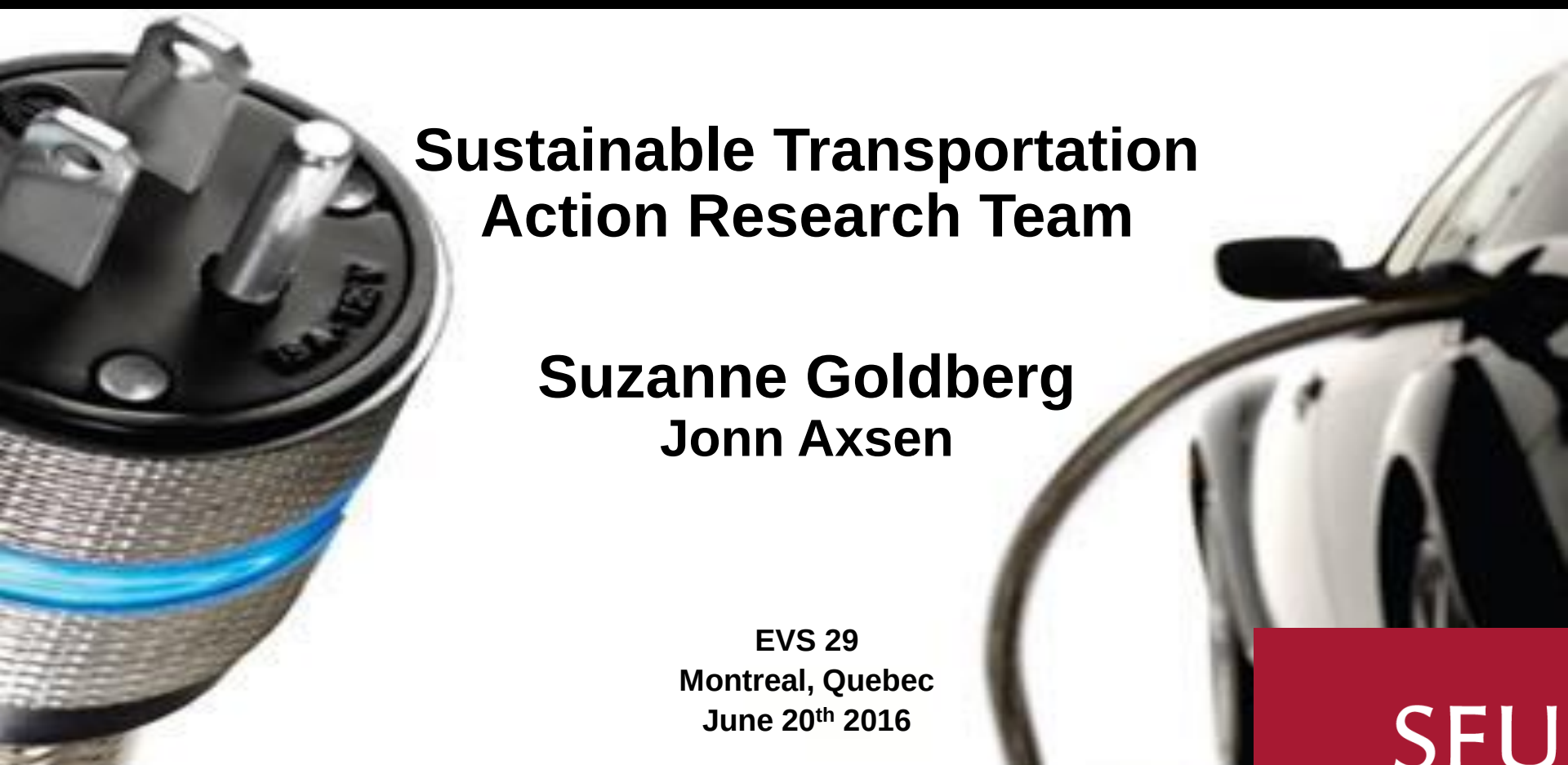


Understanding current and future potential passenger PEV buyers



**Sustainable Transportation
Action Research Team**

**Suzanne Goldberg
Jonn Axsen**

**EVS 29
Montreal, Quebec
June 20th 2016**

SFU

Sustainable Transportation Action Research Team (START)

Markets for low-carbon
transport

Low-carbon fuel supply
and infrastruc-ture

Acceptance of
alternative fuels and
policy

Modeling of low-
carbon transport
systems

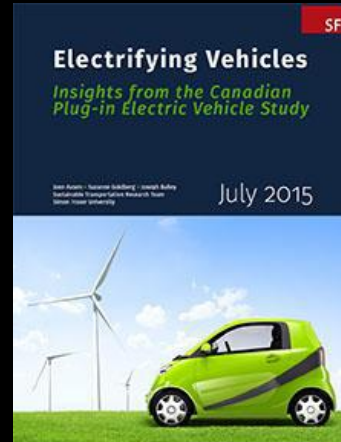
**Supporting sustainable shifts in transportation with
interdisciplinary research that assesses markets +
technologies + policies**



