What the Future Holds for Automotive Powertrains

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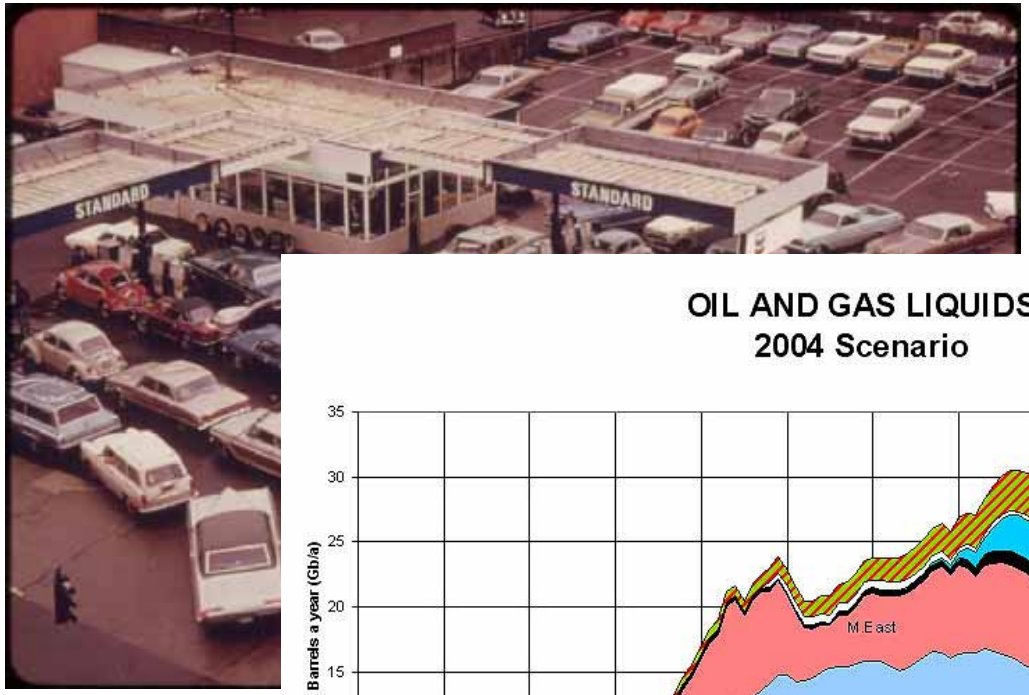
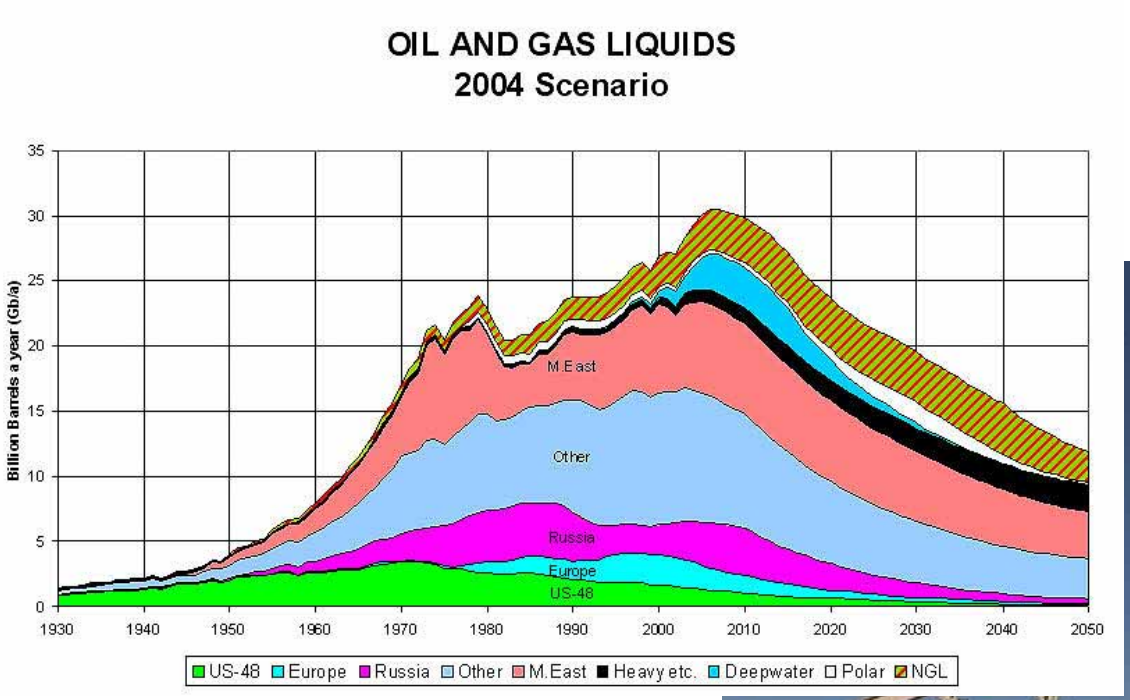
Outline

