

PEV Markets and Users, Lessons Learned

Learning from the California Experience Alternative Fuels, Vehicles, and Infrastructure

March 22, 2017

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PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER

of the Institute of Transportation Studies



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Dahlia Garas, Program Director

Dr. Ken Kurani, Consumer Studies

Dr. Gil Tal, PEV Markets, Travel Behavior

Dr. Mike Nicholas, PEV Use Patterns & Infrastructure Needs

Dr. Alan Jenn, PEV Regulations & Incentive Structures in USA

Dr. Scott Hardman, Europe PEV Markets

Dr. Angela Sanguinetti, Energy Feedback Systems

20+ affiliated Graduate and Undergraduate Students

4 Research Staff, programmers

The Plug-in Hybrid & Electric Vehicle (PH&EV) Research Center launched in early 2007.

The Center collaborates closely with California utilities, automakers, regulators, and other research institutions on research aimed at developing a sustainable market for plug-in vehicles.





ITS UC DAVIS INSTITUTE OF TRANSPORTATION STUDIES

ENERGY INSTITUTE



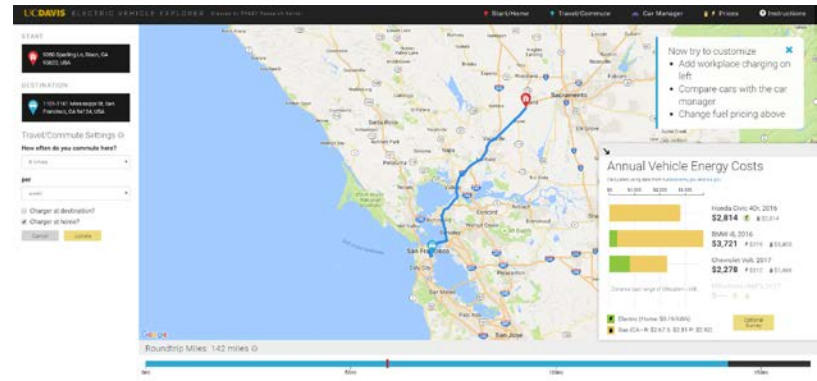
SUSTAINABLE
TRANSPORTATION
ENERGY PATHWAYS

PLUG-IN HYBRID &
ELECTRIC VEHICLE
RESEARCH CENTER

CHINA CENTER FOR
ENERGY AND
TRANSPORTATION

POLICY INSTITUTE FOR
ENERGY,
ENVIRONMENT AND
THE ECONOMY

NATIONAL CENTER
FOR SUSTAINABLE
TRANSPORTATION

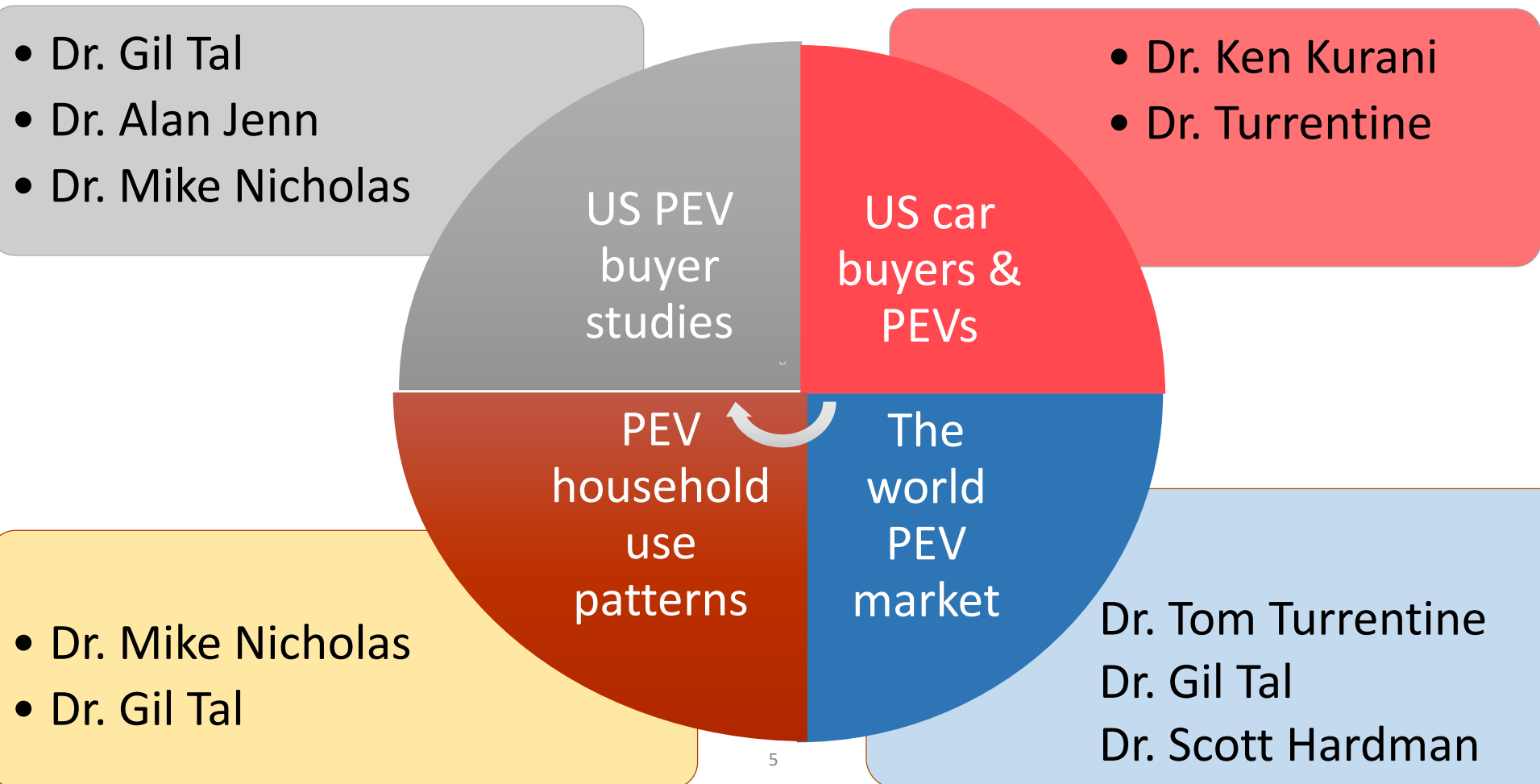


2015-16 SUPPORTERS



PH&EV Center “Roll-out & ramp-up research”

Studying the interaction of policy, technology, energy systems and consumer culture



A few of our past PEV projects

- *1991 Household PEV purchase interest & range estimation interviews (PIREG)*
- 1991 Rose Bowl drive test of electric, natural gas, methanol fueled vehicles, 10 focus groups
- *1994 UCD survey of California households on alternative fuels*
- 1997 Neighborhood electric vehicle trials in Davis
- 2002 Nissan Hypermini and Toyota Fuel-cell Vehicle trials in Davis
- 2007-13 PH&EV center funded by the California Energy Commission
- 2008-14 Plug in Conferences series with EPRI
- 2008-9 ARB funded test of PHEVs in California households (Dr. Kurani)
- 2010-11 BMW MINI E field study (Dr. Turrentine)
- 2011-13 Chrysler PHEV pick-up field study
- *2011-13 San Diego PEV Infrastructure Study (surveys & focus groups)*
- *2014-15 Surveys of future market with 10 MOU states (Dr Kurani)*
- *2014 Survey with EPRI of PEV buyers in 13 states*
- *2015 Survey of 5000 California PEV drivers*
- 2015-17 ARB / CEC data acquisition of 240 households (Nicholas)
- *2015 Survey of “used” PEV buyers (Tal)*
- *2016 Survey of 5000 California PEV drivers (Tal)*
- *2016 Survey of 2000 California car buyers (Kurani)*

PH&EV Center Data Collection



24,000 New car Buyers surveys

- 2010-2016
- 12 US states
- Focus groups
- Interviews



27,000 Electric car buyer surveys

- 2010-2016
- 12 US states, China, Germany
- Used PEV buyers
- Focus groups and Interviews



PEV and ICE on road data collection

- OBD data 264+ vehicles over a year
- GPS data 27,000 vehicles over 2.5 years
- 4,000 Vehicles second by second dataset for California

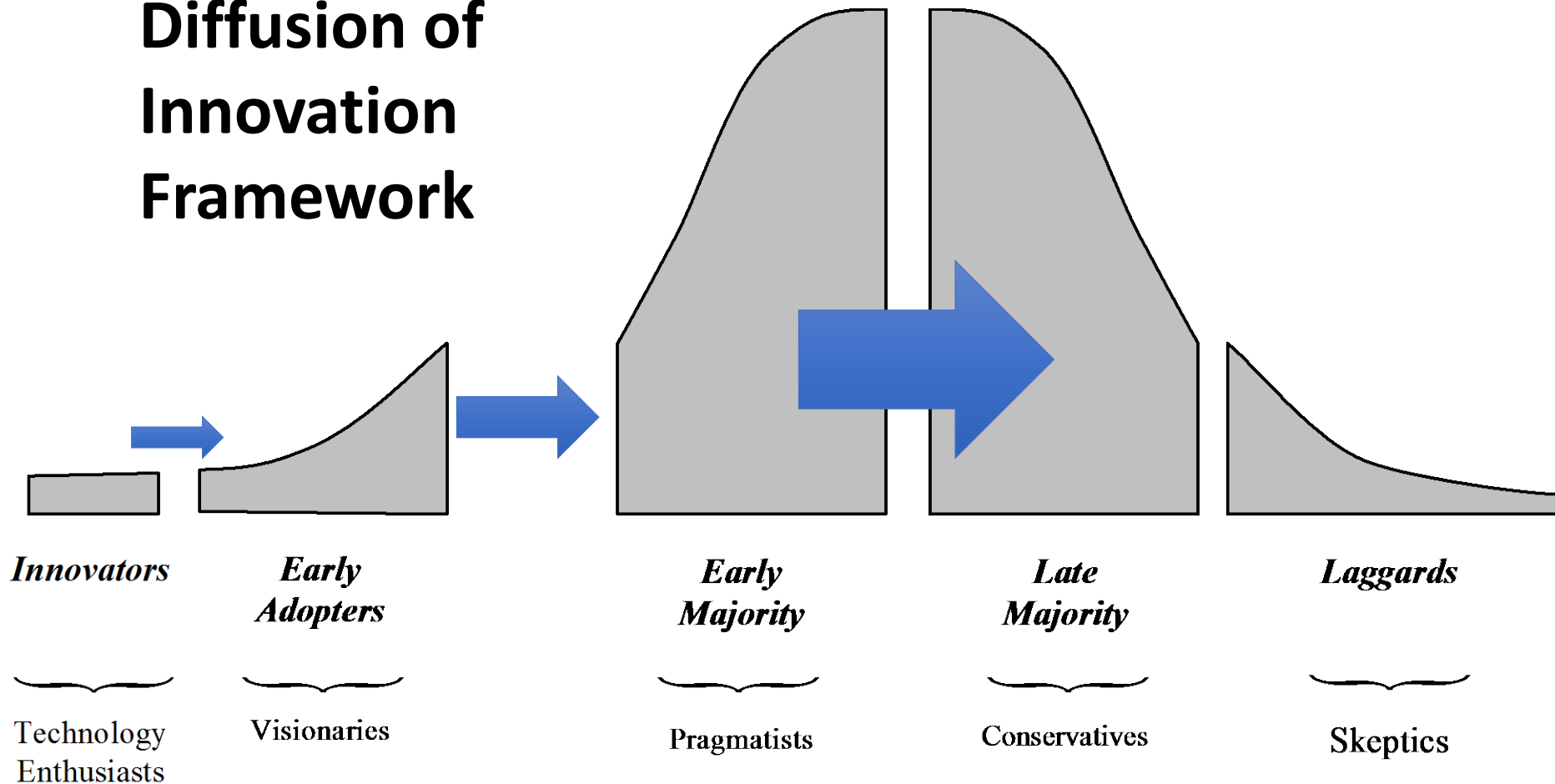


US Infrastructure Charging data 2012-2016

- 9,000,000 Level 2 charging events
- 1,300,000 DC fast charging events
- Vehicle reported charging events

And a market is developing, with early buyers influencing the next segment of buyers

Diffusion of Innovation Framework



origins in anthropology & formalized in rural sociology, now popular in high tech marketing

4th generation
3 - 4 million???

