

Charging Behavior Impacts on Electric VMT: Who is Not Plugging in?

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The Takeaway Message:

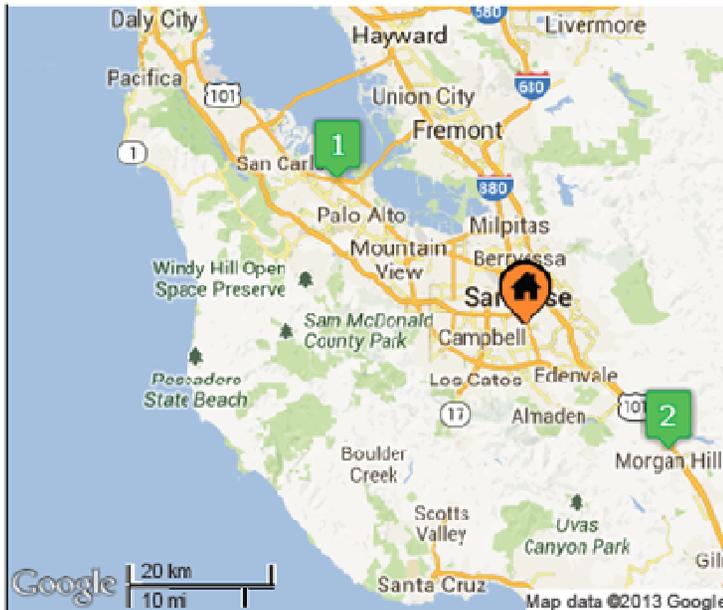
- small battery PHEV electric vehicle miles traveled (eVMT) are lower than longer range PHEV or BEVs not only because of the battery size but also as a result of charging behavior and the public charging availability.
 - Longer electric range PHEV drivers and BEV drivers charge more often and report more charging opportunities in the same areas that smaller battery PHEVs could not find chargers
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Drivers Travel Behavior and Desired Charging Locations Web Map Survey

72. Please place on the map desired chargers that you're likely to use that don't currently exist.
Please add up to 5 chargers.