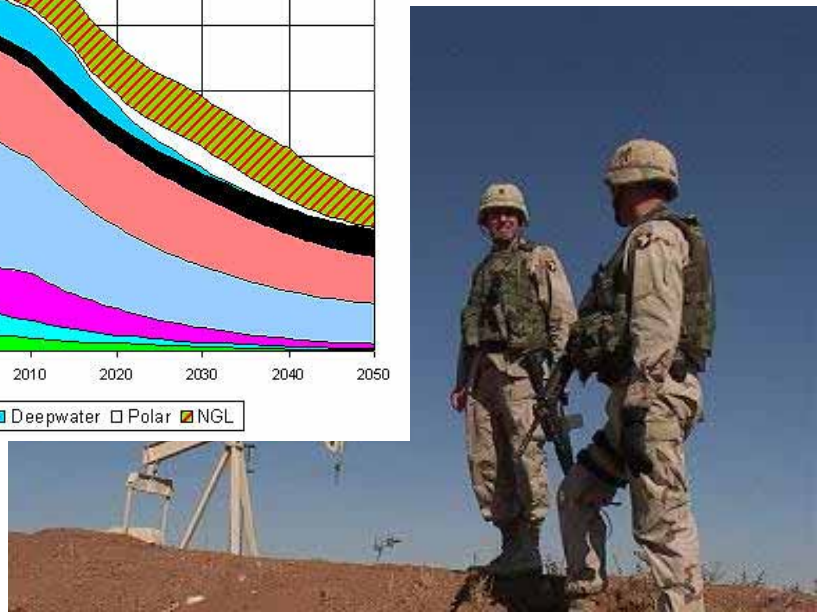
- How did we get here …… or where did all these regulations come from?
- Future powertrains already among us
  - Hybrids
  - Plug-in Vehicles
  - Fuel Cell Vehicles
- Alt fuel infrastructure
- The future