Curve based on rollout of HEVs in Japan & California 1997-2015

3rd generation:
batteries, vehicles, “core market**”**
800,000 PEVS

2nd generation
batteries, vehicles, “followers**”**
500,000 PEVs

1st generation
policy, vehicles, “innovators**” & infrastructure**
200,000 PEVs

California 2025 ZEV goal = 15% / 1.5 million BEVs, FCV & PHEVs



1-2%

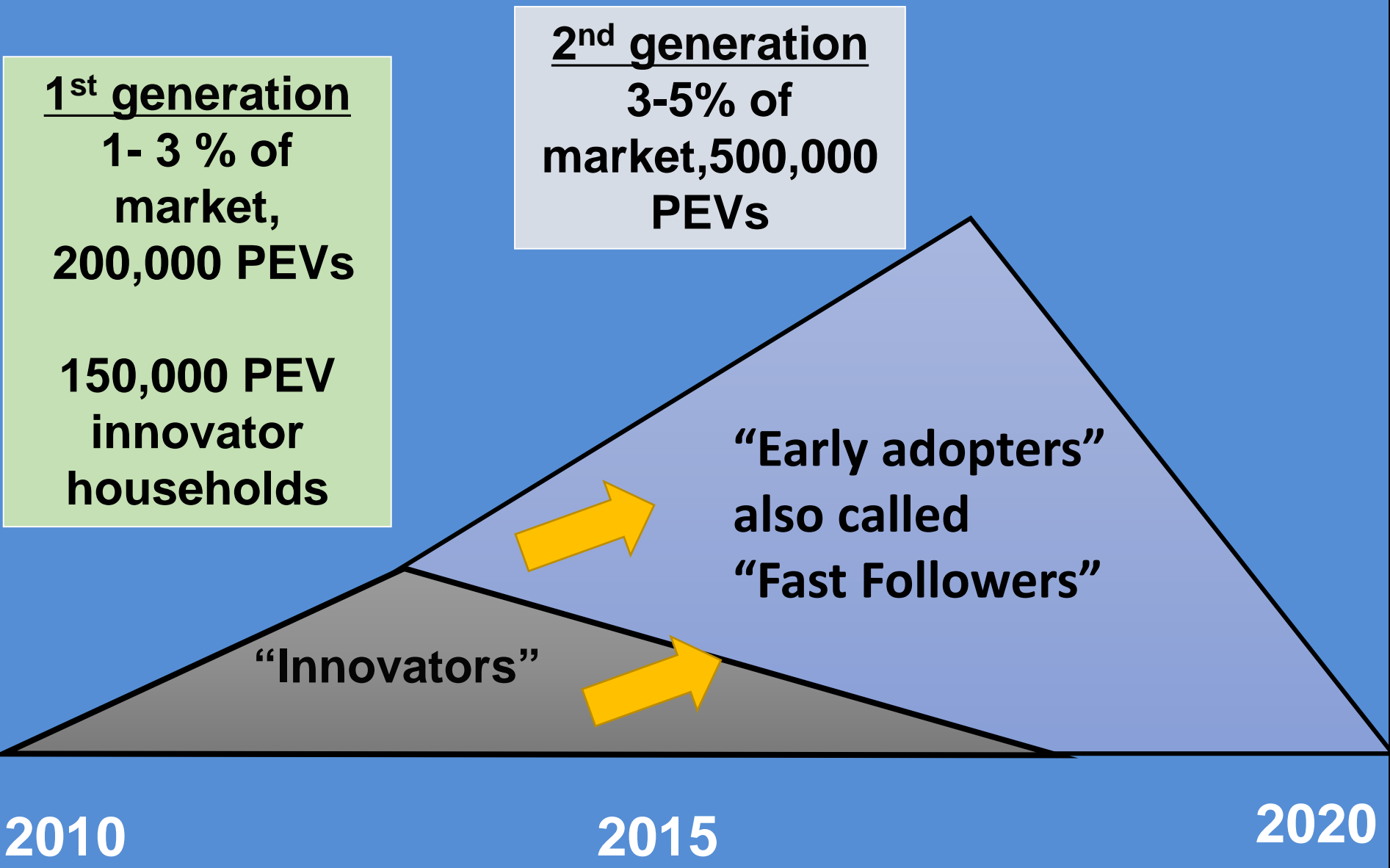
3-5% of market

Early core market:
6-15%

Main market
15-25%

700 300 200 150 Lithium pack prices per

The main market task is to assist this diffusion process



1st generation

1- 3 % of market,
200,000 PEVs

150,000 PEV
innovator
households

2nd generation

3-5% of
market, 500,000
PEVs

"Innovators"

"Early adopters"
also called
"Fast Followers"

2010

2015

2020

Innovators from 1st Generation market will be buying some portion of the 2nd Generation market – perhaps 100,000

1st generation
1- 3 % of market,
200,000 PEVs

2nd generation
3-5% of market,
500,000 new PEVs

And a growing used PEV market

150,000 PEV innovator households

“Early adopters”
also called
“Fast Followers”

“Innovators”

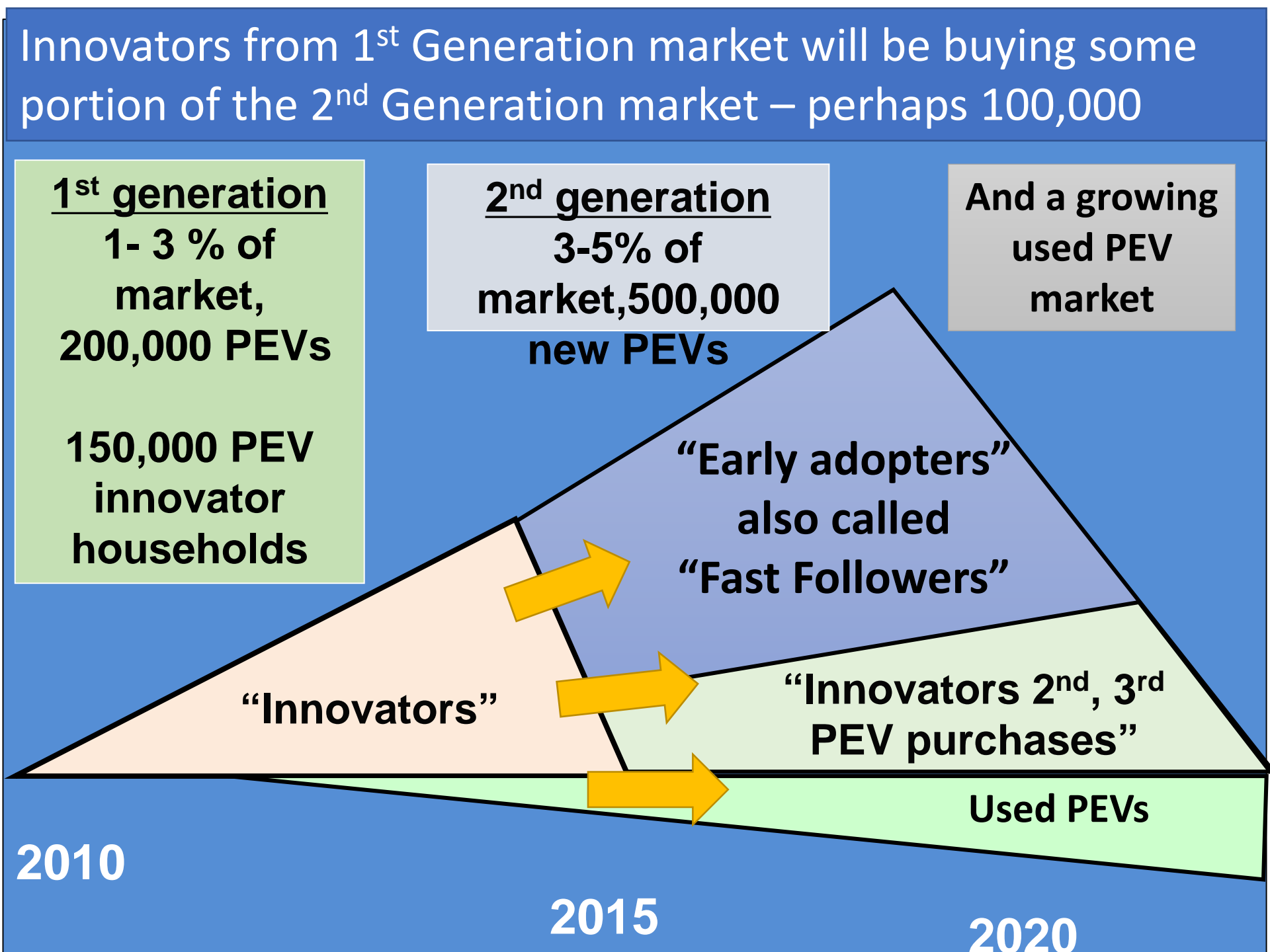
“Innovators 2nd, 3rd
PEV purchases”