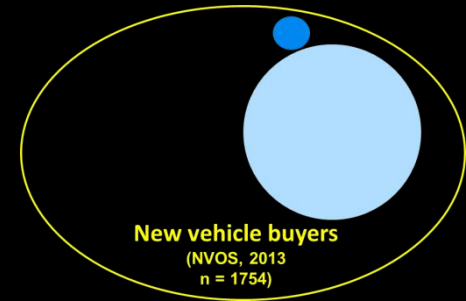
Presentation Roadmap



**PEVs policy in
Canada**



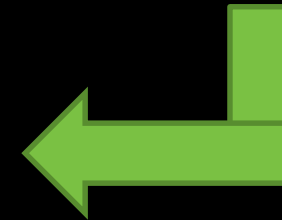
The study



**Pioneers v.
Mainstream**

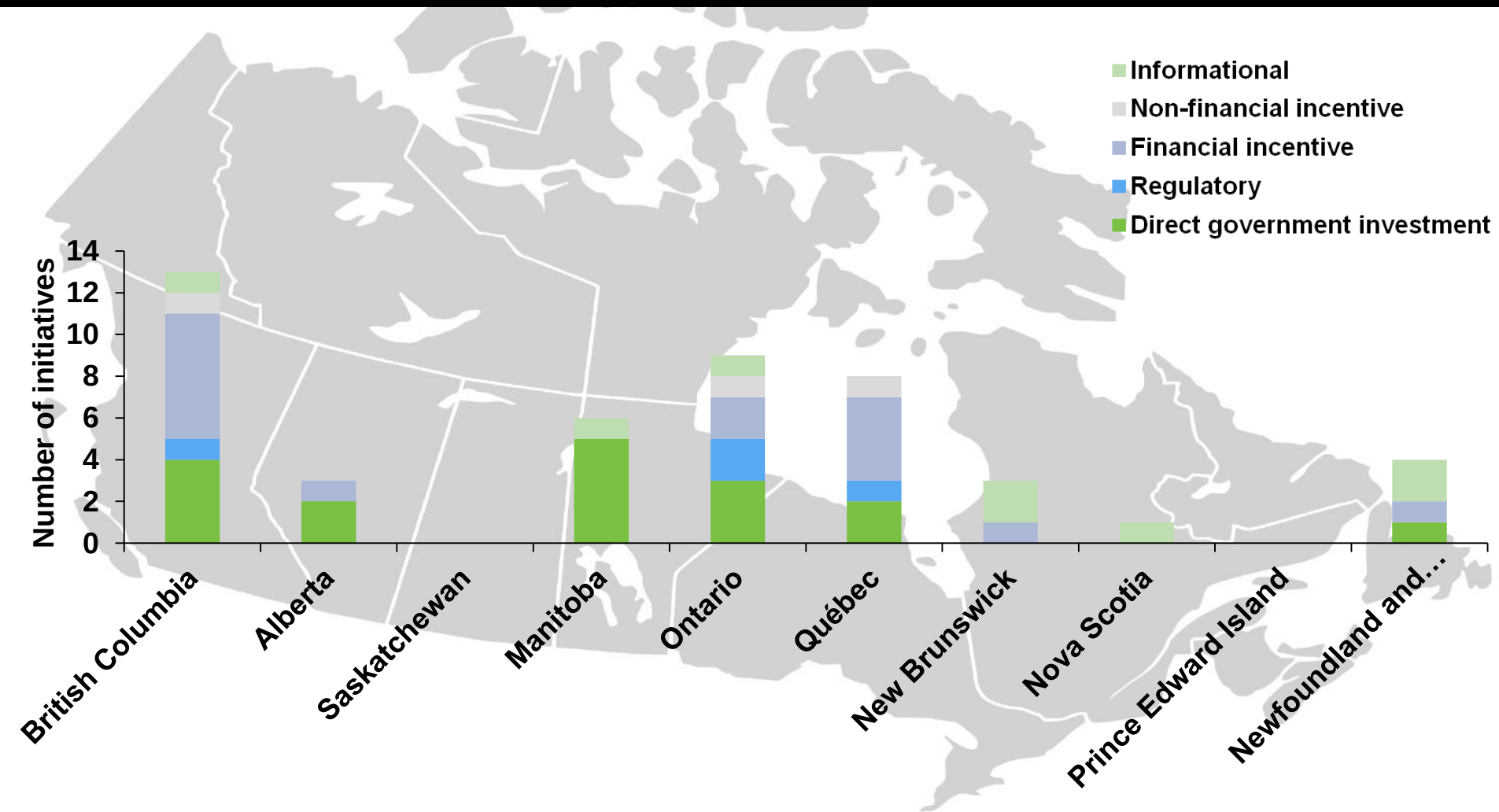


**Implications for policy makers
and auto makers**



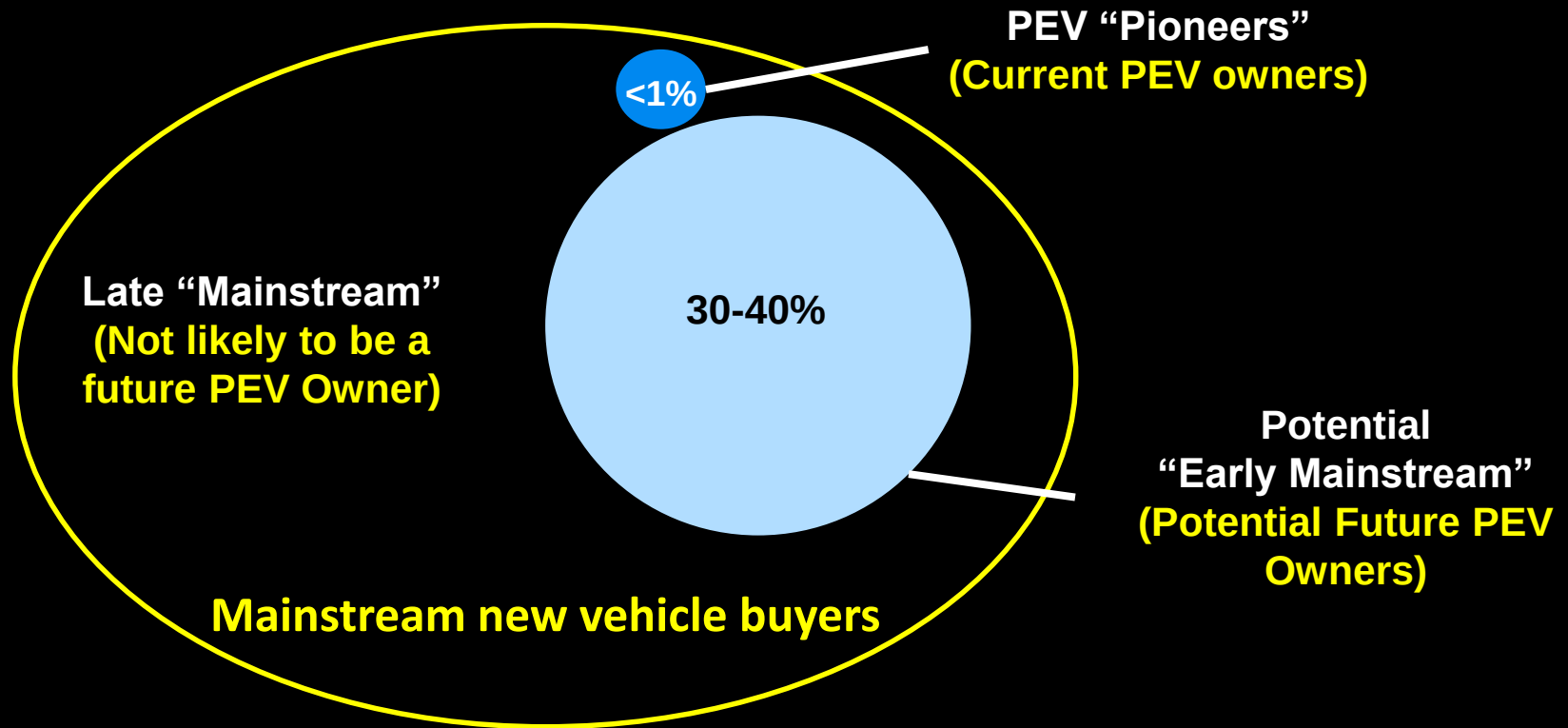
Canadian PEV policy

The 2016 Canadian PEV Policy Scan



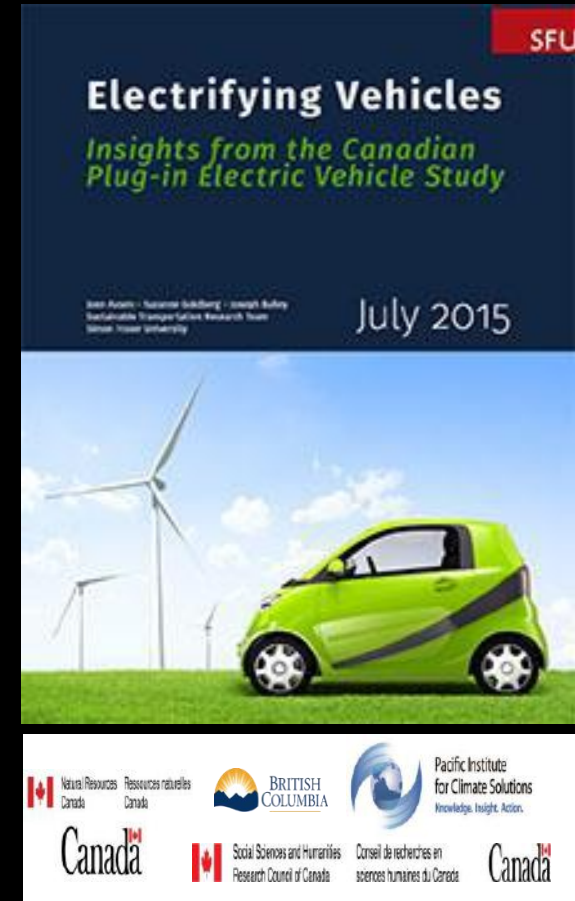
Source: Melton et al. (in-progress)

3 PEV market segments



The Canadian Plug-in Electric Vehicle Study

Study Objective: identify who current and future PEV buyers are, and understand how to anticipate and influence the future market.



SFU

Electrifying Vehicles

*Insights from the Canadian
Plug-in Electric Vehicle Study*

Ben Axtell • Susanne Goldburg • Joseph Buhay
Sustainable Transportation Research Team
Simon Fraser University

July 2015



Natural Resources
Canada



BRITISH
COLUMBIA



Pacific Institute
for Climate Solutions
Knowledge. Insight. Action.