For Decades it was About Air Pollution

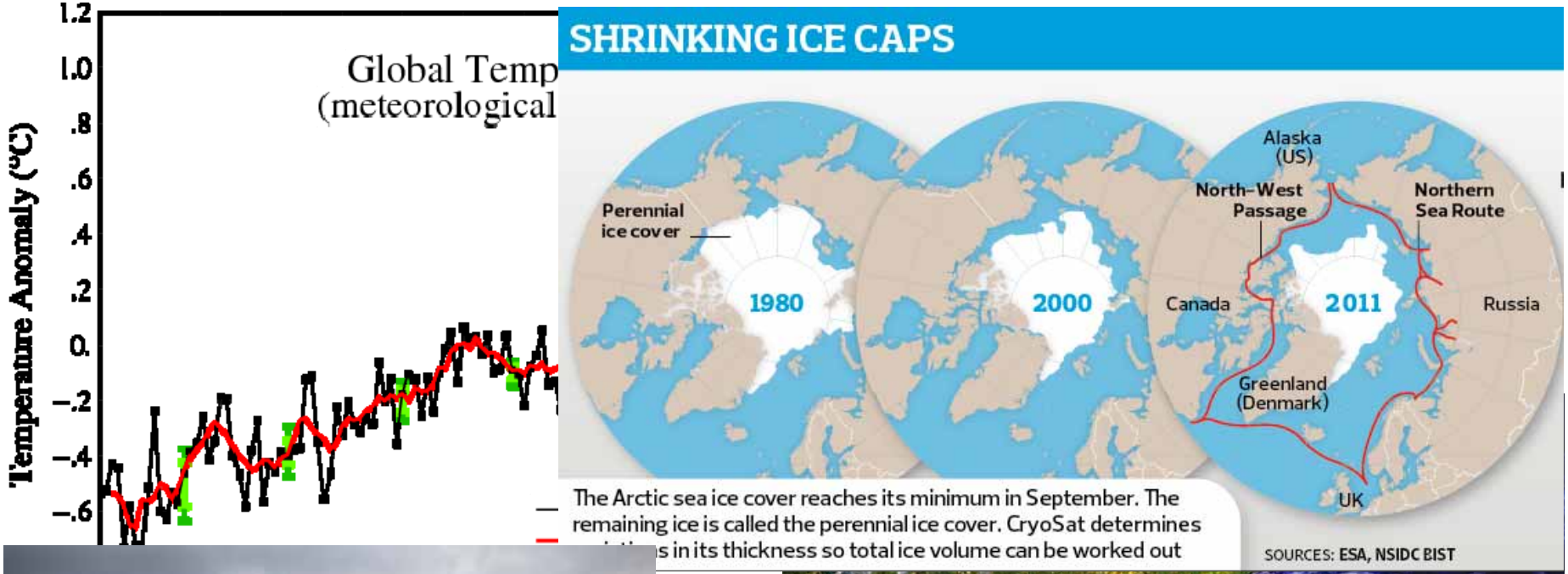
Then Energy Security







Now Green House Gases



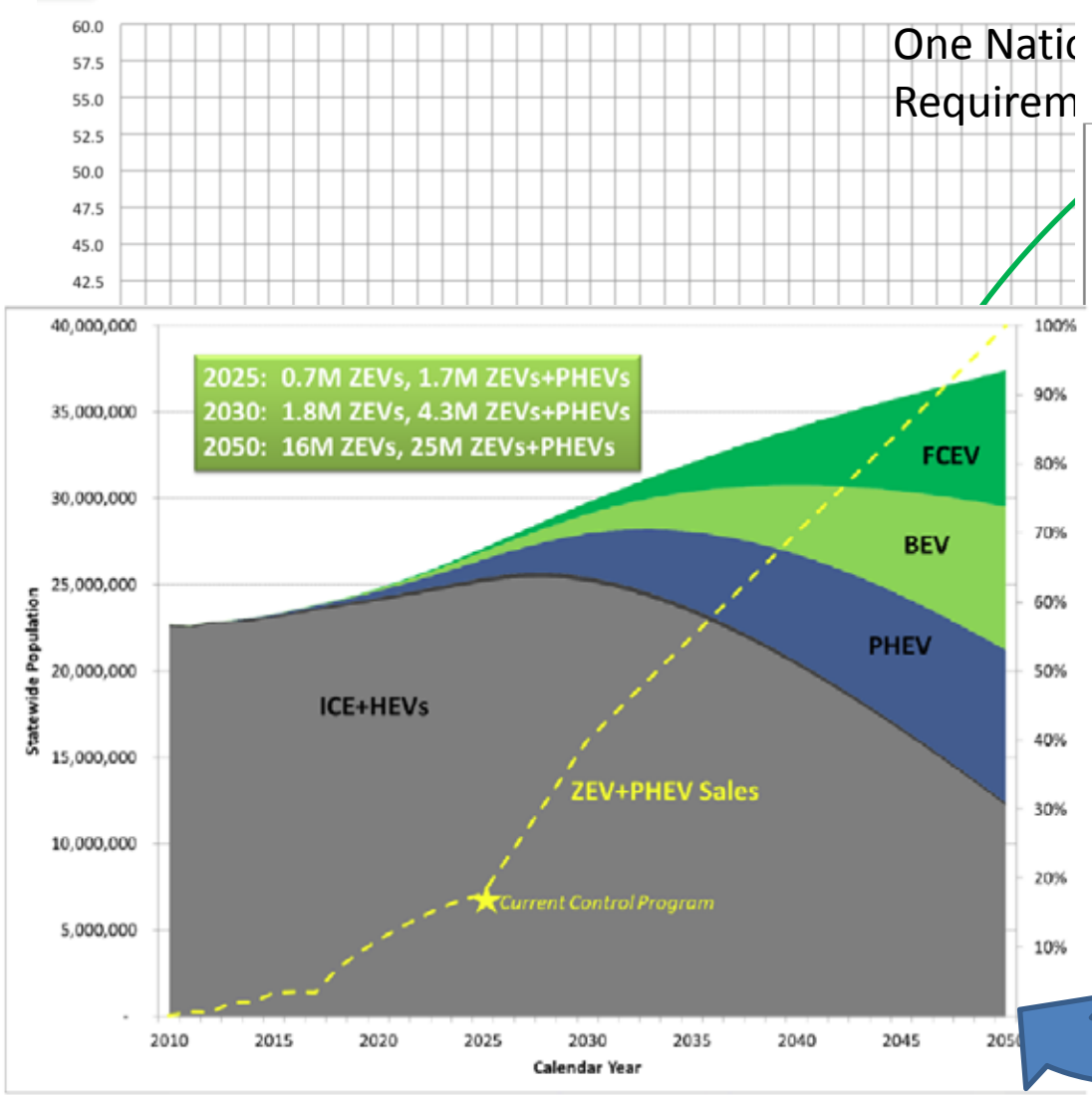
Resulting in a Plethora of Automotive Regulations

Type of Regulation	Federal		State	
	DOT/NHTSA	EPA	California	177 States
Tank to Wheel	Fuel Economy	GHG	GHG	
Well to Tank		RFS (Biofuel) RPS (Renewable Electricity)	LCFS	
Tech Mandate			Zero Emission Vehicle	Zero Emission Vehicle