Used PEVs

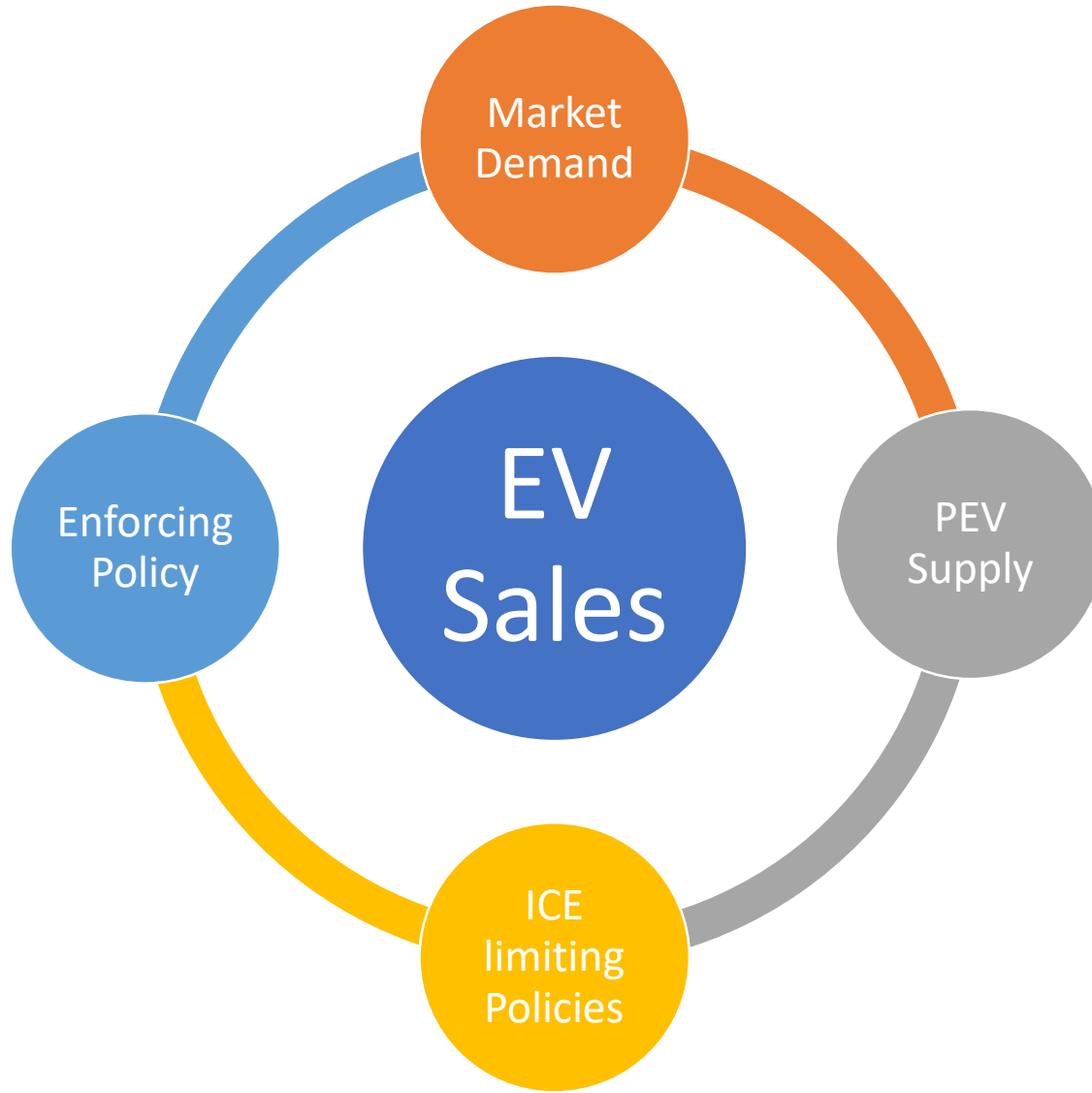
2010

2015

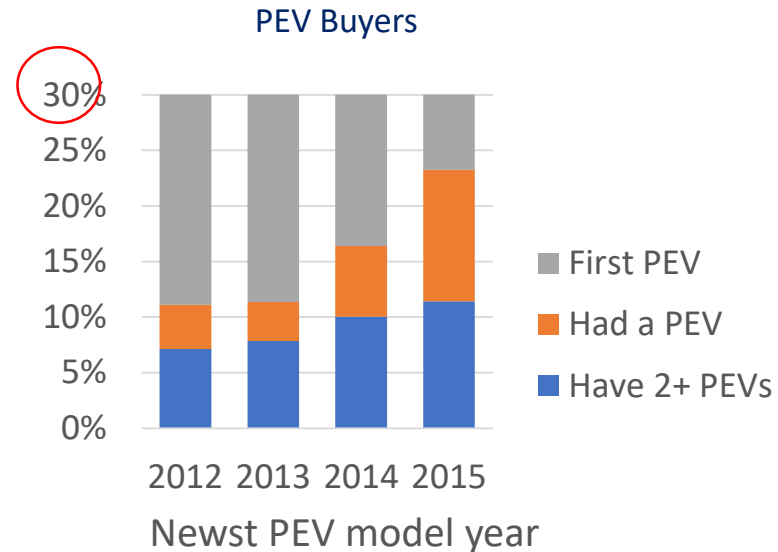
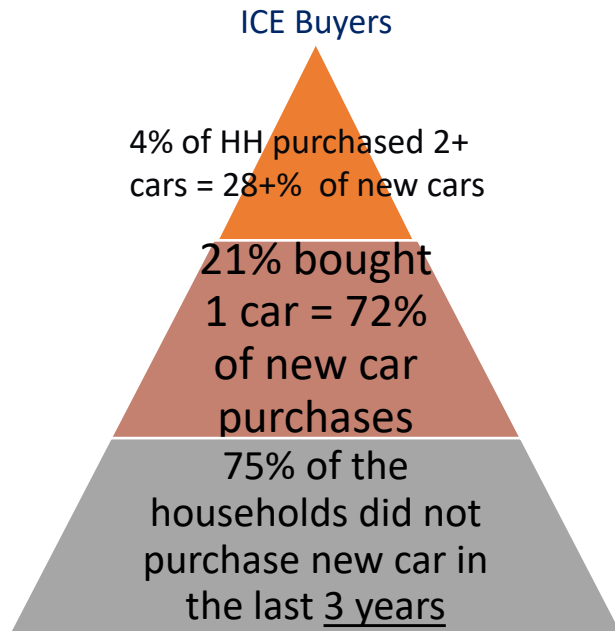
2020



EV Market Perspectives

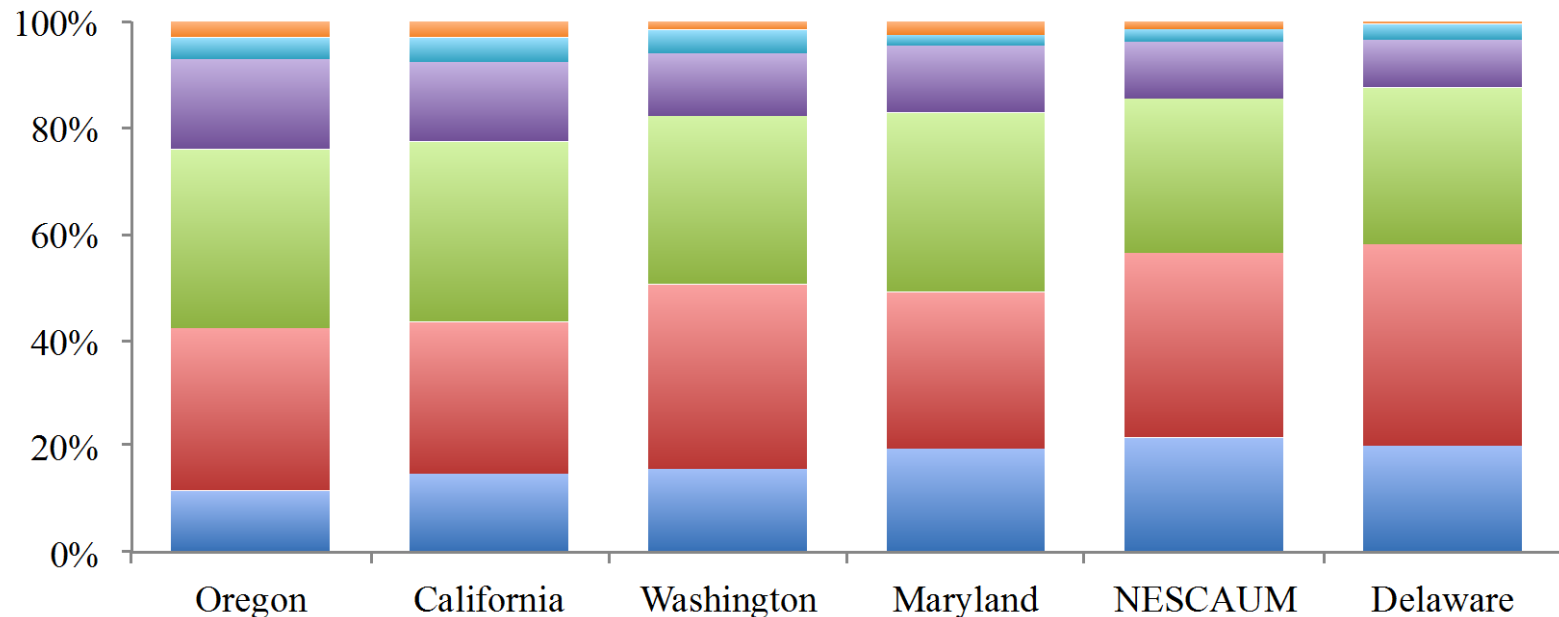


NEW CAR BUYERS AND PEV BUYERS: PEV BUYERS ARE COMING BACK FOR SECONDS



- 4% of the households are responsible for almost one third of the market over the last 3 years 2010-2012
- Up to 15% of PEV buyers are on their second PEV

Have you considered a vehicle that runs on electricity for your household?



- I (we) already have a vehicle powered by electricity
- Shopped for an electric vehicle, including a visit to at least one dealership to test drive
- Started to gather some information, but haven't really gotten serious yet
- The idea has occurred, but no real steps have been taken to shop for one
- I (we) have not considered buying a vehicle that runs on electricity but maybe some day we will
- I (we) have not and would not consider buying a vehicle that runs on electricity

Population estimates of new car buyers with positive PHEV, BEV, or FCEV valuation

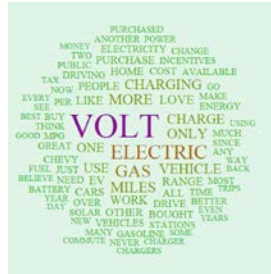
	Occupied housing units x 1,000 (US Census)	Vehicle available (ACS)	% buy new (est. from past UCD surveys)	% Design PEV or FCEV Game 3	Population Estimate x 1,000
Oregon	1,523	92%	33%	38.7%	181
California	12,617	92%	33%	38.1%	1,476
Washington	2,645	93%	33%	35.9%	295
Maryland	2,156	91%	33%	31.4%	204
Delaware	339	94%	33%	28.0%	30
NESCAUM	16,078	81%	33%	26.6%	1,151
Total					3,337

New Car Buyers Perspectives

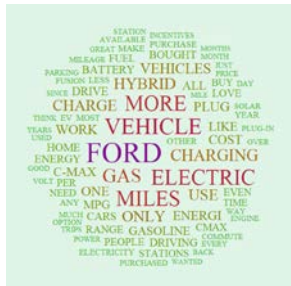
- Most households with negative ZEV valuation have yet to ask themselves, “Is a PEV right for my household?”
- The importance of awareness, knowledge, Promotional policies that mitigate up-front costs still leave the “new-technology averse” with an expensive unknown.
- The effects of incentives Among those who did not design a PEV or FCEV is very low.
- Those with positive ZEV valuations have multiple motivations, Everyone highly motivated by fuel cost savings is highly motivated by something else, too.
- Despite low awareness, knowledge, experience, and prior consideration, 24% to 39% of respondents design a PEV or FCEV as their next new vehicle.

