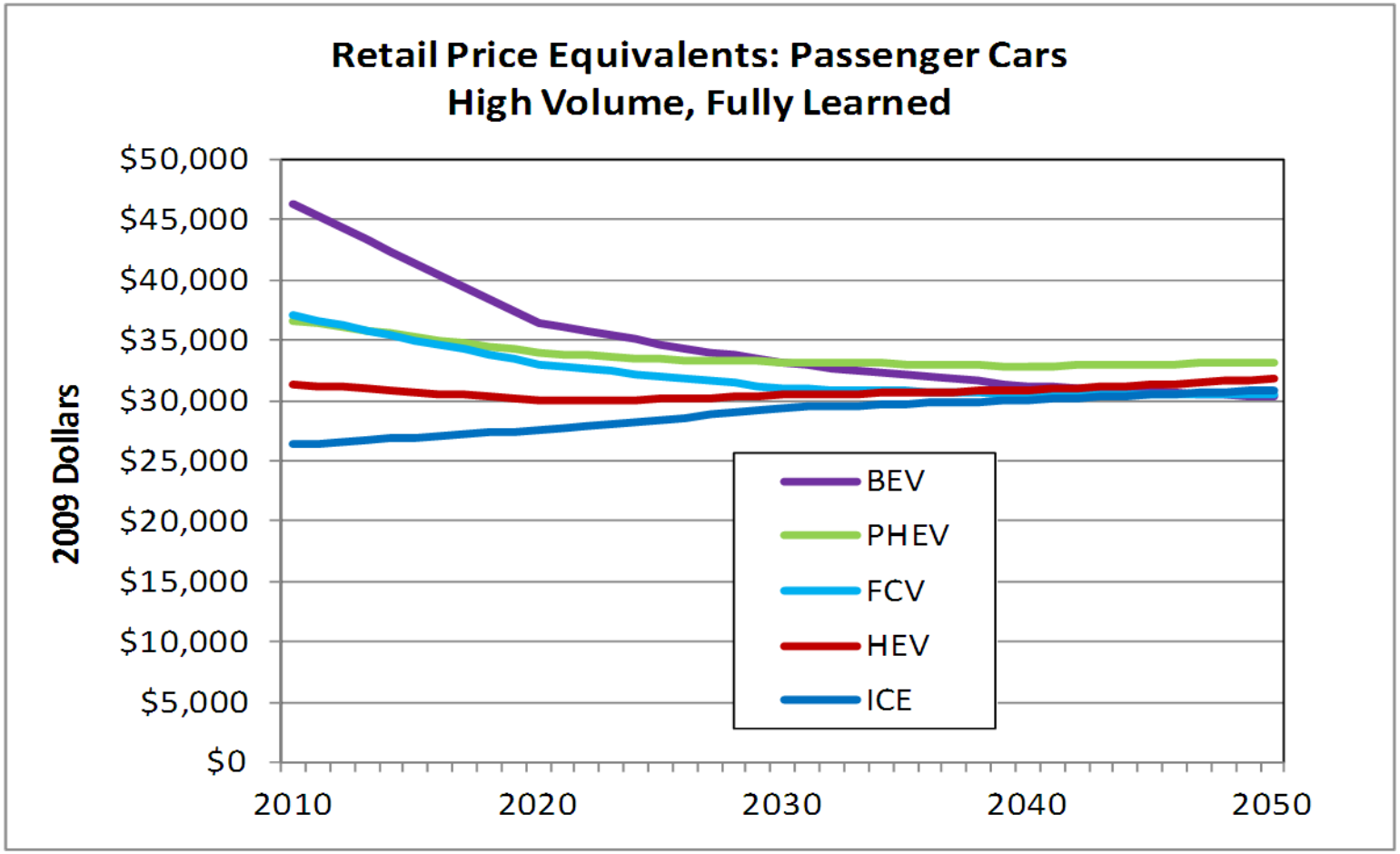
Deployment Estimates for FCV, BEV, PHEV

- In general, FCVs achieve higher deployment levels than BEVs
- Most scenarios result in mix of powertrains, but given adequate H_2 infrastructure larger share consistently goes to FCVs
- Without advance provision of H_2 infrastructure in California, FCV deployment is derailed nationwide
- PHEVs are transitional technology; do not achieve ongoing high deployment levels
- Petroleum prices do not strongly affect the pace of the transition
  - Less impact on consumer choice when all vehicles are highly efficient