 Level 2 = 240V charging station

Charger type



Frequency of expected use



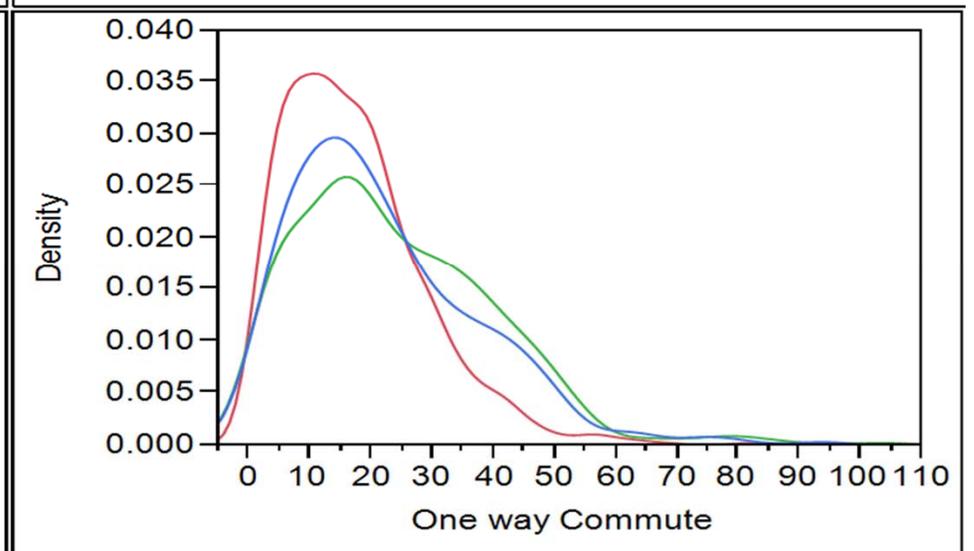
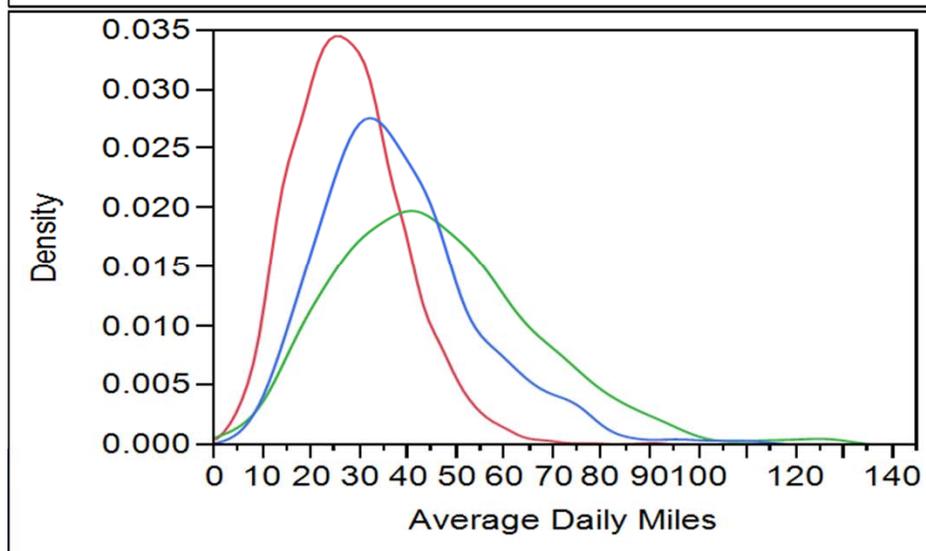
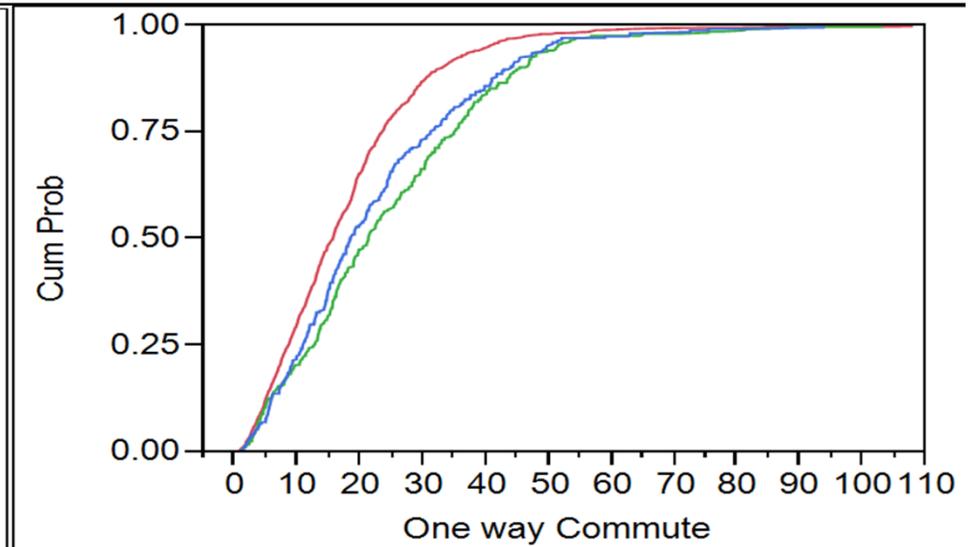
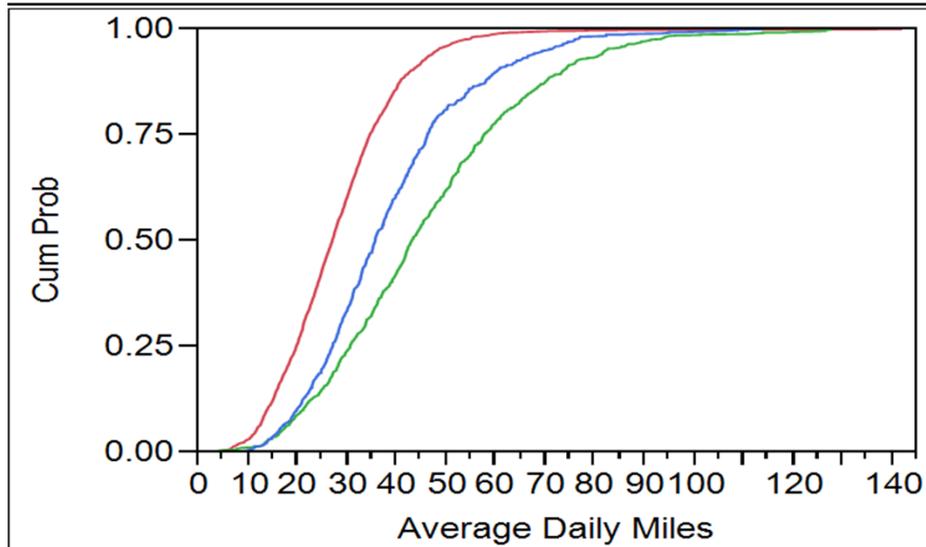
 