Plug in Electric Vehicle (PEV) Purchase Motivations

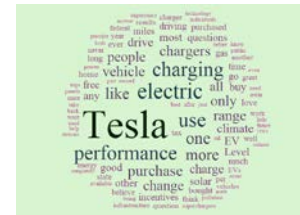
Not
using
gas



MPG



Performance



Range
Electric
experience

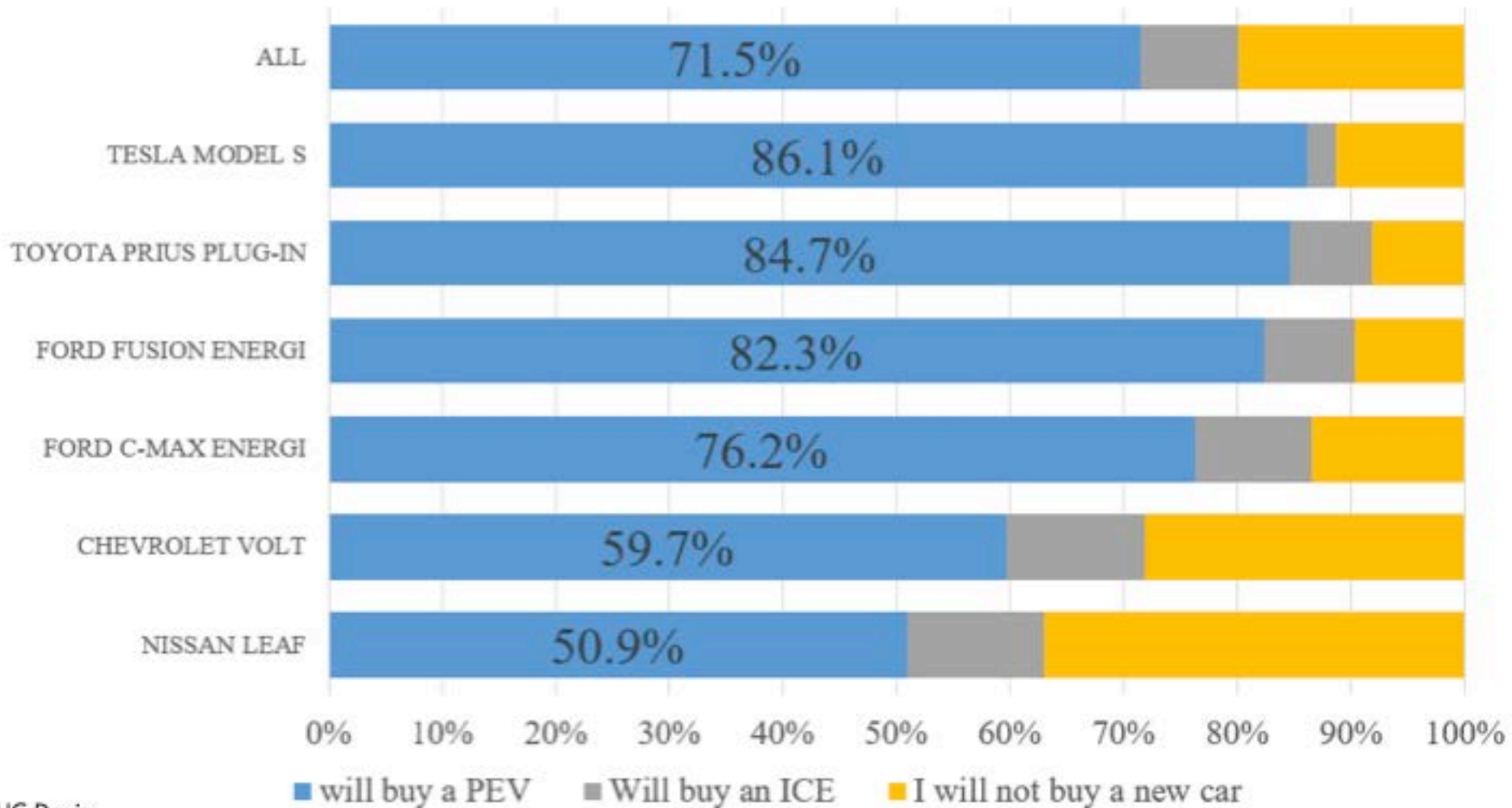


UCDAVIS

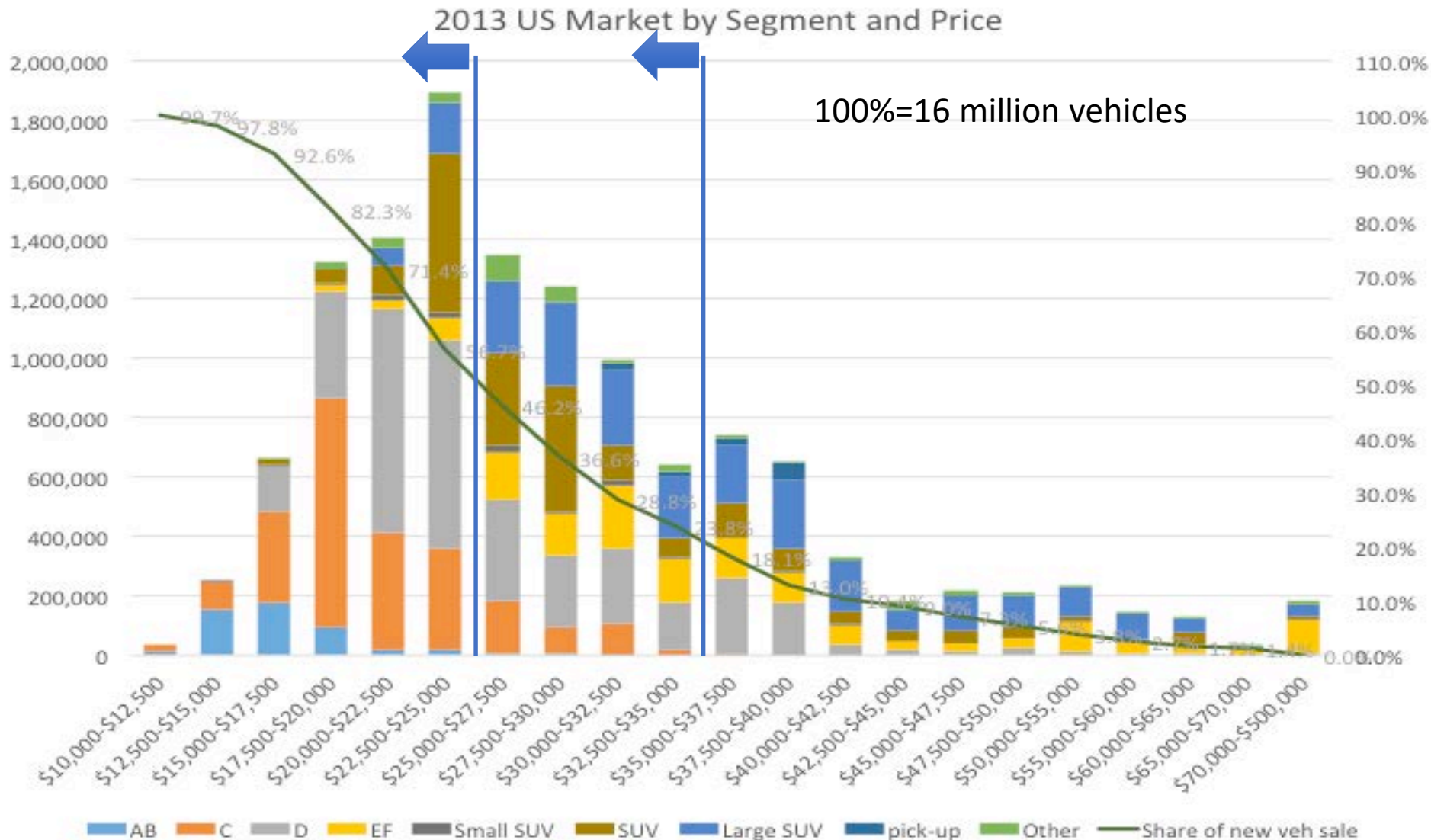
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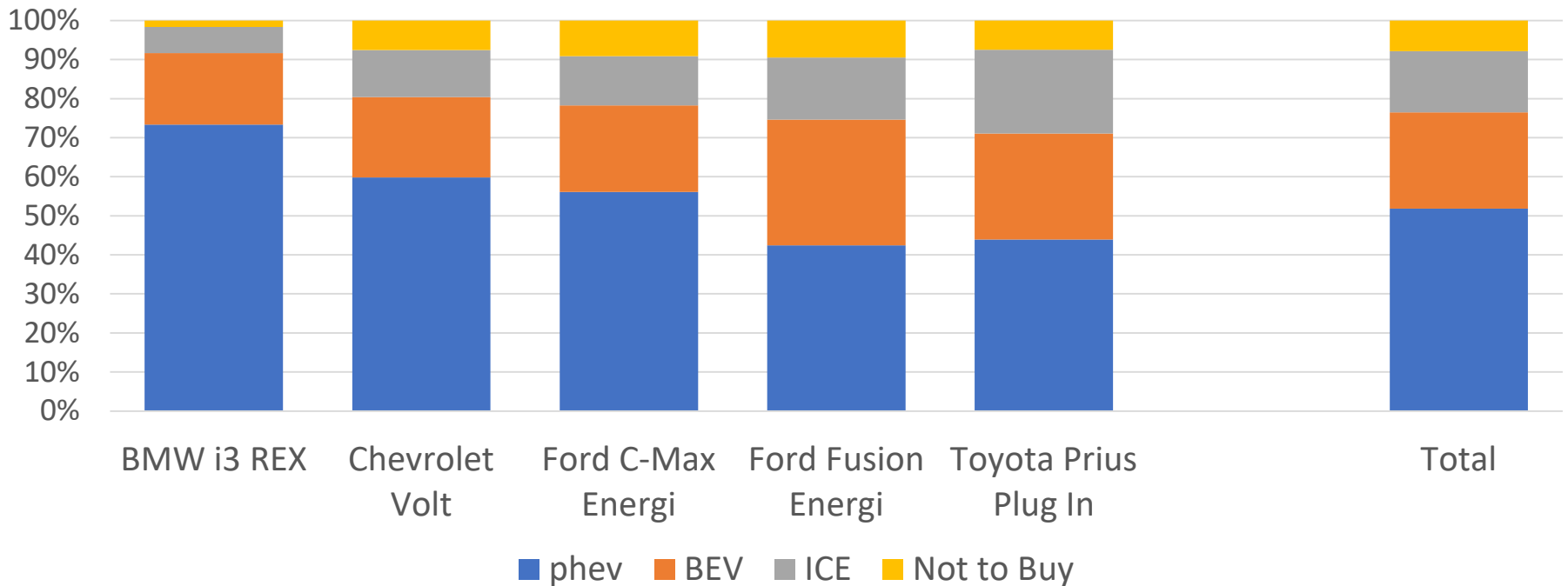
Vehicle Choice Without the Federal Tax Credit



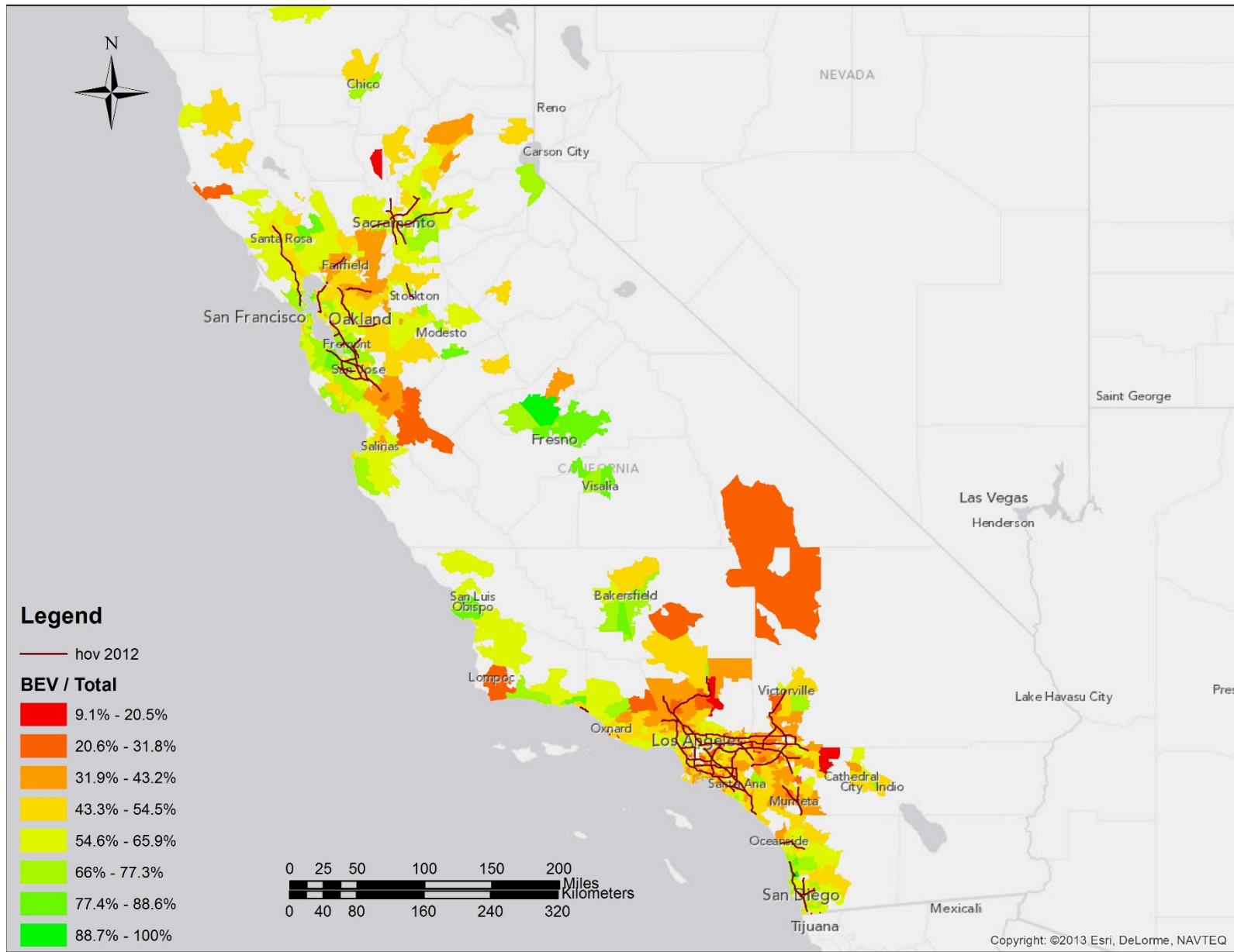
The Impact of \$1000 price Change on the Potential Market