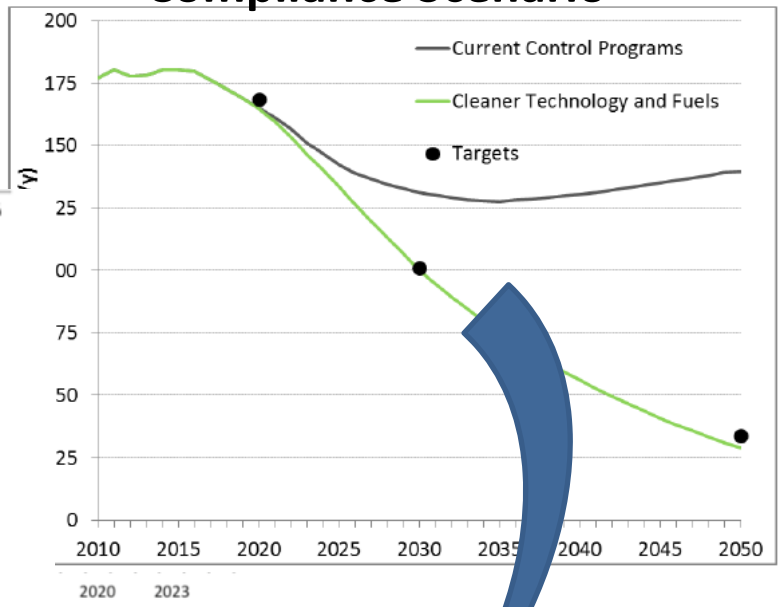
Upon request of industry, DOT, EPA & CA combined their separate requirements into a single One National Program (ONP) targeting a fleet average CO_2 of 163 g/mi by 2025.

What Does Compliance Look Like

CAFE Standards vs. Fleet Fuel Economy



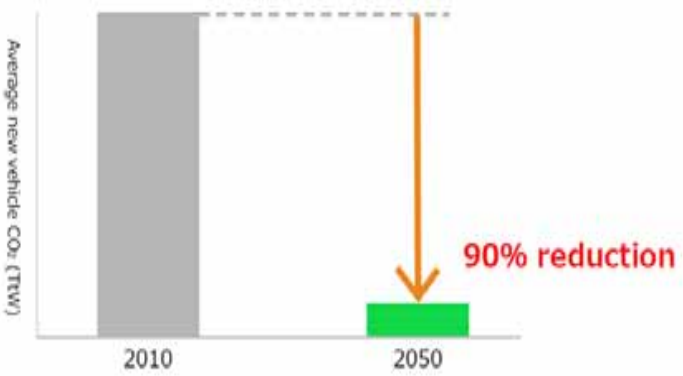
CA Air Resources Board CO_2 Compliance Scenario