Commuters Sample

Vehicle Type	Sample Size
Chevrolet Volt	502
Plug in Prius	644
Nissan Leaf	1449

Survey conducted
in California
May-June 2013
PEV owners from 2012

Drivers are Taking Long Trips



- Leaf
- Plug-In Prius
- Volt

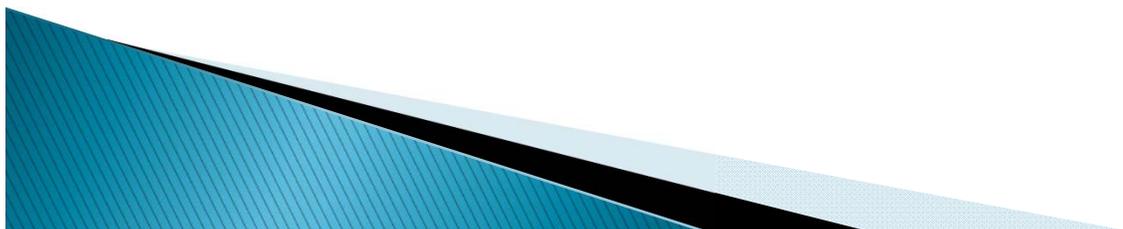


Average Daily Miles by Region and Model

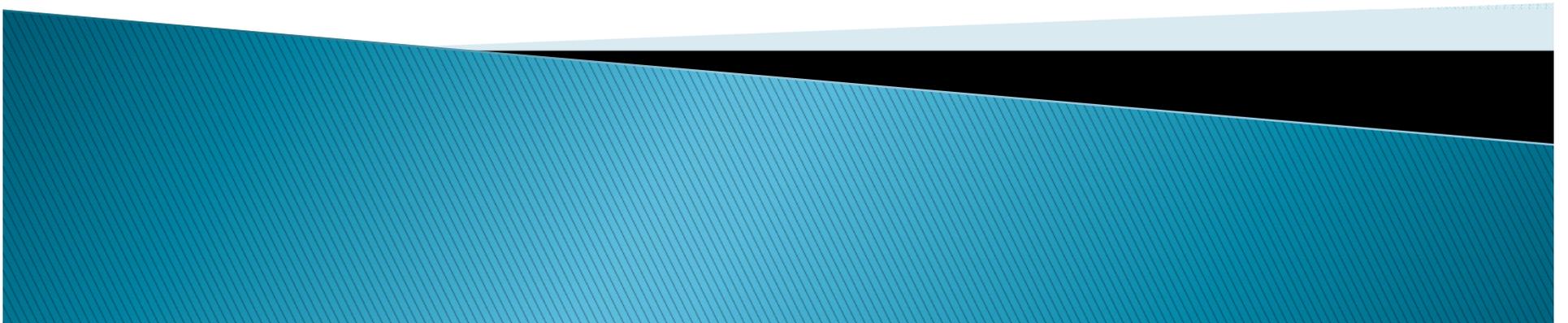
	Volt		Plug-in Prius		Leaf	
Area	N	Mean	N	Mean	N	Mean
all	659	38.2	845	45.7	2191	27.9
Bay Area	233	37.2	271	39.9	882	28.3
Los Angeles	291	38.3	451	48.8	644	28.6
Sacramento	23	34.4	19	48.3	64	26.7
San Diego	49	36.5	46	41.4	378	26.8
Rural areas	48	44.2	51	53.5	187	26.6

One-way Commute by Region and Model

Area	Volt		Plug-in Prius		Leaf	
	N	Mean	N	Mean	N	Mean
All	284	22.1	381	24.0	998	17.3
Bay Area	111	22.2	132	20.7	424	17.5
Los Angeles	119	22.9	195	26.1	297	18.8
Sacramento	7	15.3	8	18.0	26	13.0
San Diego	19	15.6	25	13.0	163	14.6
Rural areas	24	23.7	18	36.6	72	19.6