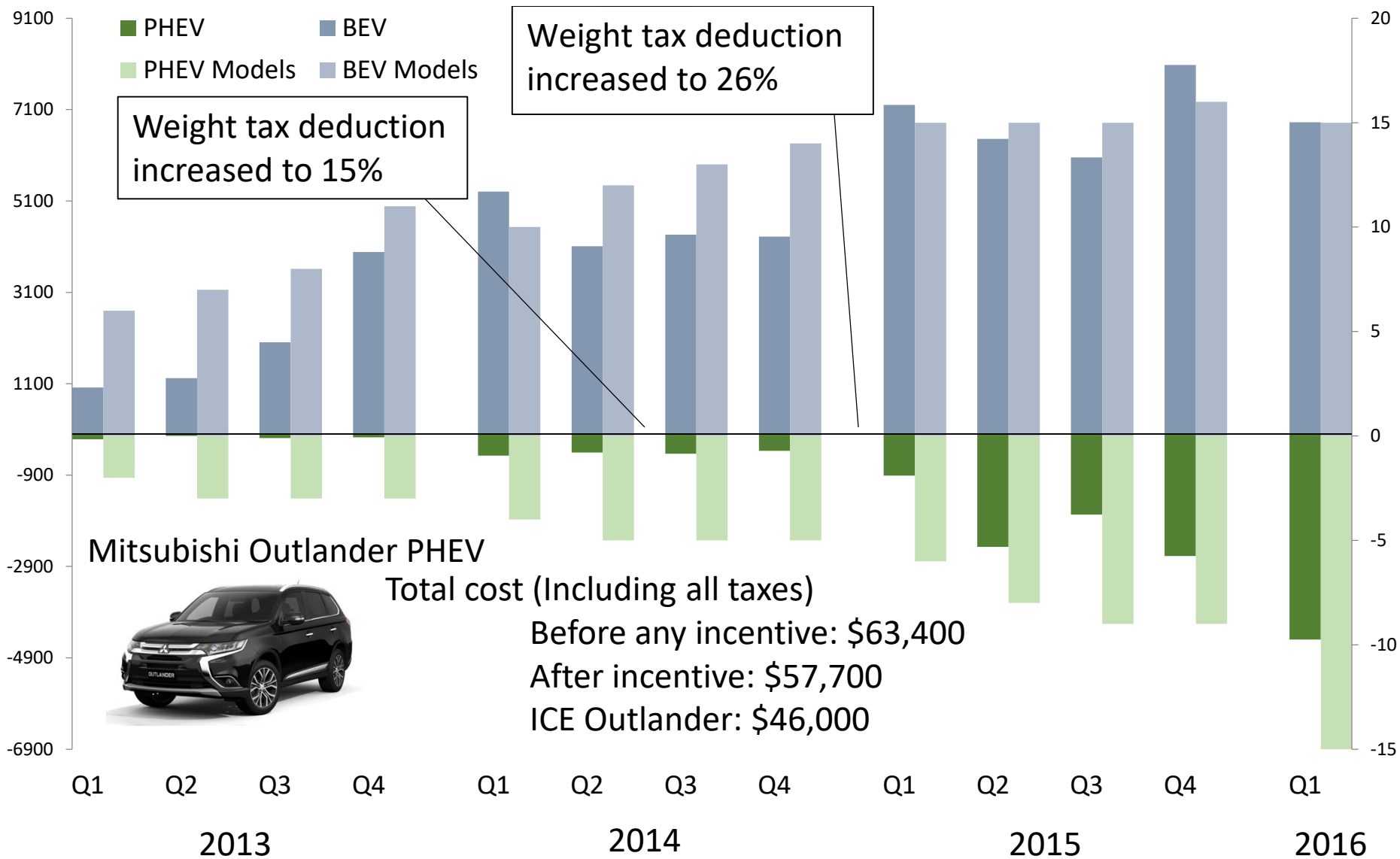
What Will a PHEV Driver Buy Without the Green Sticker?



BEV to PEV Ratio (N=100,211)

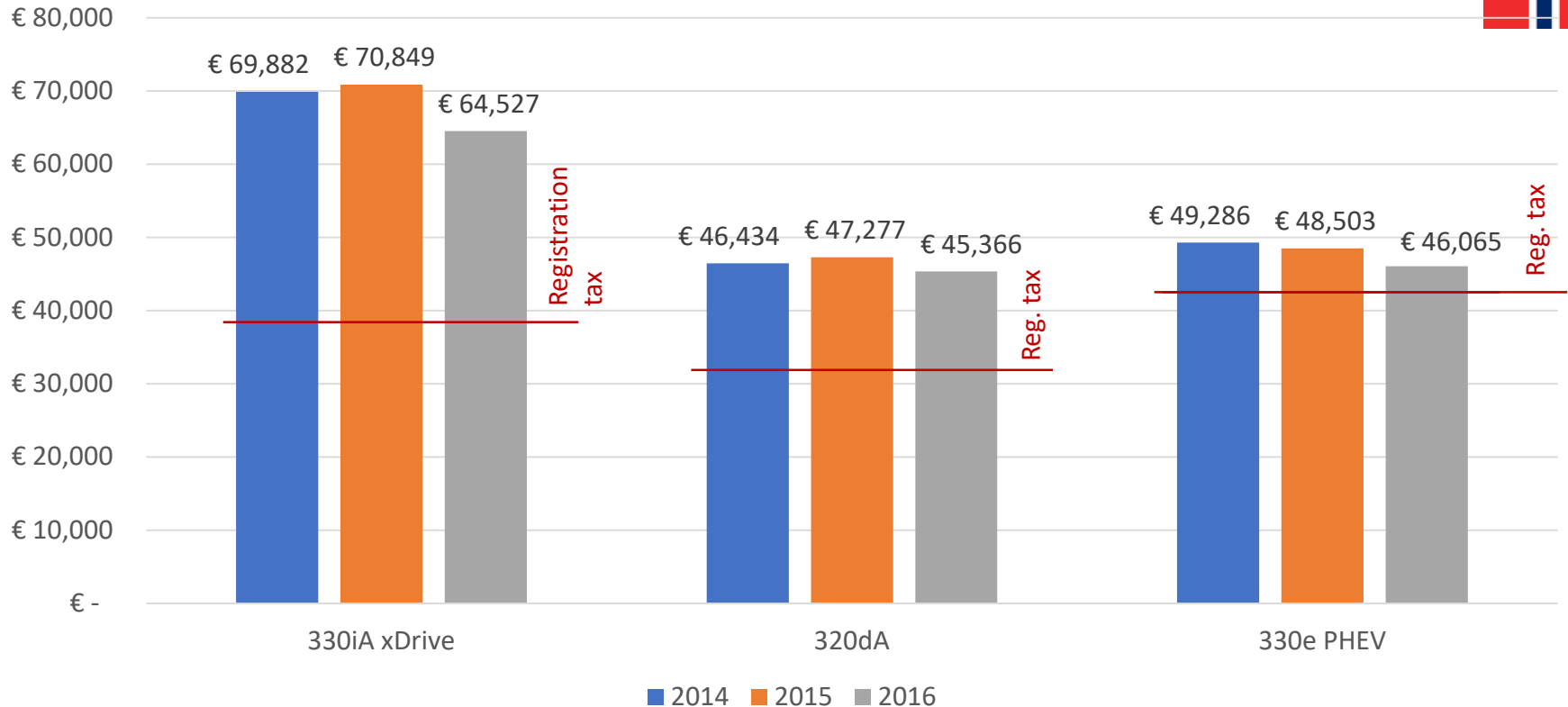


PEV Models in Norway



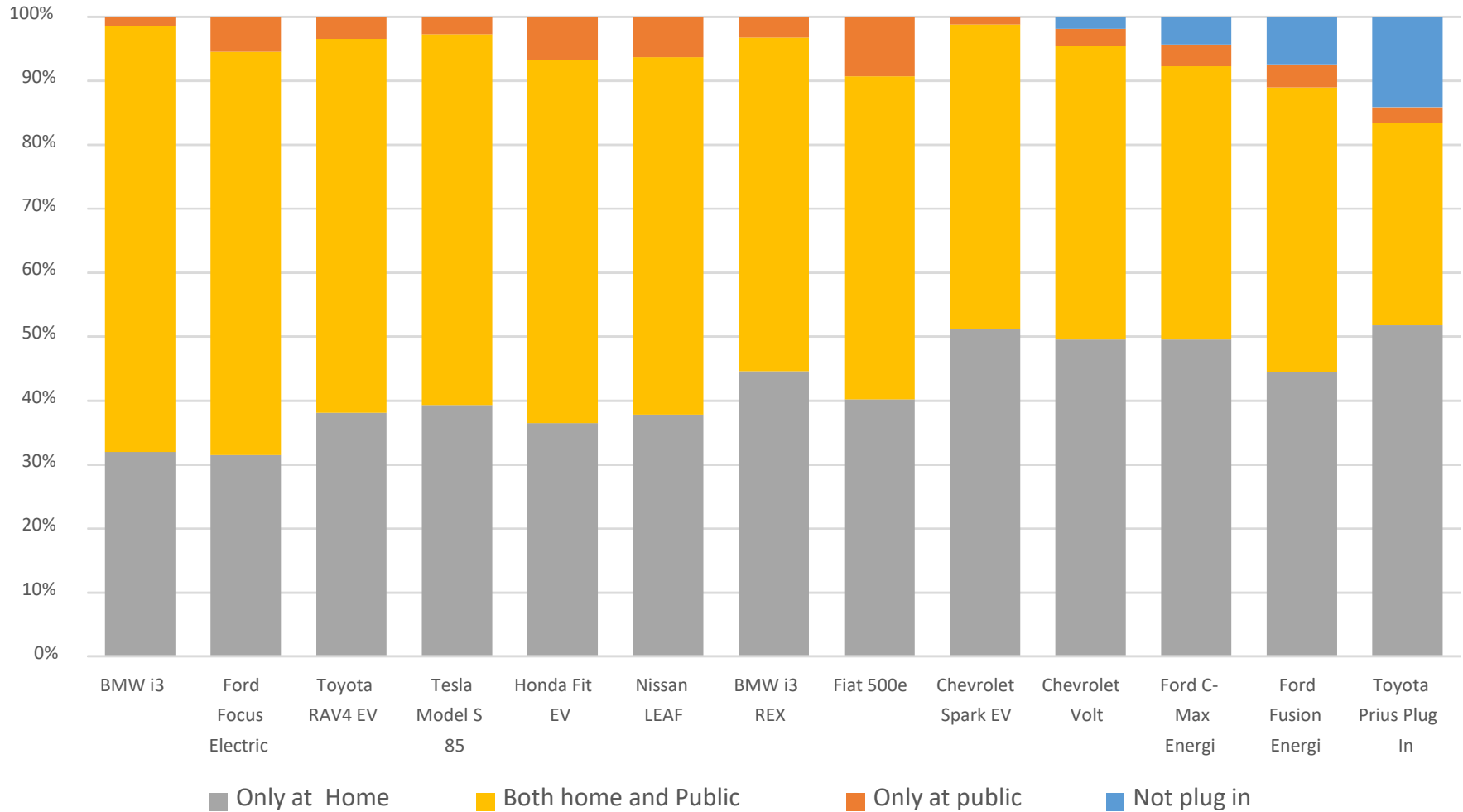
Price comparison 3-series sedan models.