Canada

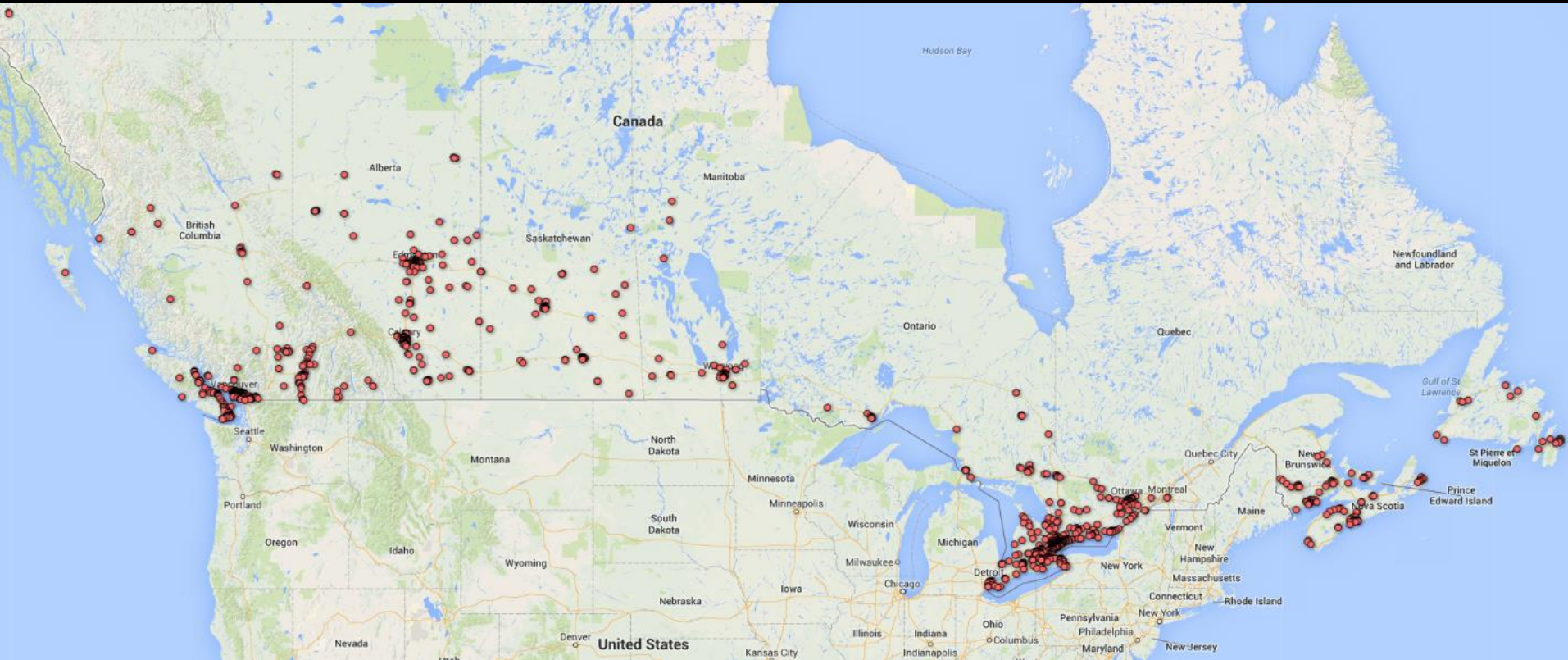


Social Sciences and Humanities
Research Council of Canada

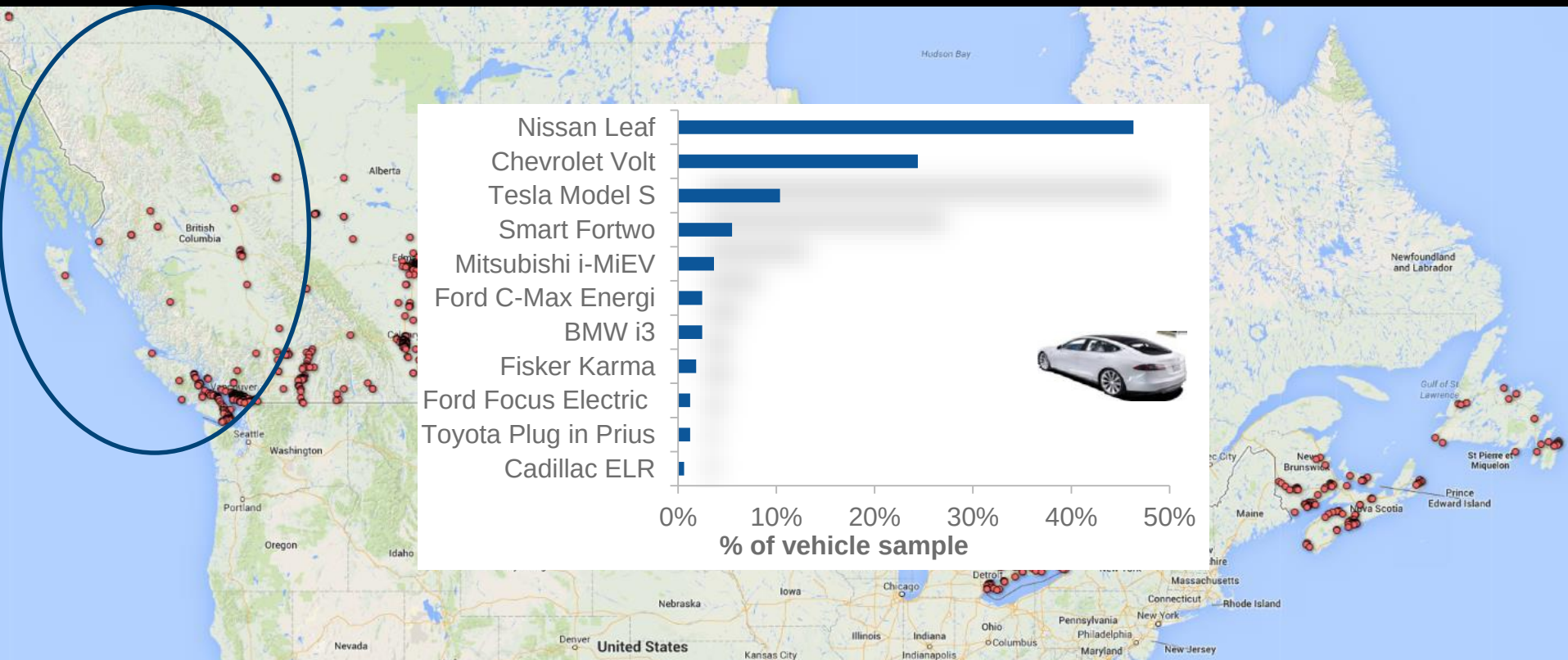
Conseil de recherches en
sciences humaines du Canada

Canada

“Mainstream” = 1754 new vehicle buyers in Canada (2013)



“Pioneers” = 157 PEV owners in British Columbia (2015)



Multi-method survey design

Background Survey

- Current vehicle fleet
 - Current electricity use
 - Vehicle parking conditions
 - Lifestyle preferences
 - Attitudes
 - Technology awareness
- 

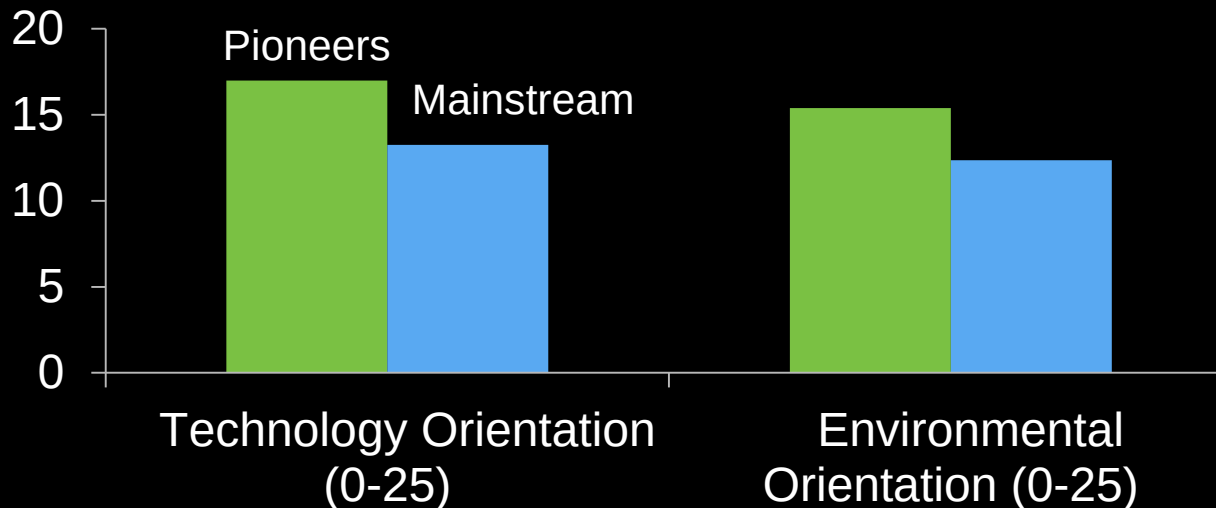
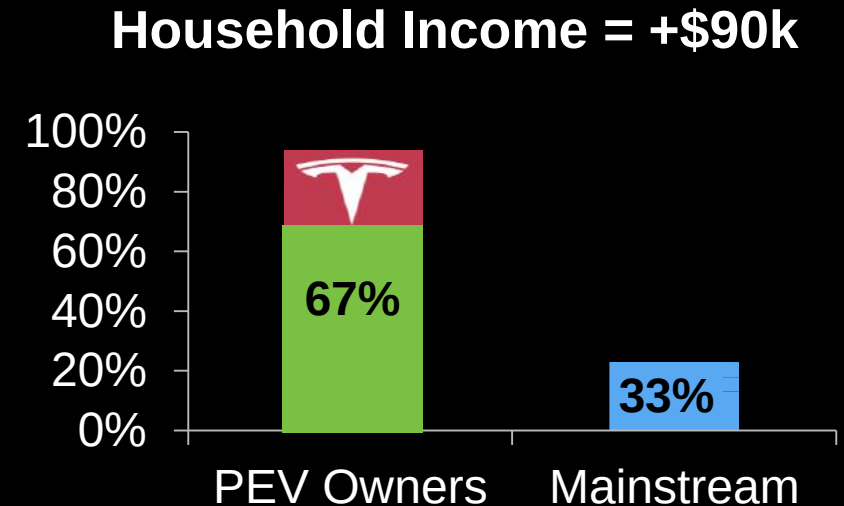
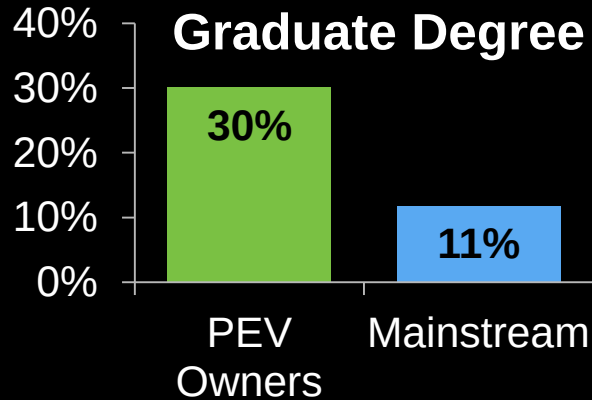
Pioneers and Mainstream Buyers in Canada