Charging Behavior



average reported charging events

	Volt		Plug-in Prius		Leaf	
	Home	Total	Home	Total	Home	Total
All	5.4	6.5	5.0	5.8	5.4	6.4
Bay Area	5.6	7.1	5.5	6.4	5.4	6.5
Los Angeles	5.2	6.2	4.7	5.3	5.3	6.4
Sacramento	5.8	6.5	5.3	6.5	5.1	6.1
San Diego	5.2	5.8	5.6	5.9	6.1	6.7
Rural areas	5.5	6.4	5.3	5.9	4.9	5.6

Charging at Work: Who Needs Charging, Who Has a Free Charger and Who Actually Plugs-In

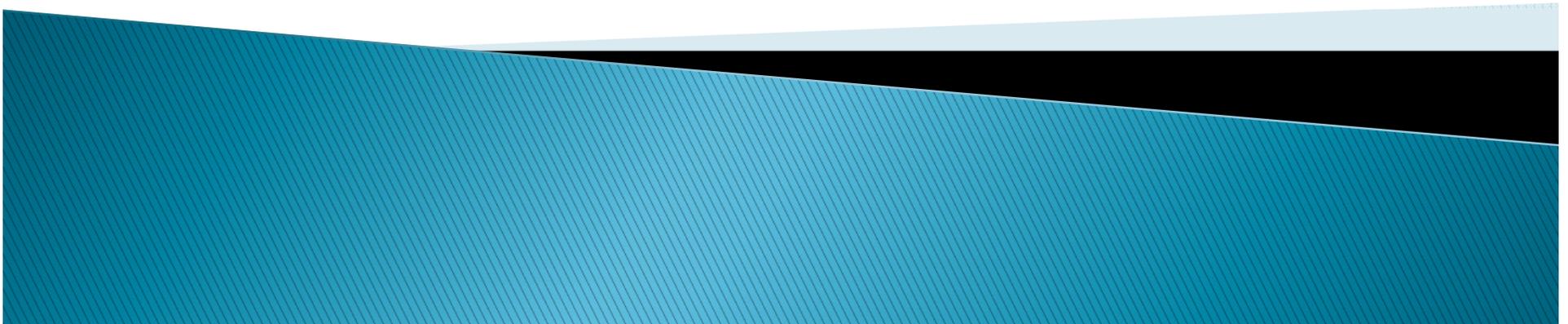
	Volt		Plug-in Prius		Leaf	
	N	% of Com	N	% of Com	N	% of Com
Total	502		644		1835	
Commuters	415	100%	545	100%	1449	100%
Have work charger	195	47%	206	38%	724	50%
Need work charger	136	33%	381	70%	67	5%
Need and Have (free) Charger	76	18%	127	23%	62	4%
Need Have (free) and Use (per commute)*	62	15%	60	11%	56	4%