Total price incl. registration tax



Price w/o tax	39,300 €	32,000 €	42,500 €
Total power	185 kW	140 kW	185 kW
CO ₂	138 g/km	104 g/km	49 g/km

Where/do they Charge?



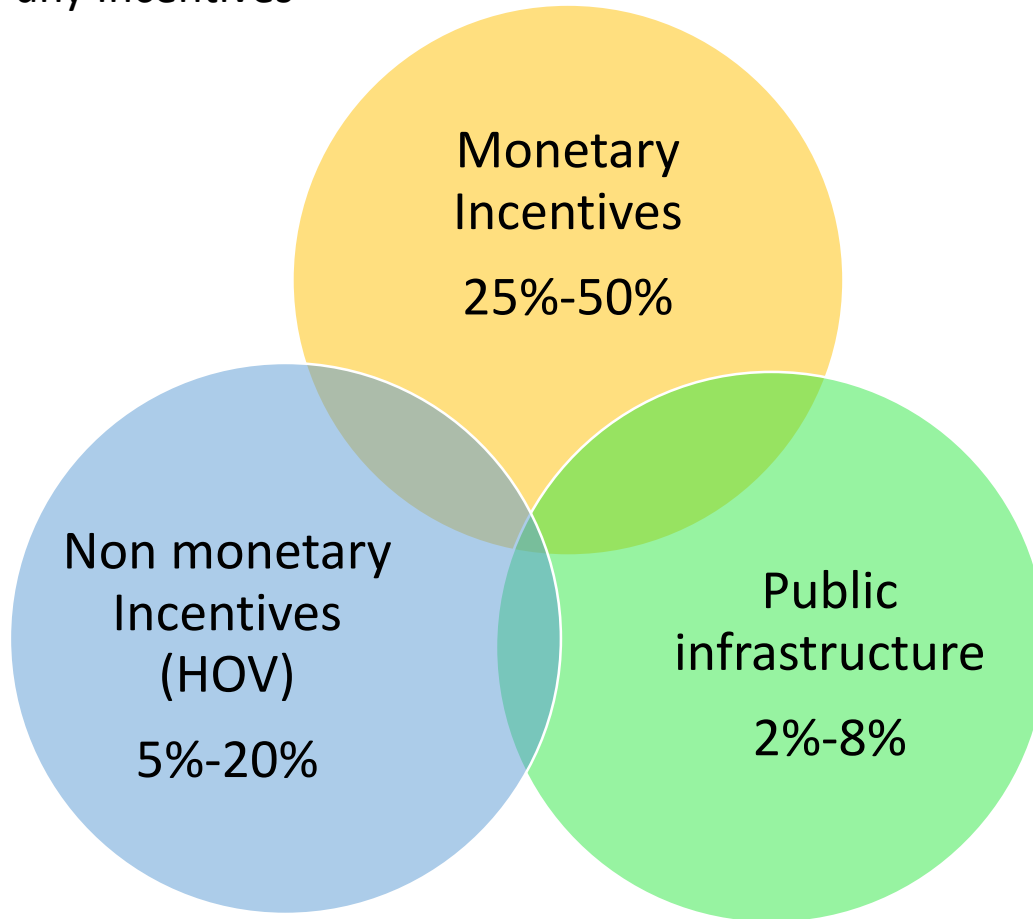
Overlapping Incentives

No Need of any Incentives
22%-50%

Monetary
Incentives
25%-50%

Non monetary
Incentives
(HOV)
5%-20%

Public
infrastructure
2%-8%



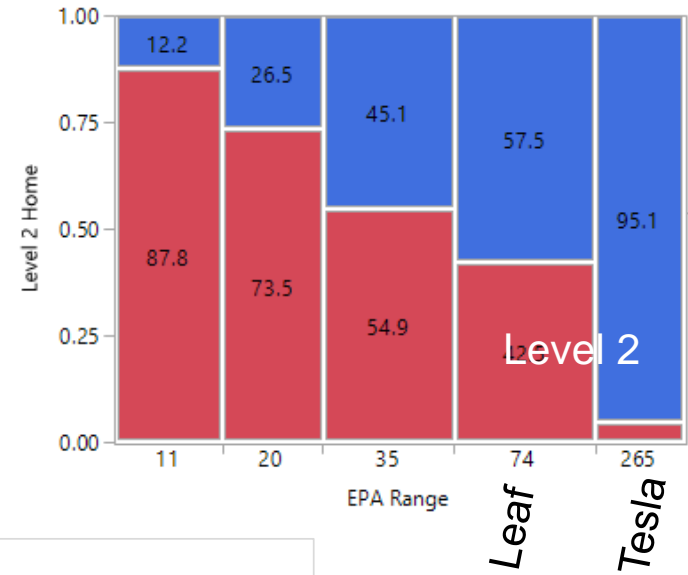
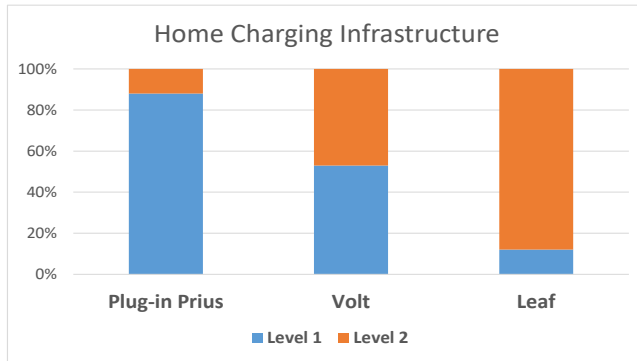
Charging