Compliance requires a portfolio of technologies

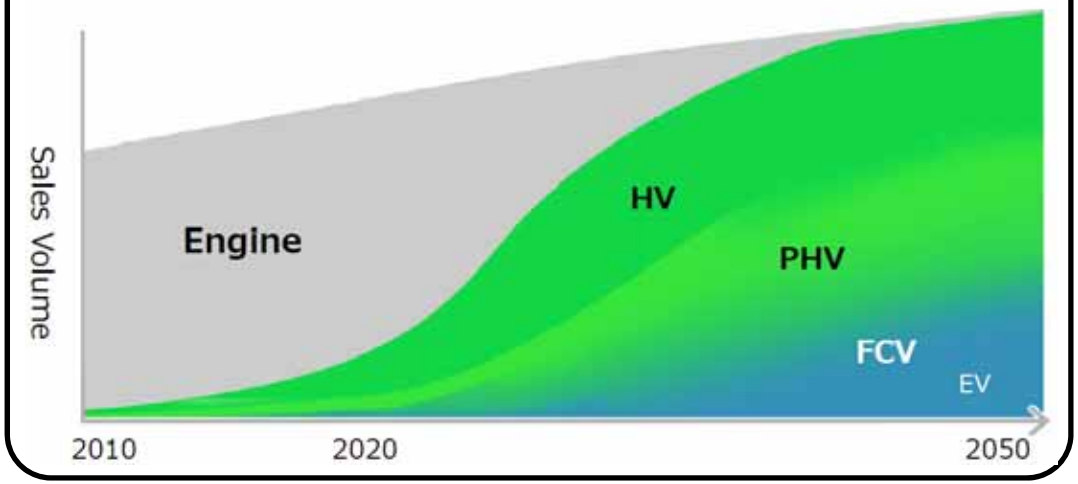
Toyota's Corporate Challenge

Reduce Tank-to-wheel CO_2 Emissions



* Compared to Toyota's 2010 global average

Powertrain Diversity will Expand



Hybrid is Step One and Toyota's Core Strategy

Toyota Prius
Up to 56 MPG

Toyota Prius V
42 MPG

Toyota Prius Plug-In
~120 MPGe/ ~55 MPG

Toyota Prius c
50 MPG

Toyota Camry Hybrid
41 MPG

Toyota TS-050 Hybrid
Li-Ion Battery

Toyota Mirai
67 MPGe

Toyota Avalon Hybrid
40 MPG

Lexus GS 450h
31 MPG

Lexus CT 200h
42 MPG

Lexus ES 300h
39 MPG

Lexus LS600hL
20 MPG

Toyota RAV4 Hybrid
33 MPG

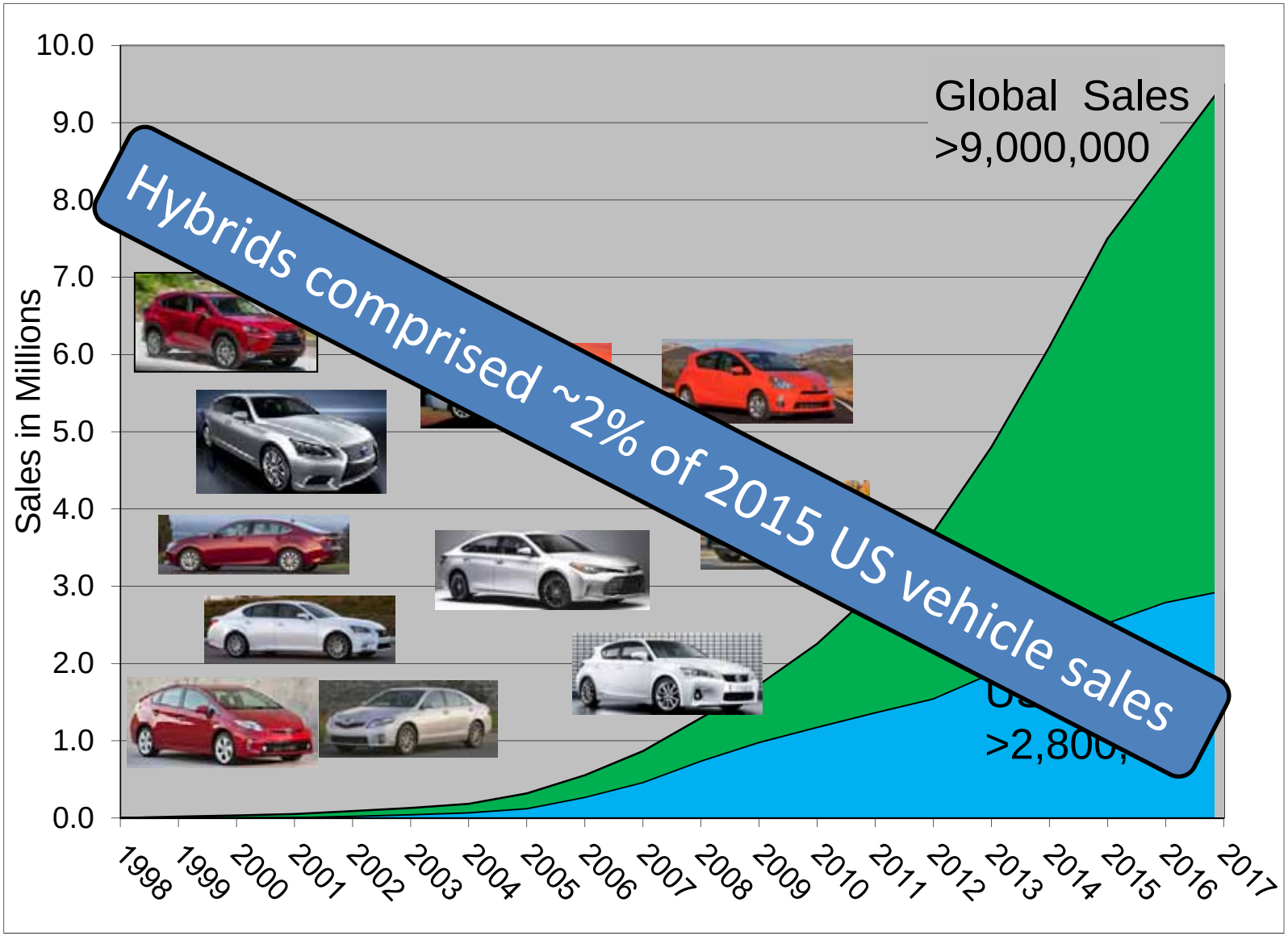
Highlander Hybrid
28 MPG

Lexus NX 300h
33 MPG

Lexus RX 450h
30 MPG

Fuel Economy – EPA MPG (Combined); Actual mileage will vary.

Cumulative Toyota Hybrid Sales



A Portfolio of Technologies is Needed

Hydrogen Fuel Cell EV (Step three)

Plug-in Hybrid EV (Step two)

Hybrid is Toyota's Core Technology

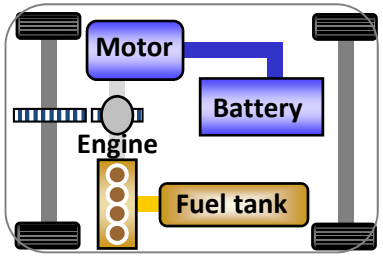
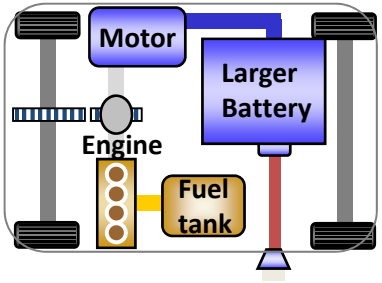
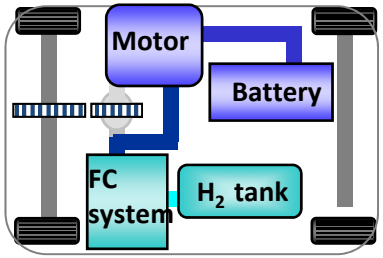