Average Daily Estimated eVMT Miles by Region and Model

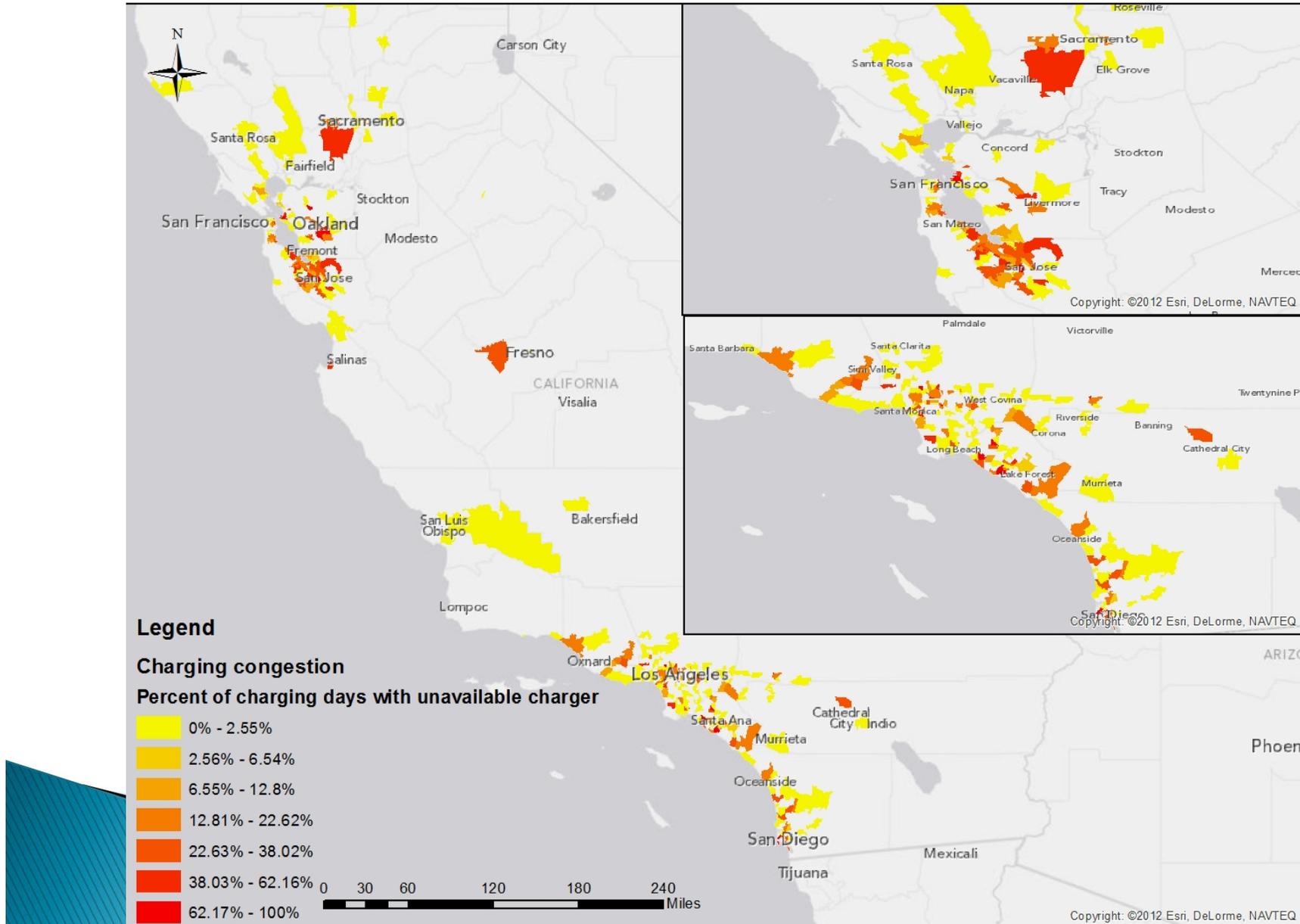
Commuters travel	Volt (commuters daily miles 48.6)		Prius (commuters daily miles 52.8)	
<u>Potential eVMT</u>	eVMT	eVMT share	eVMT	eVMT share
Home charging eVMT	30.3	62.3%	10.5	19.9%
eVMT with work charging	43.3	89.1%	19.7	37.3%
<u>Estimated eVMT</u>				
Home charging eVMT	26.6	54.7%	8.4	16.1%
eVMT with work charging	32.8	67.5%	10.6	20.1%