Comparing Pioneer and Mainstream buyers we find that...

Mainstream....

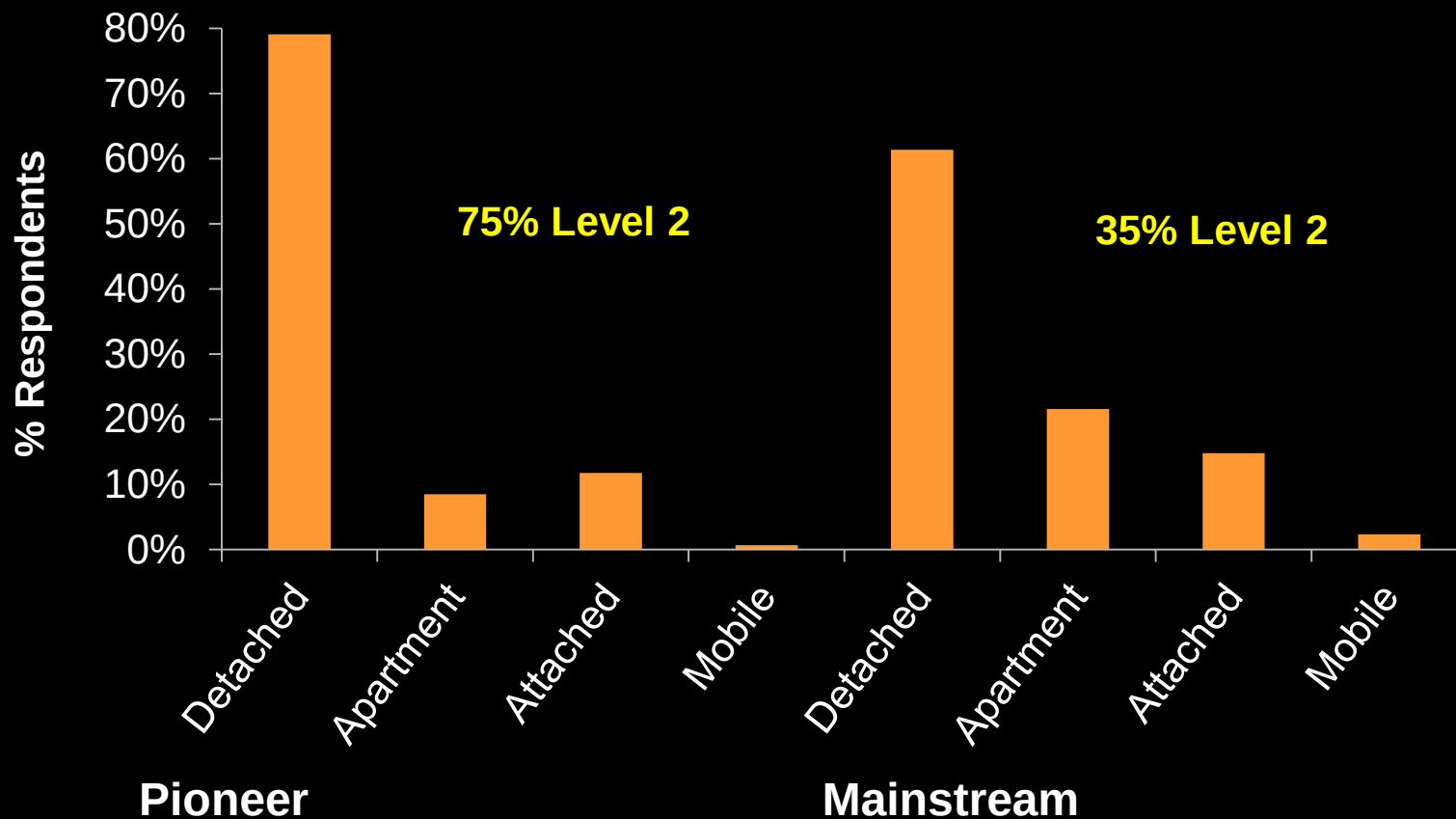
- 1. ...have lower incomes and education**
- 2. ...slightly lower enviro. and tech. orientation**
- 3. ...are less likely to have access to charging**
- 4. ...have much lower PEV awareness**
- 5. ...tend to prefer PHEVs (over BEVs)**

Mainstream report lower educated, income, “greenness” and “techie”



Mainstream less likely have access to faster home charging and live in detached homes

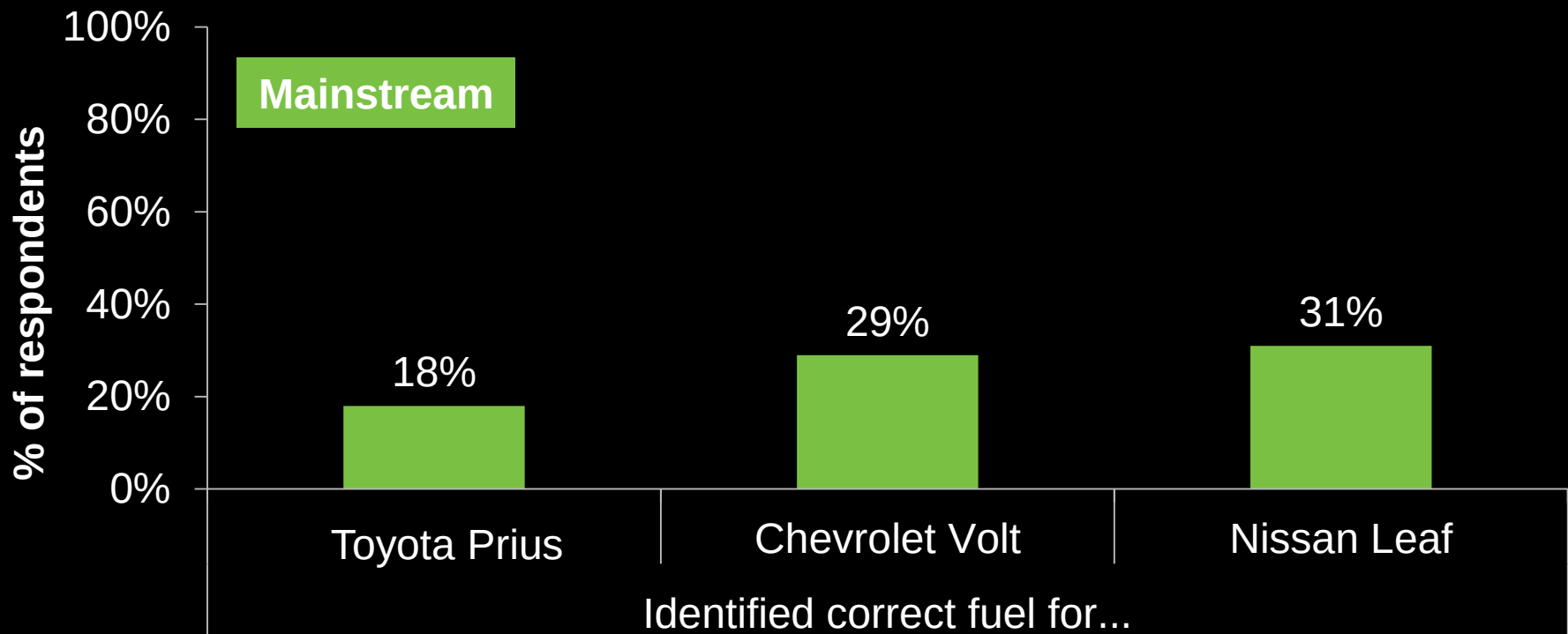
Mainstream and Pioneer recharge access ($\geq 110V$) by dwelling type