Most Charging can be done at Home

Longer Range Vehicles Have More Level 2

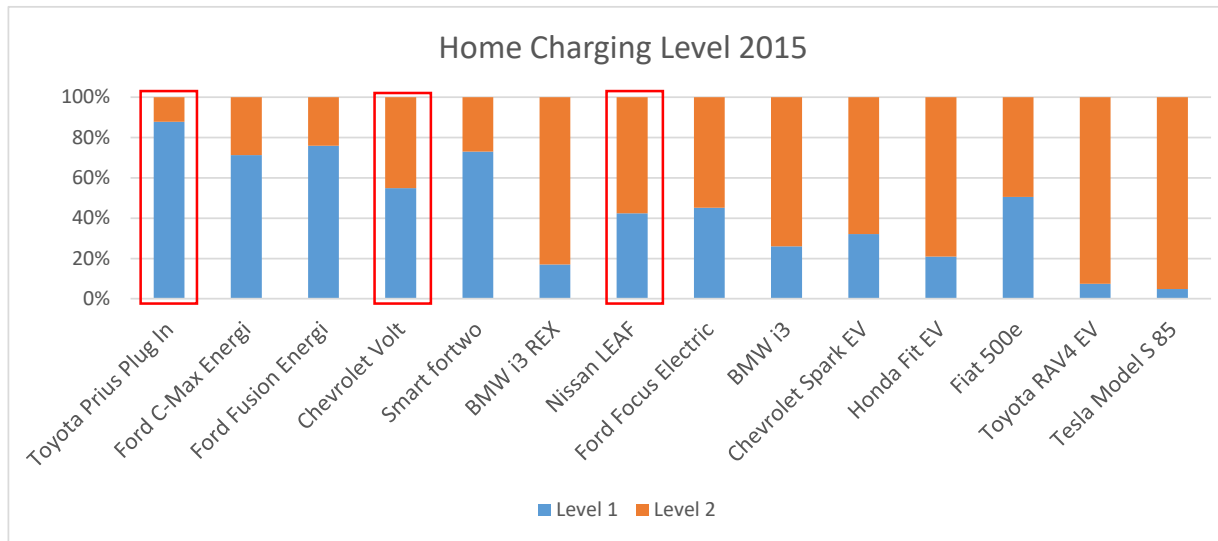
March 2013

Source: ARB
CVRP
Survey



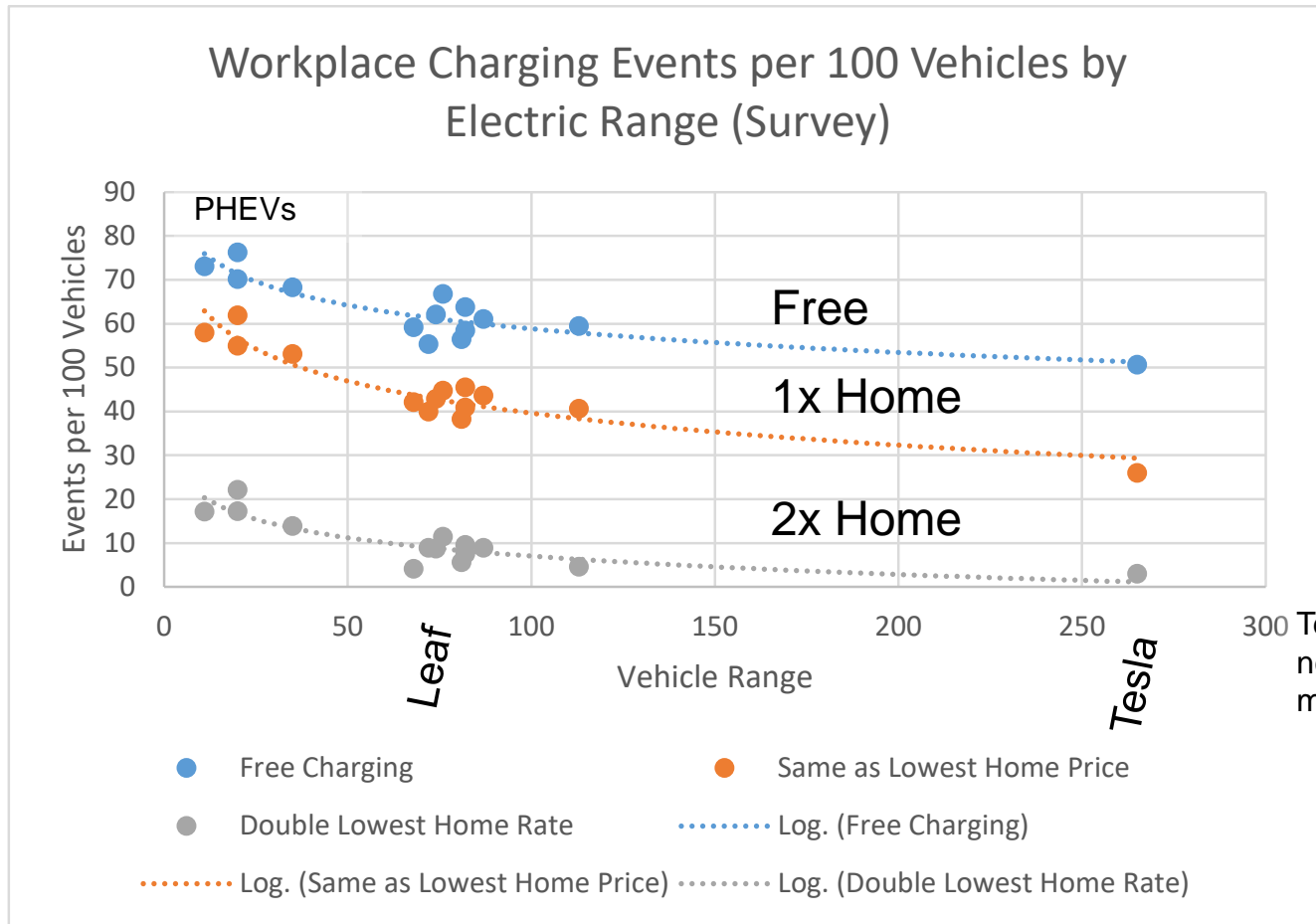
March 2015

Source: 2015
eVMT HH
Study
Recruitment
Survey

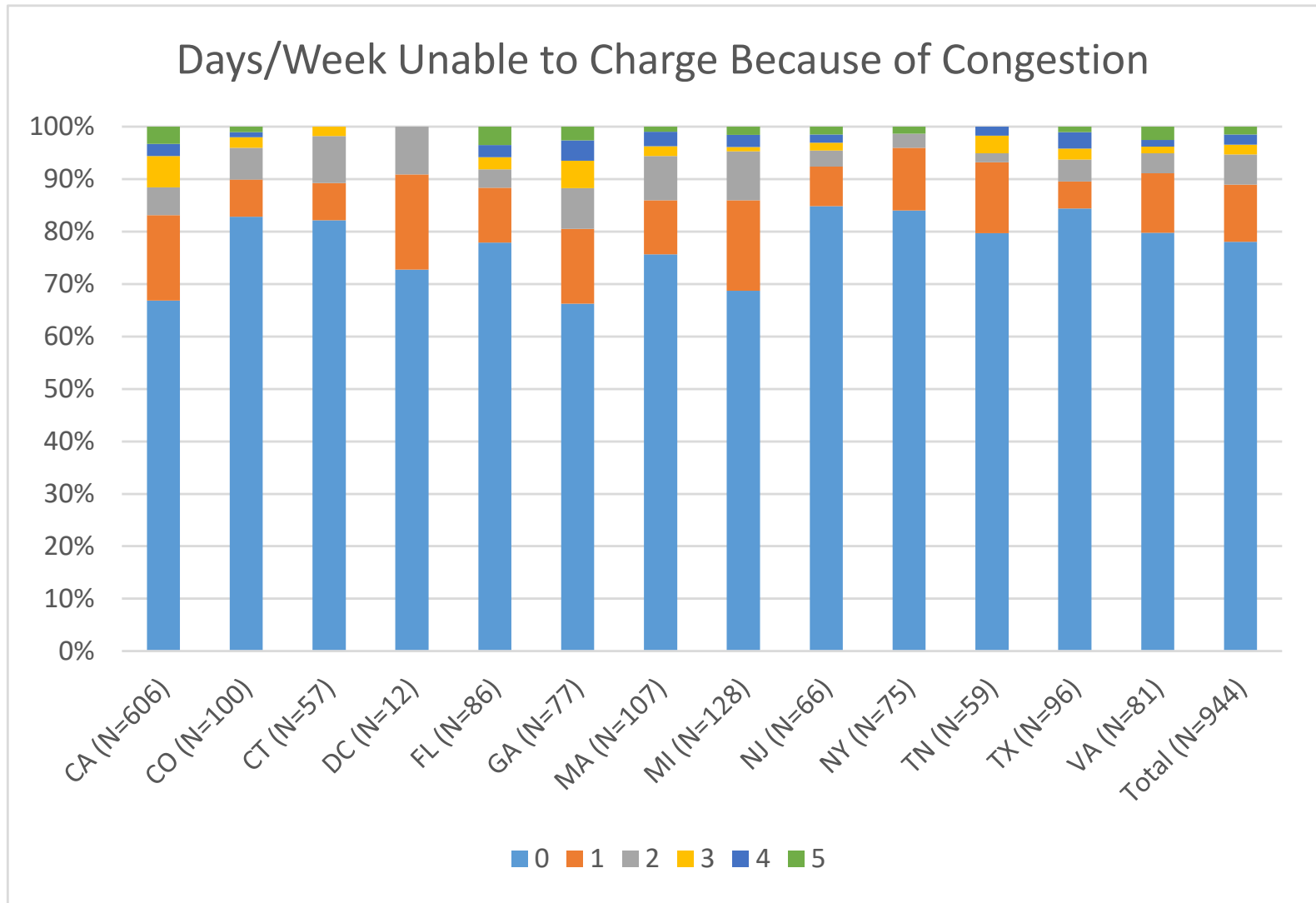


Everyone Likes Free Charging

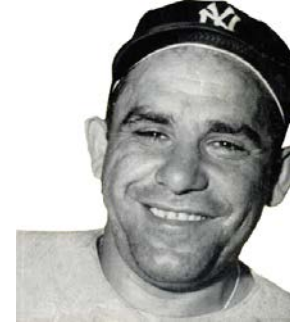
March 2015
 Source: 2015
 eVMT HH
 Study
 Recruitment
 Survey



What do Users Report about congestion? About 20%.

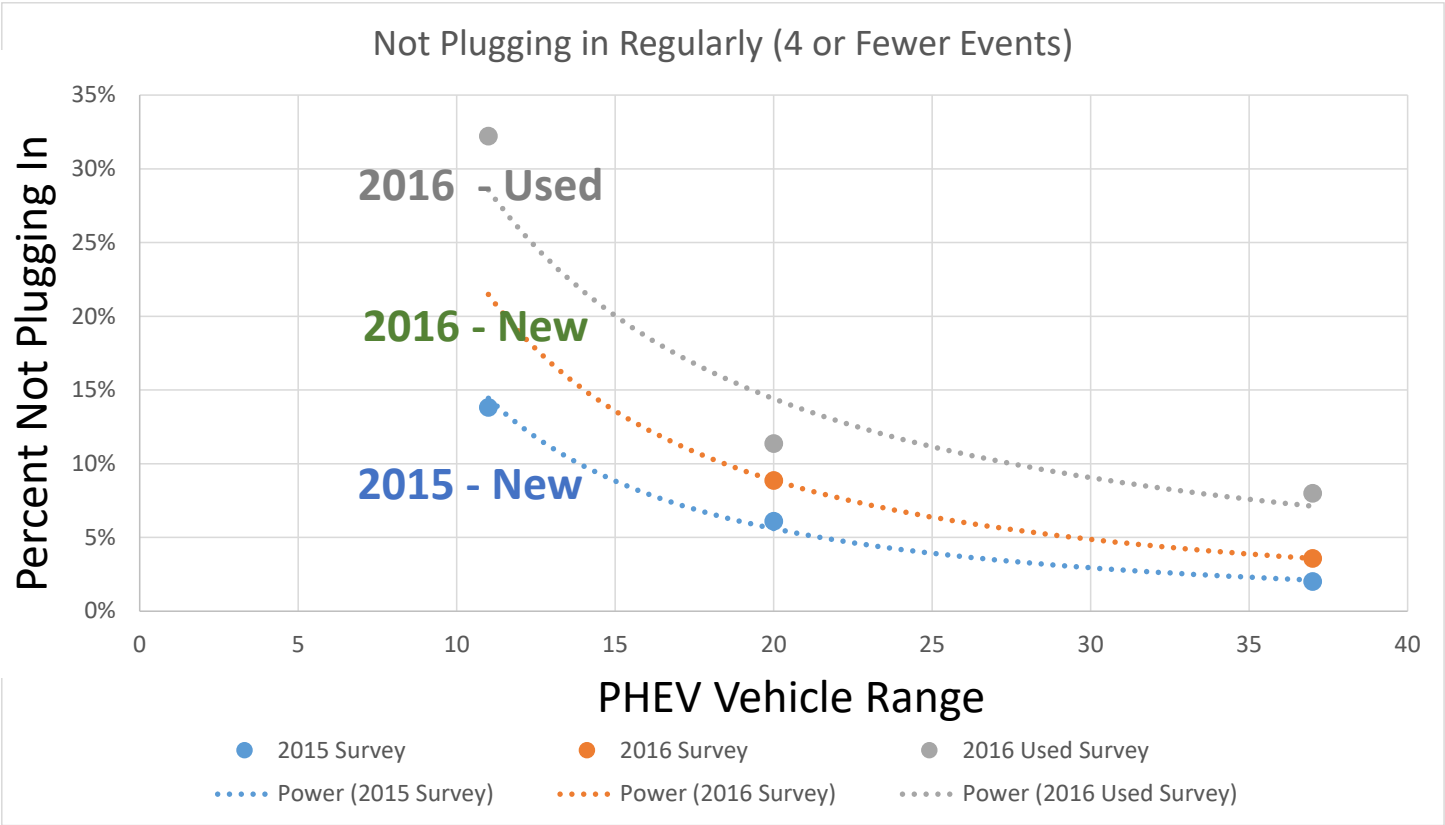


Nobody goes there anymore. It's too crowded



- If public charging is free we need about 60 chargers per 100 PEVs
- If public charging is congested nobody goes there anymore
 - Especially not those who need it in order to go back home.
 - The only one who can use it are those who can charge at home anyway.
- Paid public charging may reduce market share but increase the usability of BEVs.

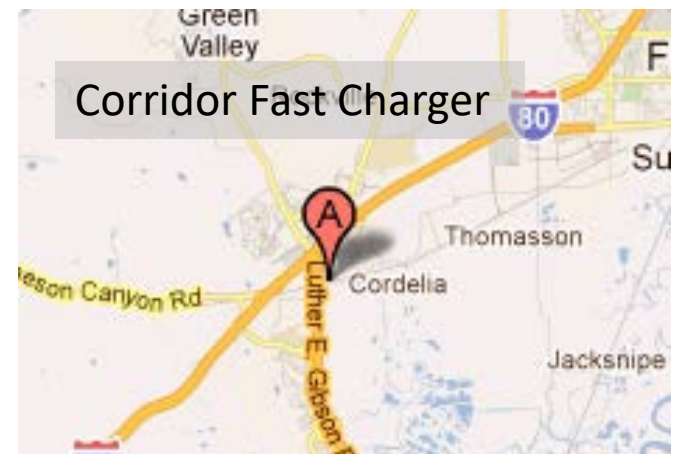
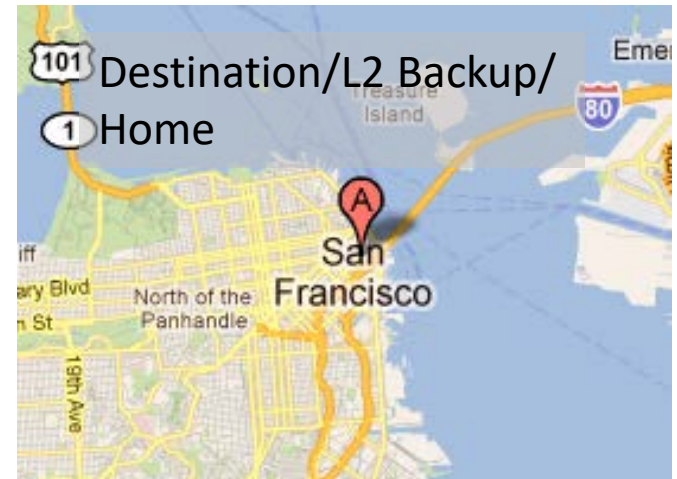
Because Low-Range PHEVs Provide Little Cost-Benefit, They are More Likely to Never Be Plugged in, even for free



Source: Nicholas, Michael and Tal Gil. 2017 (Forthcoming), January 8-12. You Can't Take It With You: Examining The Role Of Phev Range In The Decision To Plug In. In Transportation Research Board. Washington DC.