Basis for Conclusions

- National Academy of Sciences Study: “Transitions to Alternative Vehicles and Fuels” March 2013
- Included new cost curves for existing and new drive trains prepared by John German (ICCT)
- Same model used by David Green for NAS and ICCT studies

Fully Learned, High-volume Costs for BEVs and FCVs Become Lower than PHEVs, HEVs And ICEs



Sustained Investment is Justified

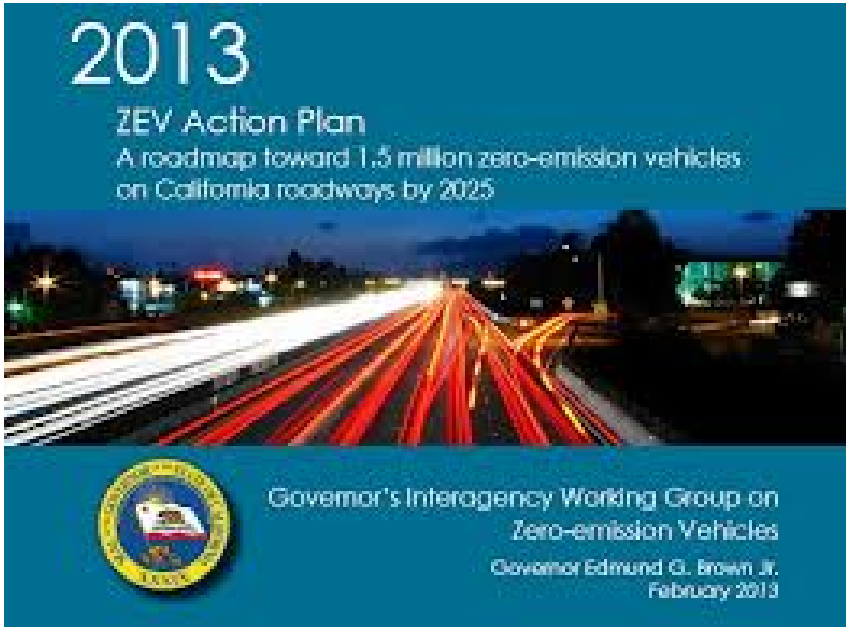
- Given expected technology progress and strong public policies, benefits of transition to electric drive appear to be about 10X greater than costs
- Additional investment is justified based on large benefits of achieving the transition
  - NPV of $190-290B for CA and Section 177 states

Efforts in California

- California has a well developed effort by most stakeholders

Governor's ZEV Action Plan

- Action Plan goals
  - Complete needed infrastructure and planning
  - Expand consumer awareness and demand
  - Transform fleets
  - Grow jobs and investment in the private sector



http://opr.ca.gov/docs/Governor's_Office_ZEV_Action_Plan_(02-13).pdf

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Plug-In Electric Vehicle Collaborative

- Multi-stakeholder effort
  - Automakers, utilities, government, NGOs, infrastructure providers, researchers
- Working to ensure strong and enduring transition to plug-in market
- Focusing on workplace and multi-unit dwelling charging

http://www.evcollaborative.org/

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CALIFORNIA PLUG-IN ELECTRIC VEHICLE COLLABORATIVE

California Fuel Cell Partnership

- Longstanding effort (since 1999)
- Automakers, energy companies, fuel cell technology providers, government
- Targeting infrastructure availability

http://cafcp.org/

Electric Drive Needs Clean Electricity

- Total decarbonization requires renewable energy for electricity for BEVs and H_2 for FCEVs
- California has 30% renewable requirement going to 50% by 2030
- Timing is right– future trend to distributed generation, self-generation and battery storage
- Potential to get off grid completely for BEVs
- Power to gas approach can provide renewable hydrogen and decarbonized natural gas supply

Summary

- Public health and climate concerns demand ultimate elimination of C and most combustion
- Transition will take time, and natural gas can play a role during this time
- Ultimate goal of e-drive with renewables is necessary and feasible
- Takes advantage of:
  - Reducing costs and increasing performance for BEVs and FCEVs
  - Trend to DG and self generation utilizing competitively available renewables
- While transition will require time and investment, it is viable, necessary and benefits are about 10x investment

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Thank You!

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