**Home charging access is a
significant predictor of Mainstream
PEV interest**

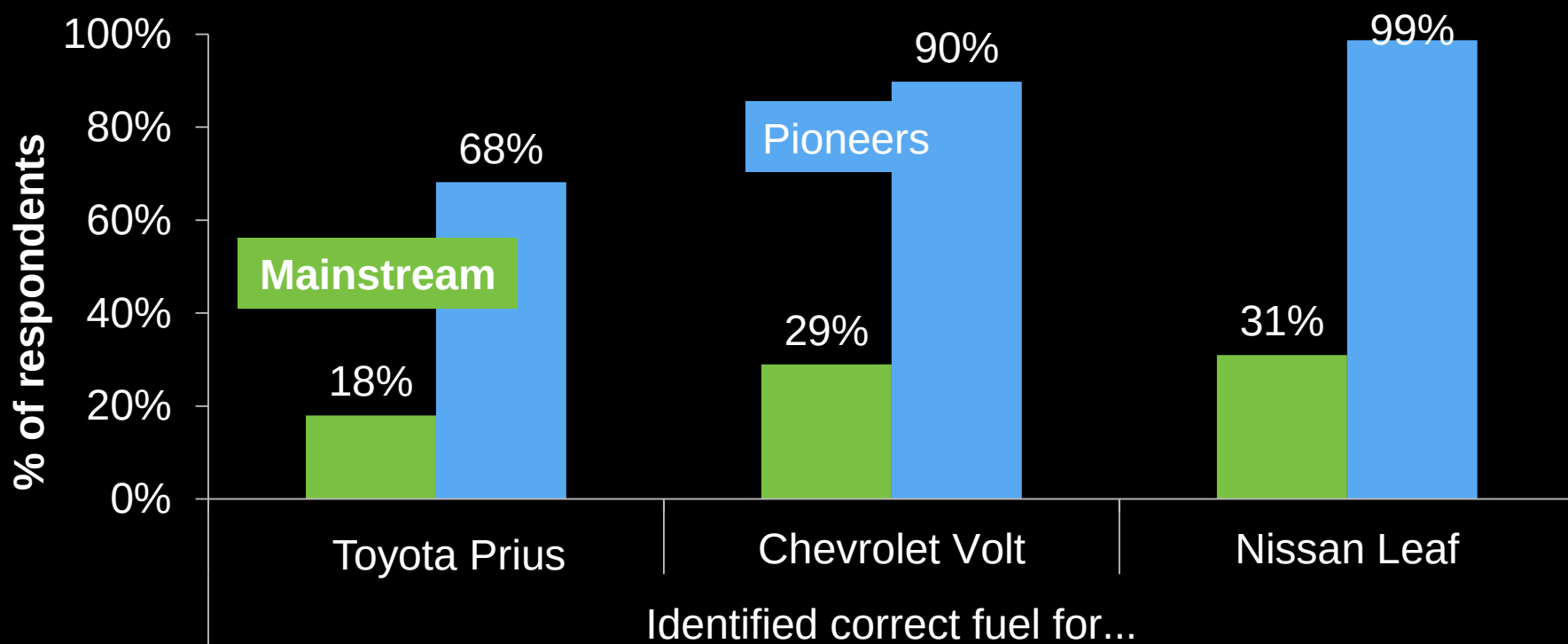
Mainstream are confused about vehicles

“How is each of the following vehicles fueled?”

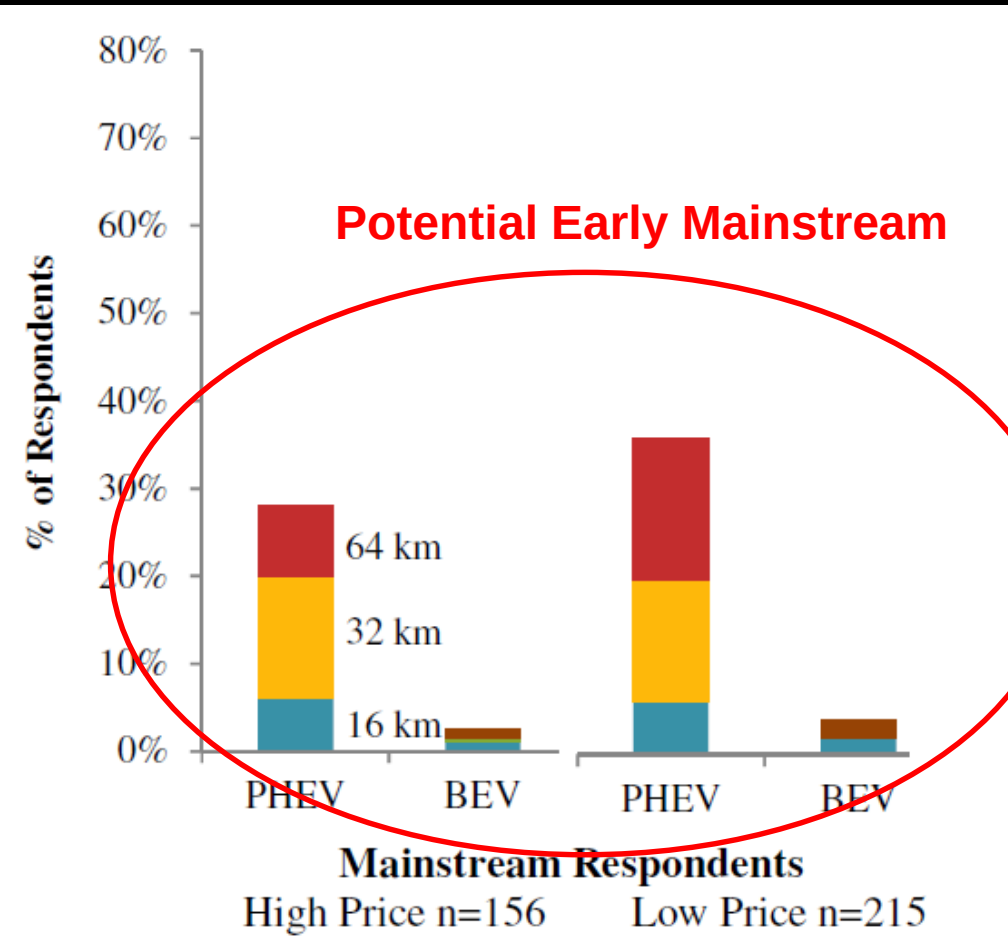


...Pioneers demonstrate little confusion

“How is each of the following vehicles fueled?”