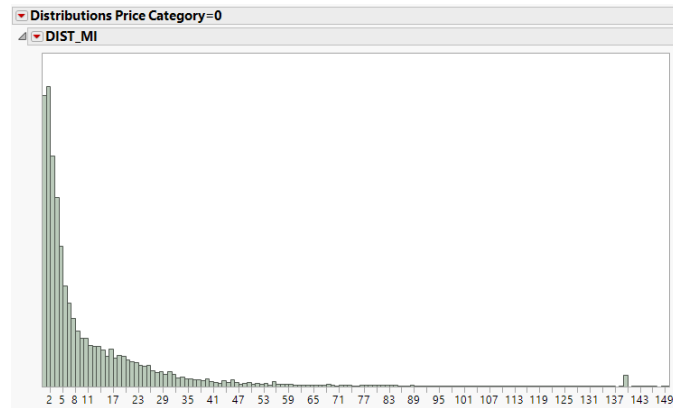
Use Cases for Fast Chargers

- Destination fast charger perhaps near regional centers.
 - “I have to meet someone for dinner and I won’t spend long enough at dinner to charge”
- Level 2 backup
 - “I have the time to charge, but I can’t find an open L2 charger”
- Home charger/home backup
 - “I have no home charger”
 - “I only have level 1 at home”
- Corridor fast charger
 - “I don’t have the range and need to charge”



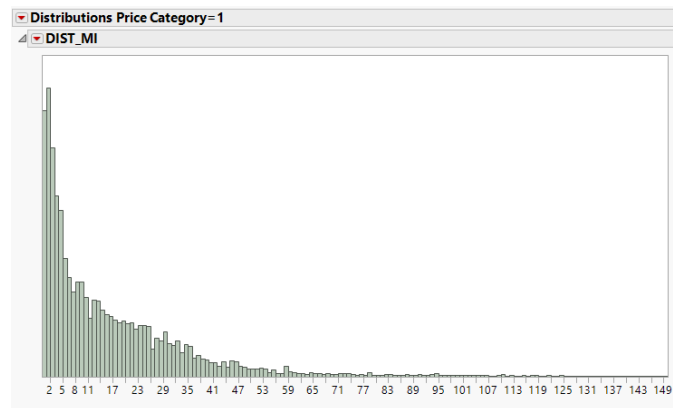
Fast Charging by BEV80-BEV90 is Currently Close to Home

- Analyzed 1.2 Million Sessions From Evgo
- Calculated the Euclidean distance from home zip code to charge event
- Differentiated from Home to free
- Median Distance from home for free charger is 5 miles
- Median Distance from home to paid charger is 10 miles



Quantiles		
100.0%	maximum	2648.453
99.5%		699.9105
97.5%		61.60775
90.0%		28.054
75.0%	quartile	14.512
50.0%	median	4.812
25.0%	quartile	1.929
10.0%		0.763
2.5%		0
0.5%		0
0.0%	minimum	0

Summary Statistics	
Mean	21.081996
Std Dev	127.41904
Std Err Mean	0.1619675
Upper 95% Mean	21.399447
Lower 95% Mean	20.764545
N	618889

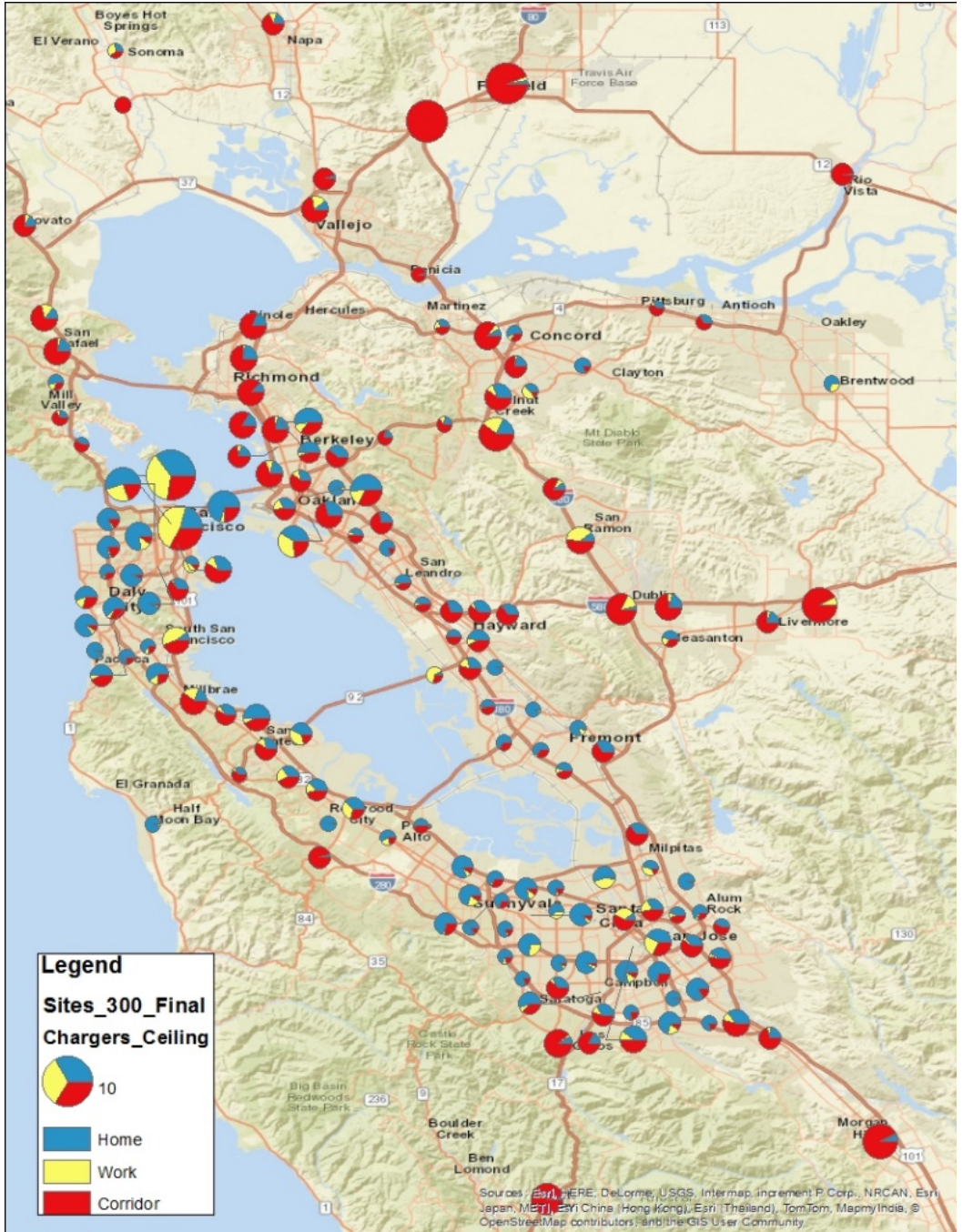


Quantiles		
100.0%	maximum	2706.058
99.5%		1879.142
97.5%		169.337
90.0%		41.5188
75.0%	quartile	24.387
50.0%	median	10.565
25.0%	quartile	3.211
10.0%		1.262
2.5%		0.327
0.5%		0
0.0%	minimum	0

Summary Statistics	
Mean	39.637222
Std Dev	191.41279
Std Err Mean	0.4403134
Upper 95% Mean	40.500226
Lower 95% Mean	38.774218
N	188981

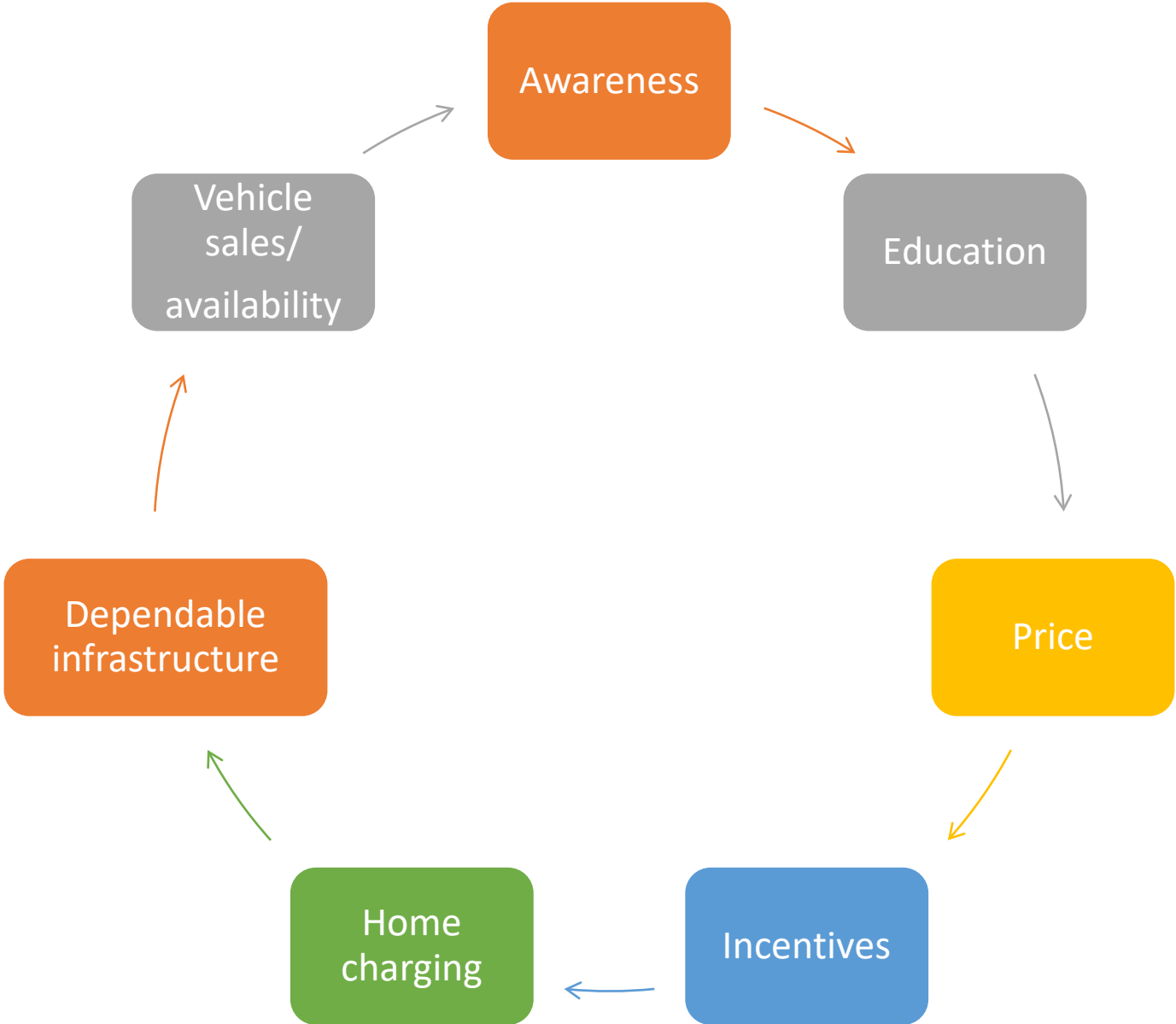
PG&E Scenario 2025

- Home dominates in urban areas (10 AM peak)
- Work centers have work based demand (noon and 6pm peak)
- Corridors draw from far away (5-8 pm peak)
- Corridors are the most speculative. Depends on confidence of availability and increase in battery Size



• https://www.pge.com/pge_global/common/pdfs/about-pge/environment/what-we-are-doing/electric-program-investment-charge/EPIC-1.25.pdf

Conclusions



Thank you

Questions?

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