Technology Kinship

Fuel		Hybrid		CO_2 Emissions
Gasoline	→			Low (up to 58 mpg city)
Gasoline Electricity	→	**Plug-in Hybrid** 		Lower (up to 25 mi all electric range & 55 mpg city)
Hydrogen	→	**Hydrogen Fuel Cell** 		Zero Tailpipe (Only water vapor)

One Size / Technology Does Not Fit All

2017 Mirai Fuel Cell Electric Vehicle Benefits

Energy Diversity

Hydrogen generated from variety of sources

Zero Emissions

Zero tailpipe emissions

Sustainable

When hydrogen is produced from low/no carbon sources

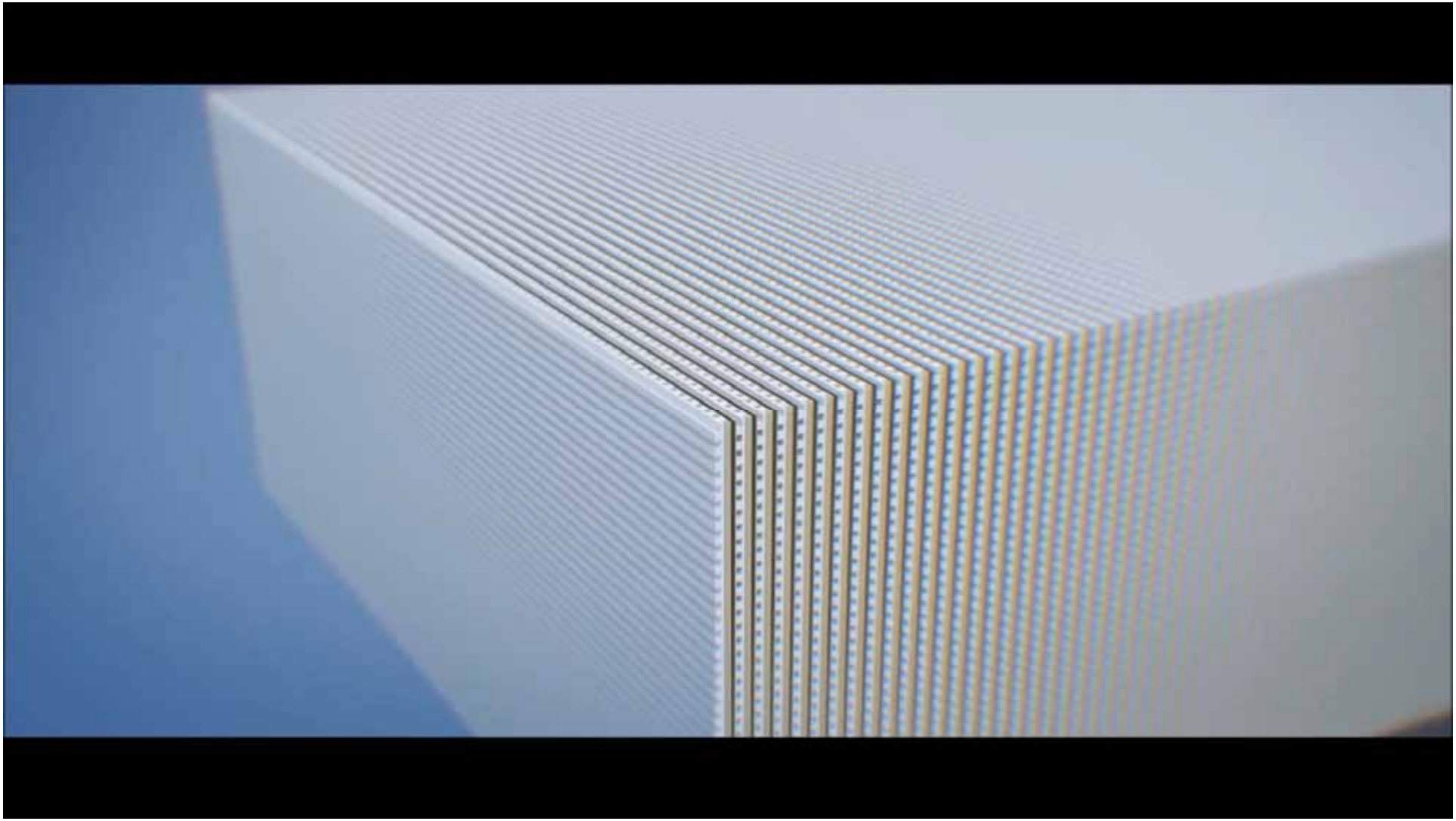
Fun to Drive

- High torque electric drive
- Low CG for nimble handling

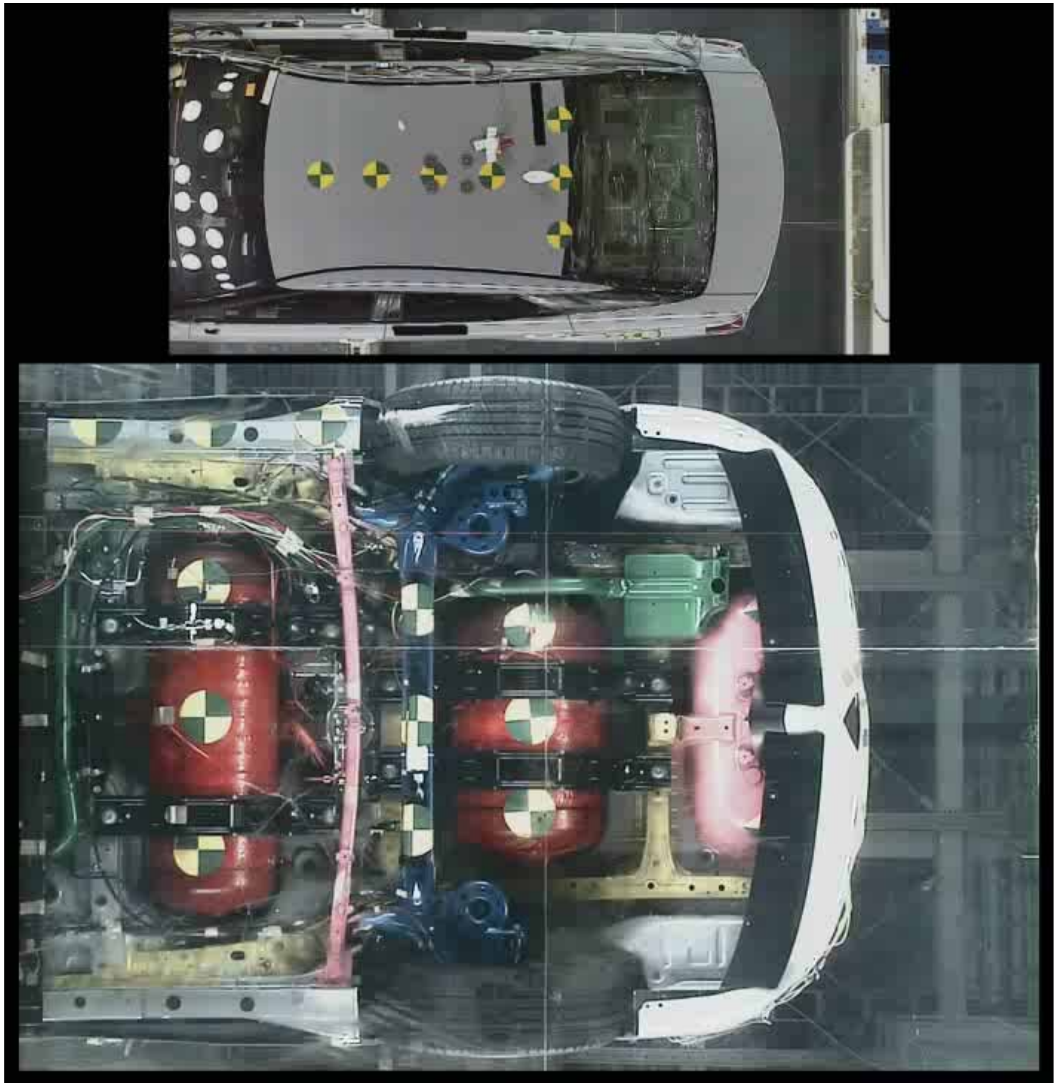
Attributes

- + 300 mile range
- 3-5 minute refueling

How a PEM Fuel Cell Works



Fuel Tank Safety



Zero Emission Vehicle Attributes Vary by Technology

Attribute	Battery EV	Fuel Cell EV
Vehicle Availability	Many nationwide	CA & NE (in 2017)
Fuel Price	Varies – free to ???	Free for 3 yrs ($10-$12/kg)
Vehicle Price	$30K - +$135K	$57,500 (Mirai)
Incentives	Up to $7500	Up to $8000 (Expires 12/31/16)
Range	100 – 315 miles	265 – 366 miles
Refueling Speed	~3 mi/min (fastcharger)	~ 100 mi/min refueling
Infrastructure Availability	Inconsistent	Limited in CA & NE in 2017
Renewable Fuel Potential	Possible	Possible
Cold Weather Performance	Degraded	Little impact