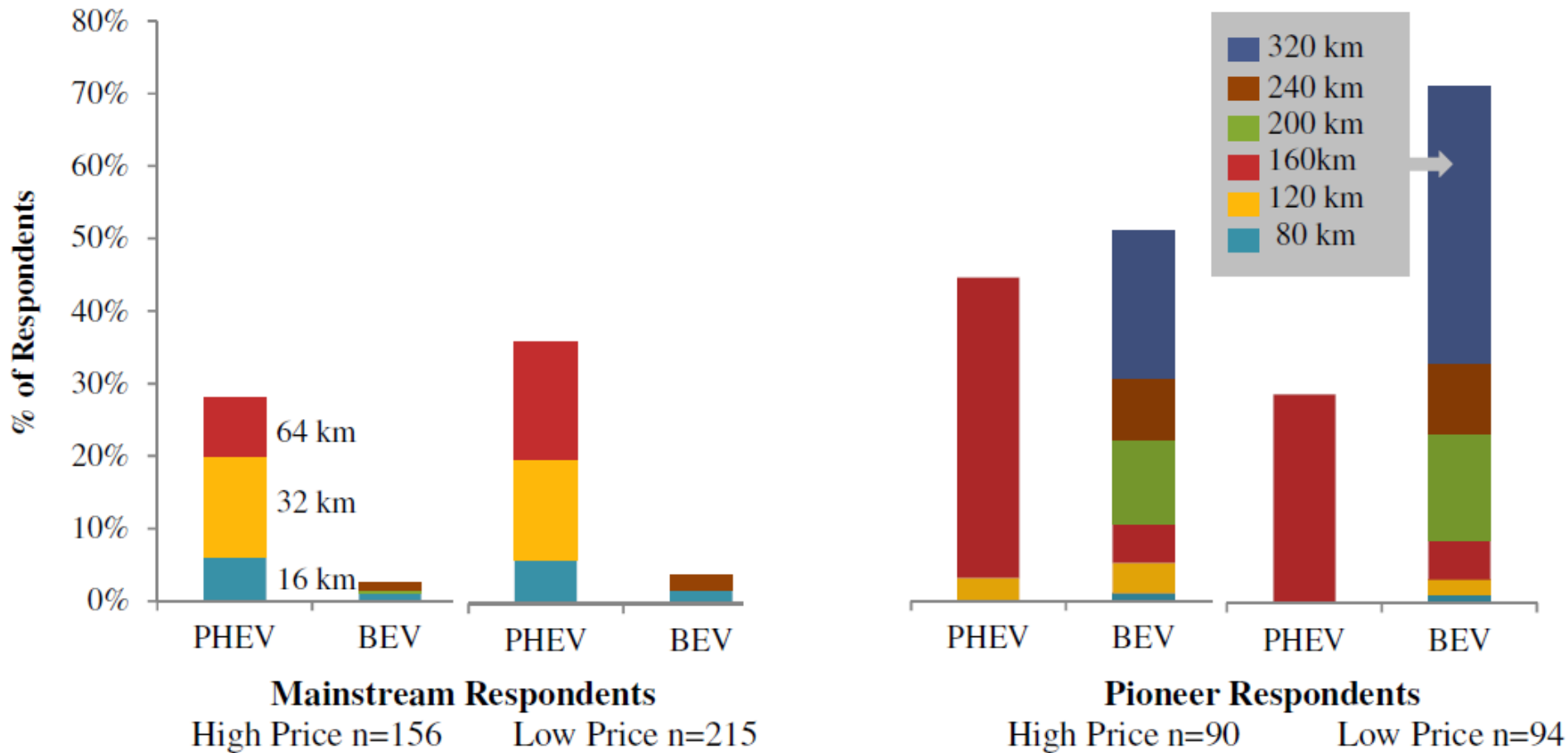


About 1/3 of Mainstream buyers designed PEVs, and most preferred PHEVs



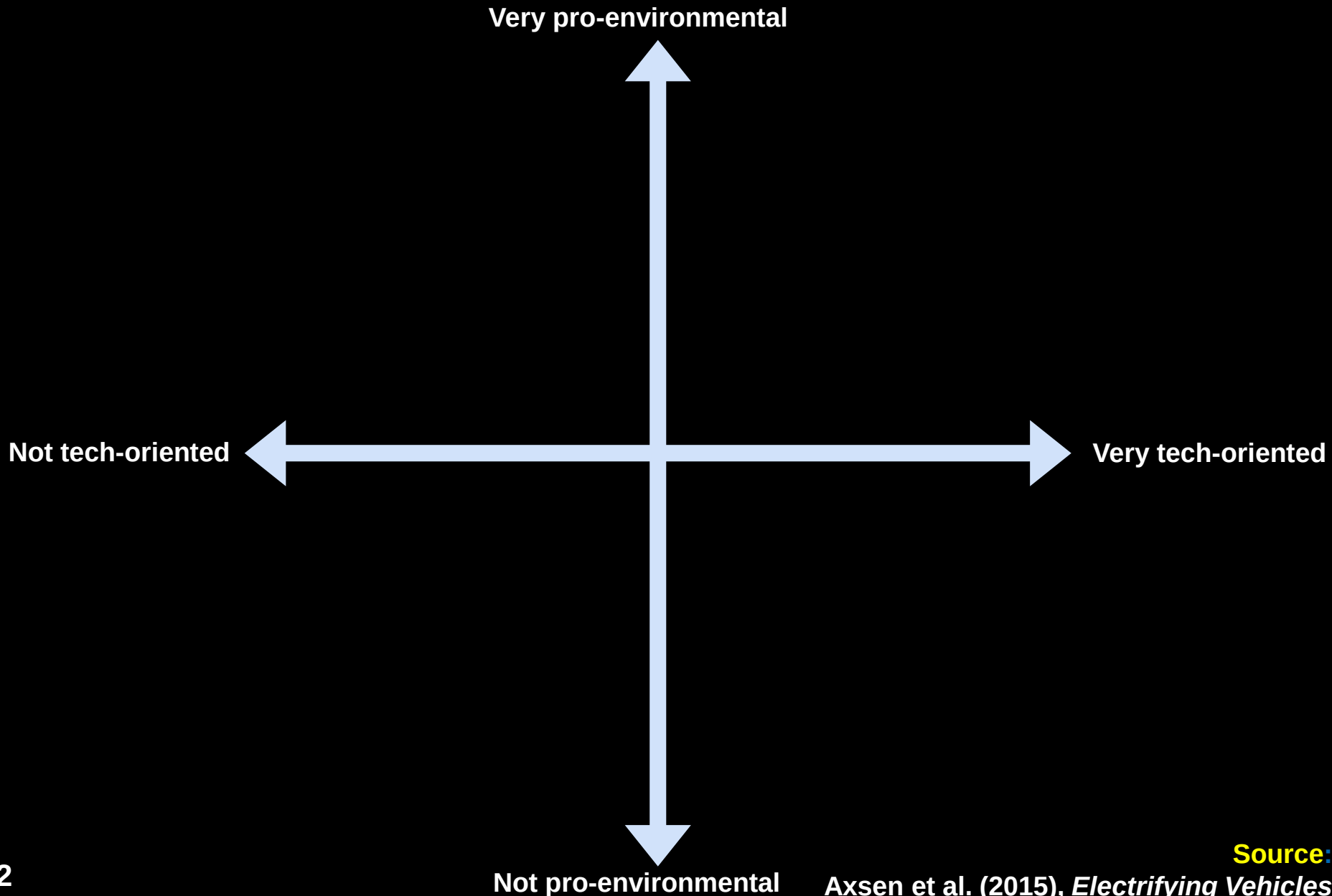
28-36% of respondents designed a PHEV as their “next new vehicle”

Almost all Pioneers designed a PEV, and preferred BEVs when vehicle prices were low



Not all Pioneers and Early Mainstream have the same motivations, despite PEV interests