9 Reasons for not Plugging-in



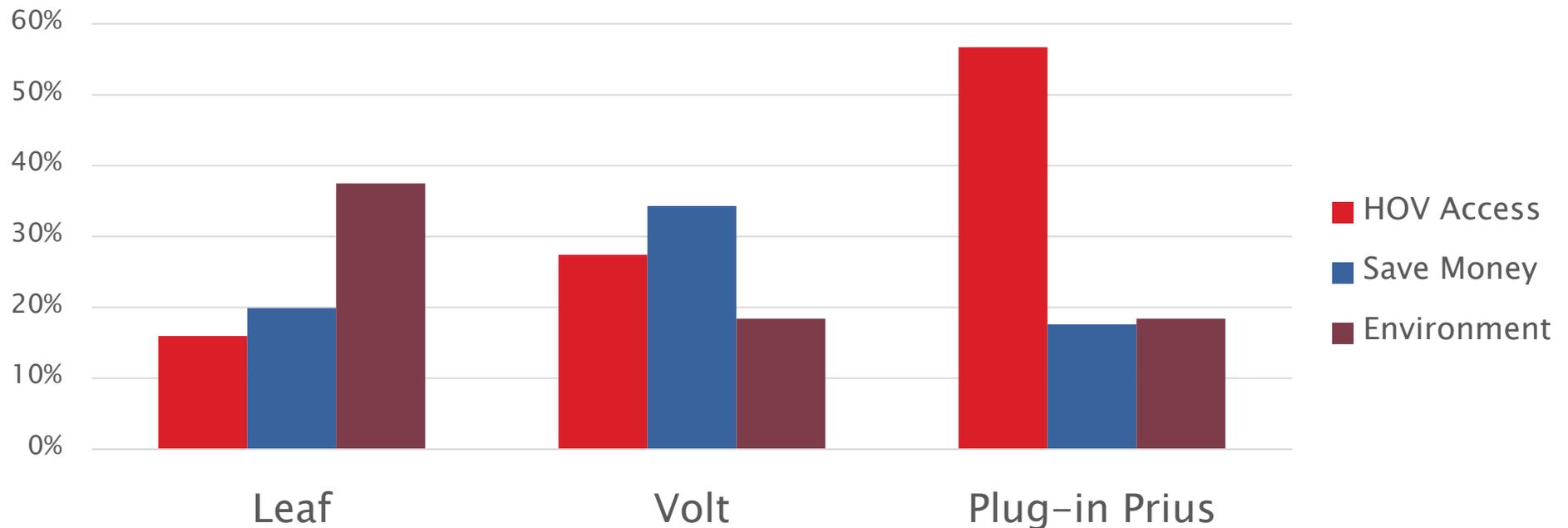
1. Congestion at workplace



2. Self Selection

- ▶ A driver paying higher electricity rates commented in our survey stating, *“the Toyota Prius only gets 10 miles per charge which could take several hours charging. It makes no sense to charge this vehicle. Your survey has no provisions for customers that choose not to charge the vehicle.”* .