H_2 Station Status

- 23 public H_2 stations open in CA. Expecting ~25 by years end.
- 12 stations in the Northeast (NJ, NY, CT, RI & MA)

Northern California

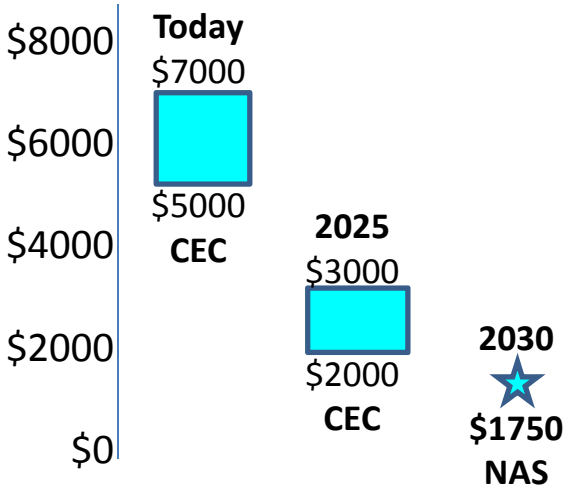
Southern California

Plug-in Infrastructure

- ~15,000 Public charging stations
- ~38,500 Chargers

ZEV Infrastructure Cost per Vehicle

Hydrogen Infrastructure

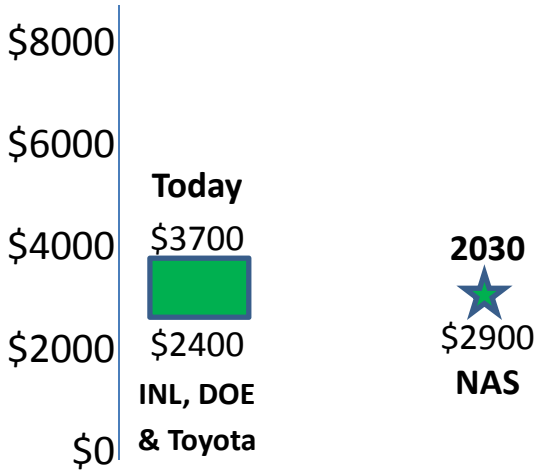


CEC Est. Assumes

- 75% utilization
- 67 mpge today, 85 mpge in 2025

CEC = CA Energy Commission,
NAS = National Academies of Science

Battery Infrastructure (Home Level 2 + share of public)



Assumes

- Capital & Install cost
- Cost burden/EV = 10-40% of single public charger

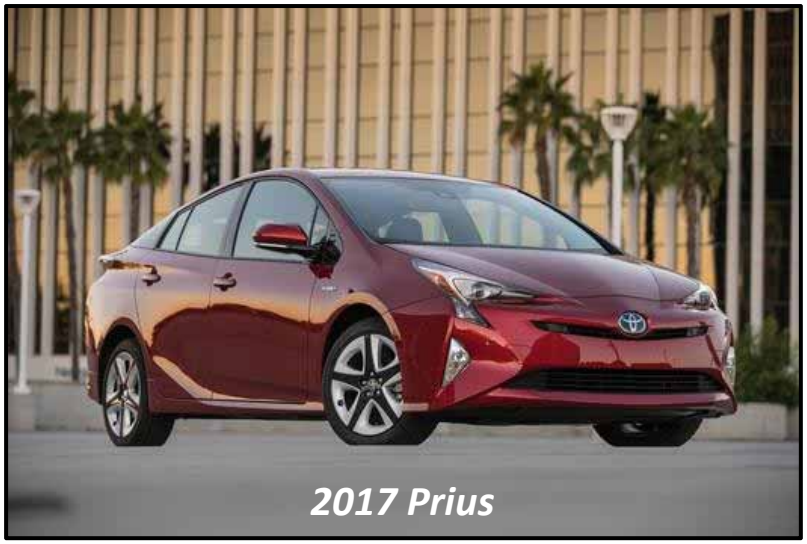
INL=Idaho National Lab

Mirai Status

- Over 880 Mirai delivered in CA since introduction (Oct 2015)
  - Retail, fleet & employee purchase/lease
  - 2016 models sold out
- Enhanced pricing on 2017 models
  - Lease - $349/mo for 36 months, $2499 due at signing (12,000 mi/yr)
  - Purchase - $57,500, 0% for 60 months & $7500 purchase support
  - Continues to include three years' worth of complimentary fuel
- Sales begin in NE states late next year
- Targeting 3000 deliveries by end of 2017

Future

- A transition to electric drive & renewable fuels will be required to meet long-term climate goals
- A portfolio of technologies is needed to meet:
  - Customer needs & wants
  - Achieve compliance volumes
- Consumers, not technology, are the greatest challenge
- Autonomous and shared use vehicles will impact this transition. In what way is TBD.



2017 Prius

2017 RAV4 Hybrid

Thank You For Your Attention

2017 Avalon Hybrid

2017 Mirai