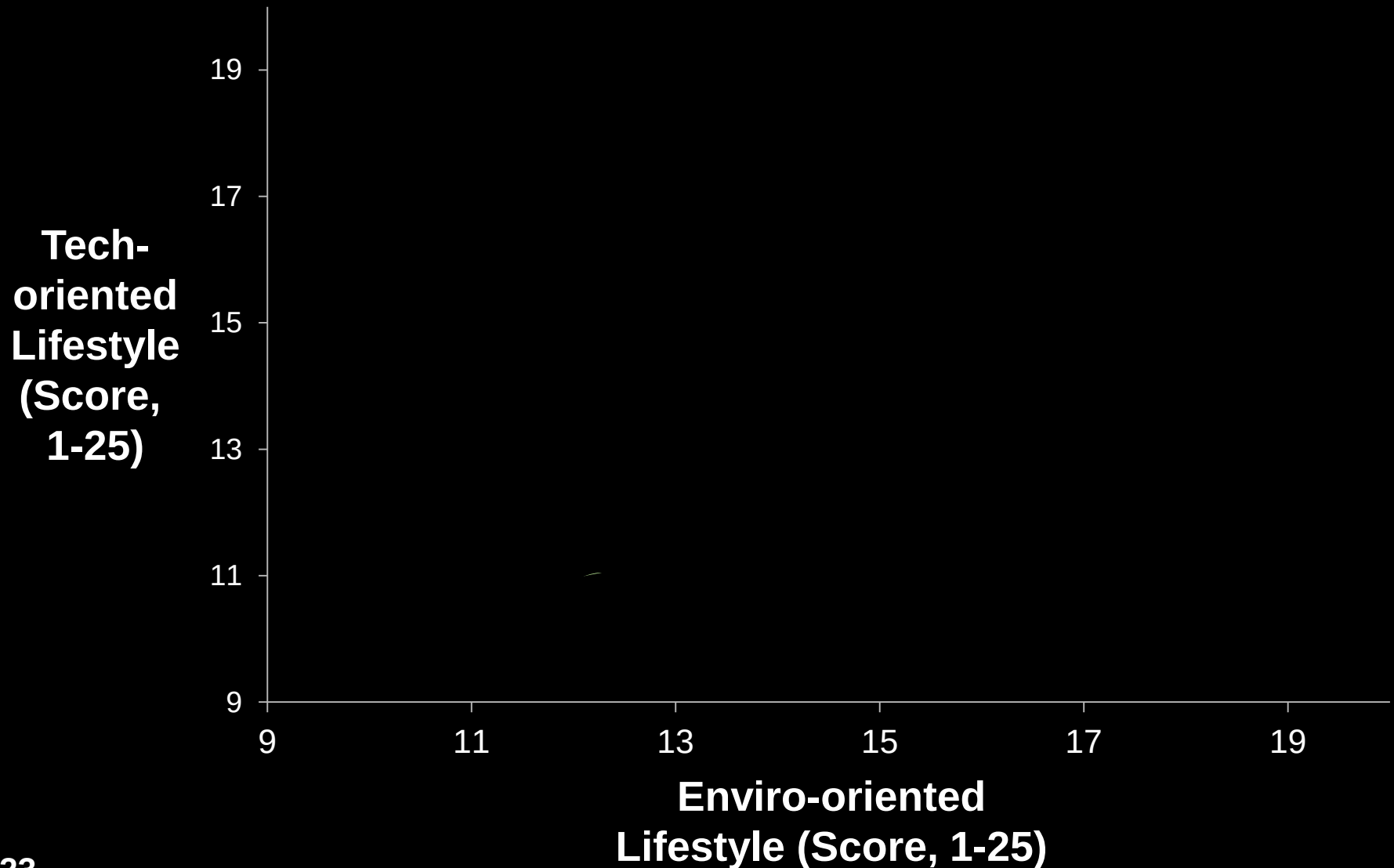
4 lifestyle segments of Pioneers



Source:

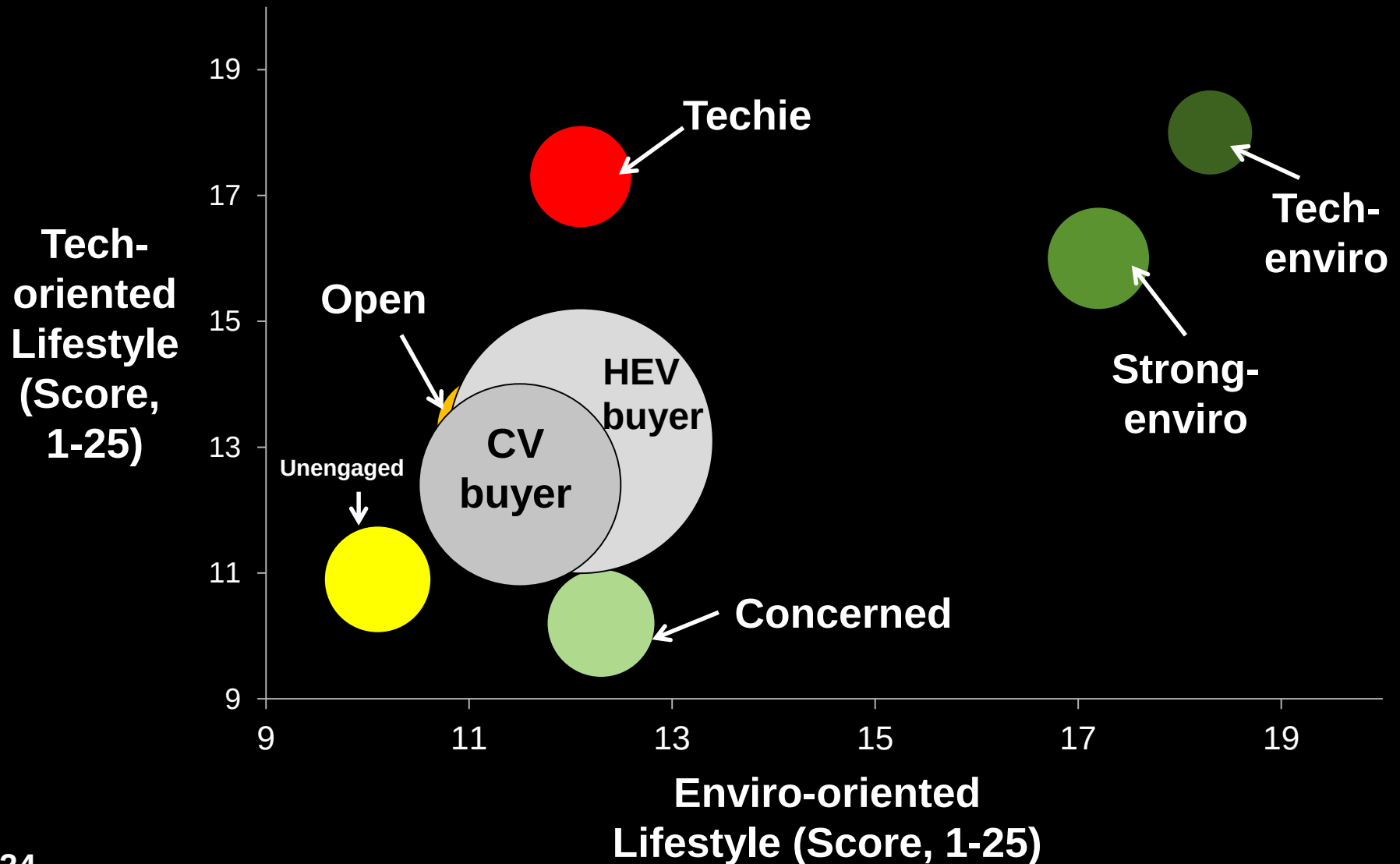
Axsen et al. (2015), *Electrifying Vehicles*

6 Lifestyle segments of Early Mainstream



Source: Axsen et al. (2015), *Energy Economics*

6 Lifestyle segments of Early Mainstream



Source: Axsen et al. (2015), *Energy Economics*

Implications for policy makers and automakers

Early Mainstream is an important segment...