Primary Motivations for Vehicle Purchase



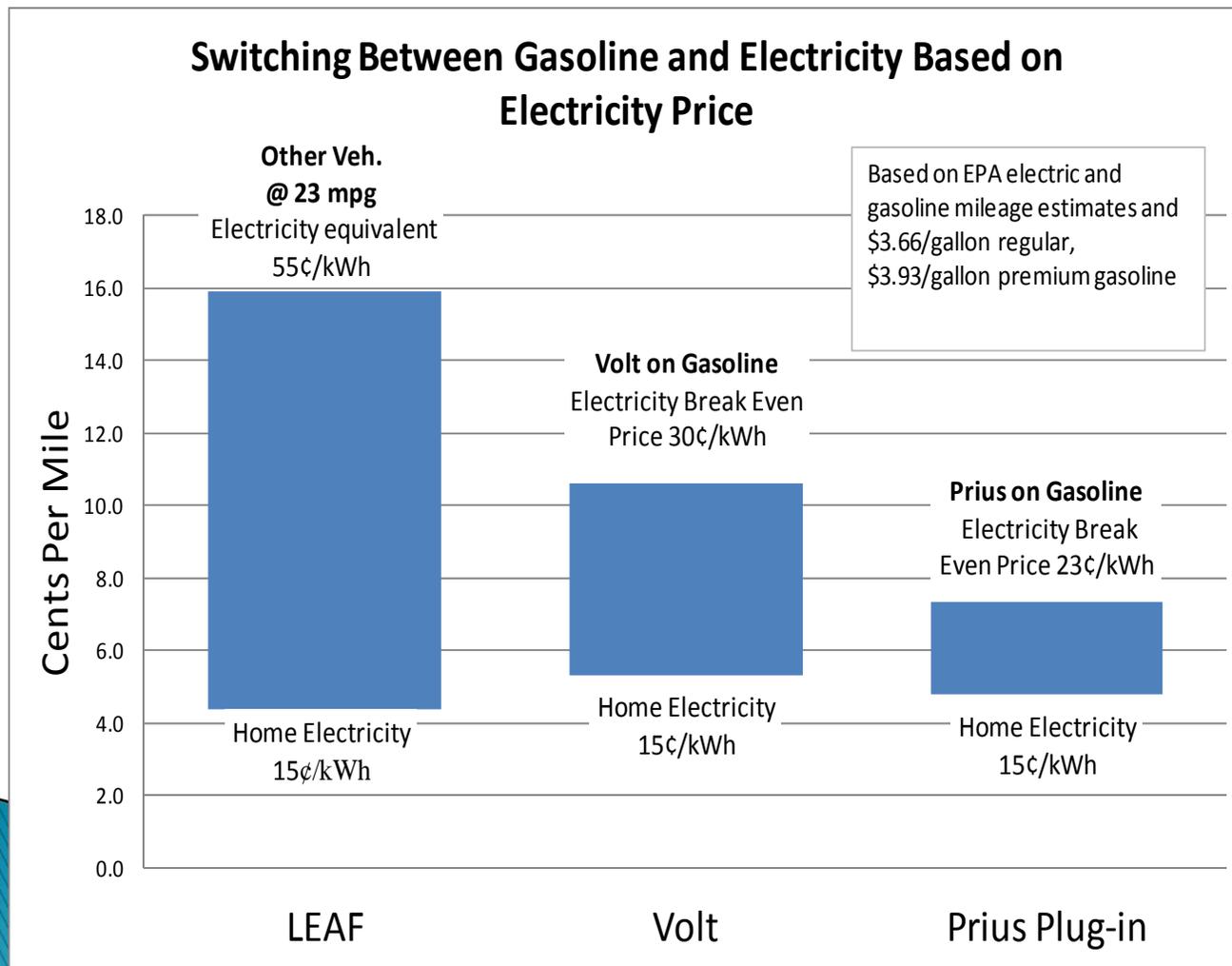
3. Cost of home electricity

- ▶ A driver paying higher electricity rates commented in our survey stating:

“My Plug-in Prius increased my electricity usage by 10% but my bill by 30%. This would be tough sell going electric paying 38 cents a kW/h if I had to charge at home.”



4. Cost of Alternative Driving



5. No dedicated EVSE at home

12% of Leaf owners, 53% of the Volt owners, and 89% of the Prius owners do not have level 2 (208–240V) chargers at home.

5.1. Less convenient at home

5.2. Leaving 120V cord at home

Many PHEV drivers leave the cord at home and do not use level 1 in public



6. Risking the convenience cord at a public location

The need to use the vehicle's convenience cord posed a high financial risk (up to \$1,000) in the case of theft or damage to the cord.

*Reviewing the open comment section of the survey revealed only Prius owners mentioned the level 1 convenience cord as a problem.



7. Connection Fee or Minimum Time Fee

Pricing on level 2 charging was a barrier especially for Prius drivers who resist high connection payment (per plug-in event fee), and don't want to move their car after a short time charging.



8. The Engine Starts Anyway

When driving a PHEV 10, users reported little EV experience that would reinforce charging.

“Prius Plug-in EV Mode is a blended operation of electricity and gas and can work under certain conditions up to 11 miles on a full charge. Quick acceleration and braking, road and vehicle conditions, or climate control use may prevent or limit usage or effectiveness of EV Mode”

<http://www.toyota.com/prius-plug-in/#!/Welcome>



9. Slow PHEV Onboard charger

- ▶ The return on the time invested for plugging-in is low for PHEVs. Additionally time-based fee systems are unfavorable to slow onboard chargers.



CONCLUSION

- ▶ We see unmet eVMT potential of PHEVs due to inefficiencies related to charging availability and charging behavior.
- ▶ We find differences in charger availability issues between vehicles as Prius drivers reported on much lower availability than Volt and Leaf drivers.
- ▶ Charging at home is also more frequent when level 2 is installed. small battery PHEV owners are less likely to install EVSEs at home or to plug in their car on level 1 when possible.
- ▶ Cost of charging has an impact both at home and at public charging especially for Prius drivers but also for Volts.
- ▶ Short EV range of small battery blended PHEVs may not create a high enough incentive to encourage users to charge their car as often as PHEV with all electric operation.



PHEV Performance and Charging Behavior

Performance	Plug-in Prius	Ford Enrgi	Chevrolet Volt	BMW I3 range extender
EV only performance	Limited speed limited acceleration	limited acceleration Freeway speed	High	High
	*uncontrolled engine start	*controlled engine start	*uncontrolled engine start	
ICE performance	High	High	ICE=EV	Limited speed limited acceleration
EV/ICE experience	Low	Medium		
Motivation to plug in	Low			High

Can We Fix it?

Yes. But first we need better data on actual on road performance and charging behavior.

Policy Recommendations:

1. Higher minimum electric range
2. Dependable charging infrastructure
3. EVSEs at home
4. Faster (6.6kW) onboard chargers
5. eVMT based incentives



Thank You!

Questions?

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