Prefer PHEVs

Policy Maker

Provide support for BEVs+PHEVs

Automaker

Produce a range of PHEVs

Drive change with us

Help shape Canada's transportation future



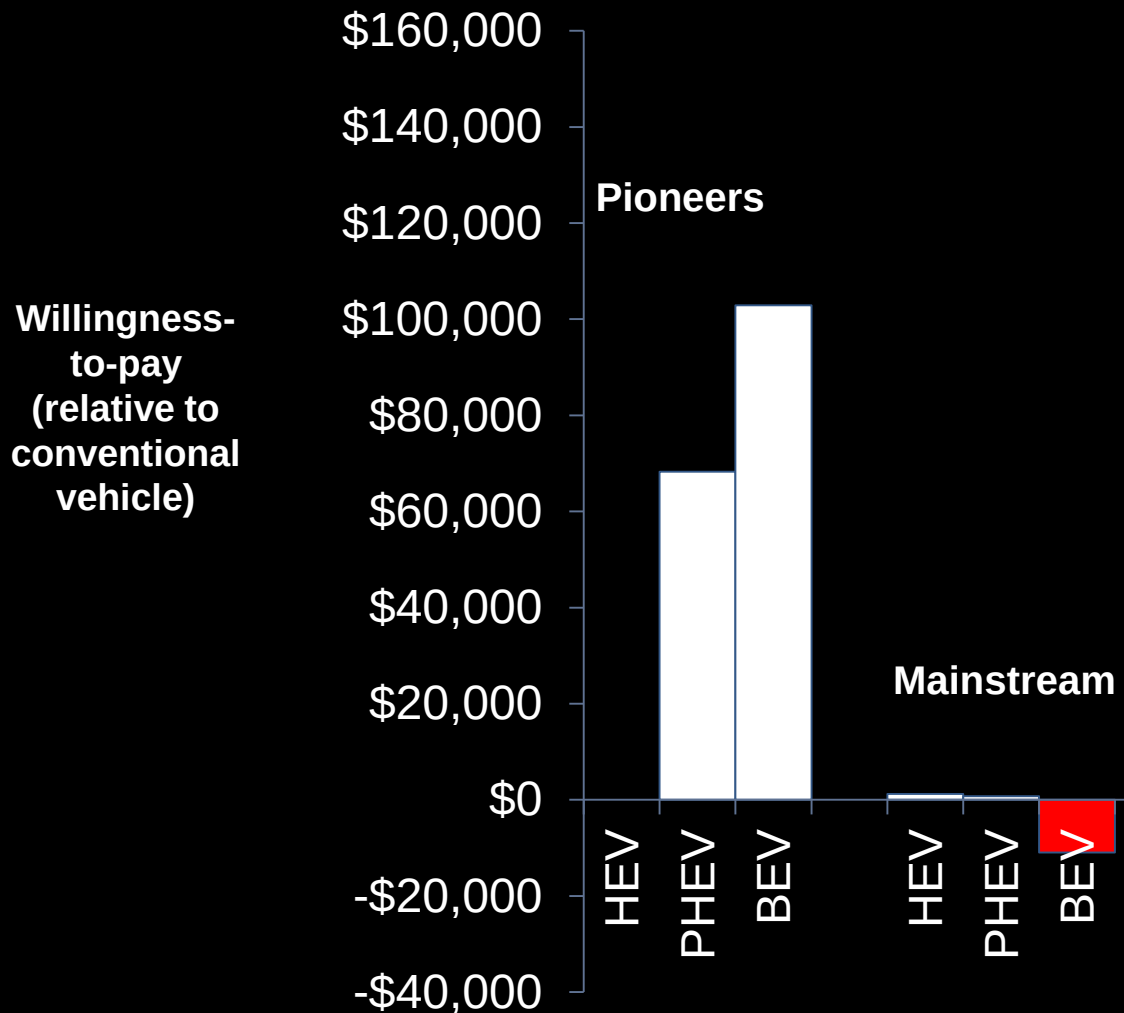
Suzanne Goldberg
START Director of
Research
sgoldber@sfu.ca

Dialogue with us
Tuesday @ 1:45

SFU

Informing Market Share Forecasts and Policy with Survey Data BC Case Study

Pioneers value PEVs more than Mainstream

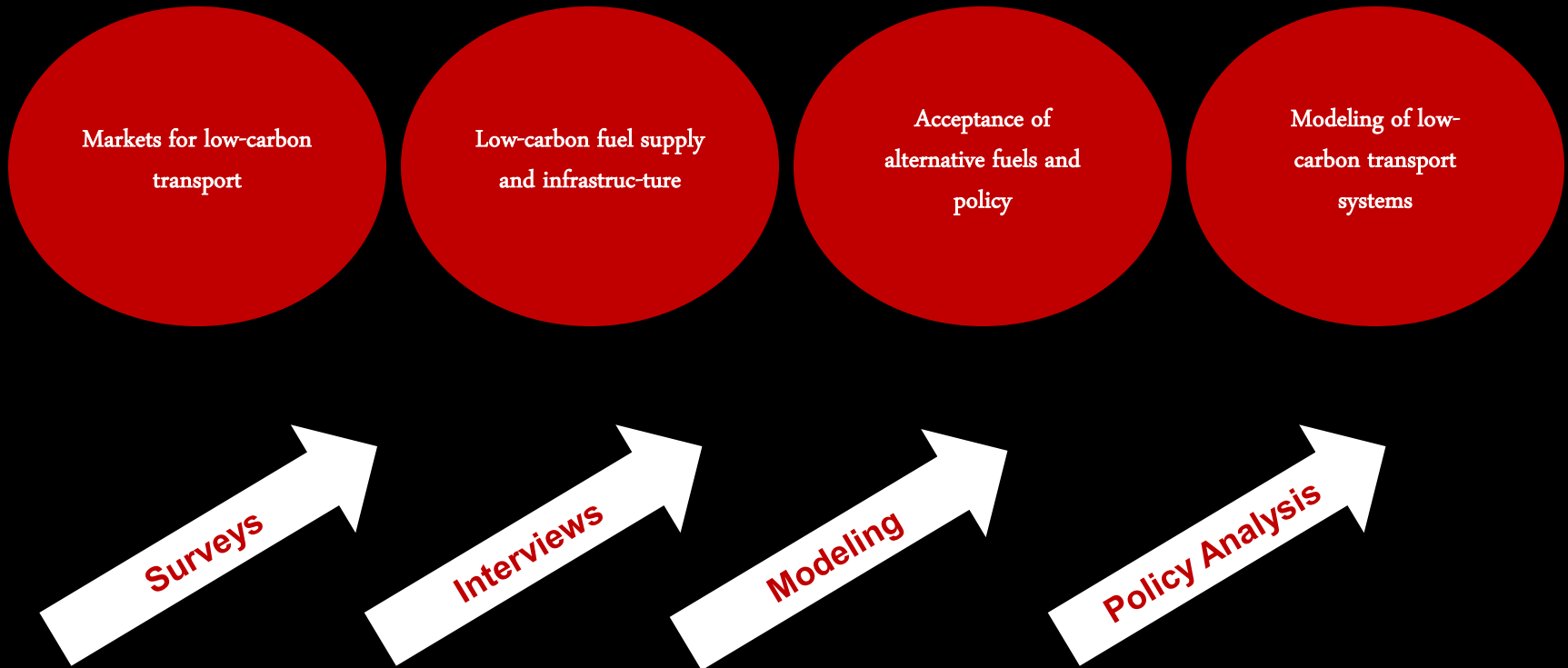


Sustainable Transportation Action Research Team (START)

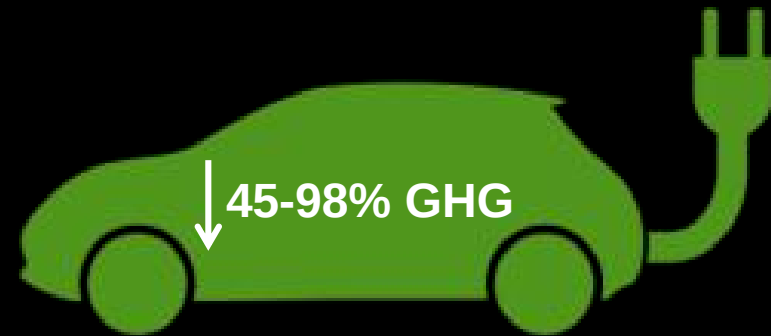
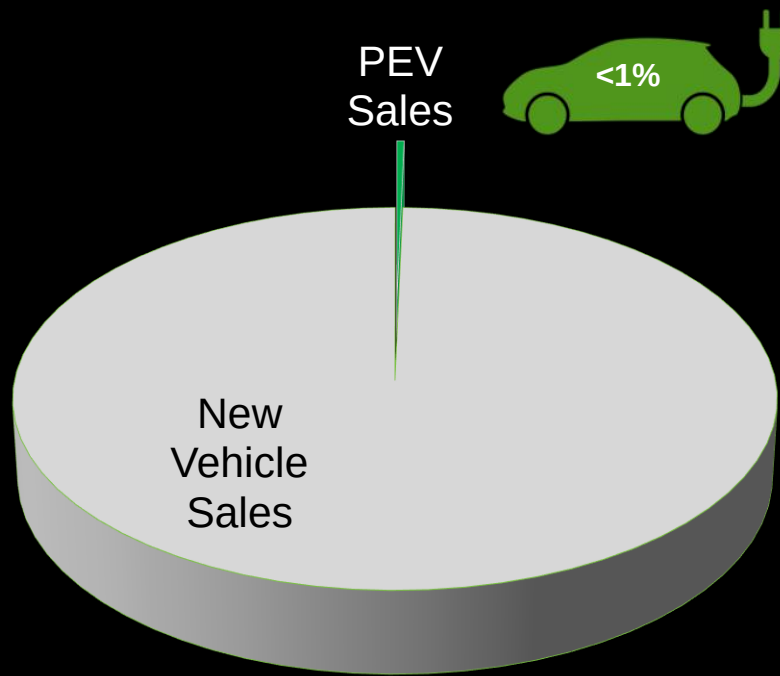
Supporting sustainable shifts in transportation with research that assesses consumers + markets + technologies to provide business and policy advice



Four main themes of our research:

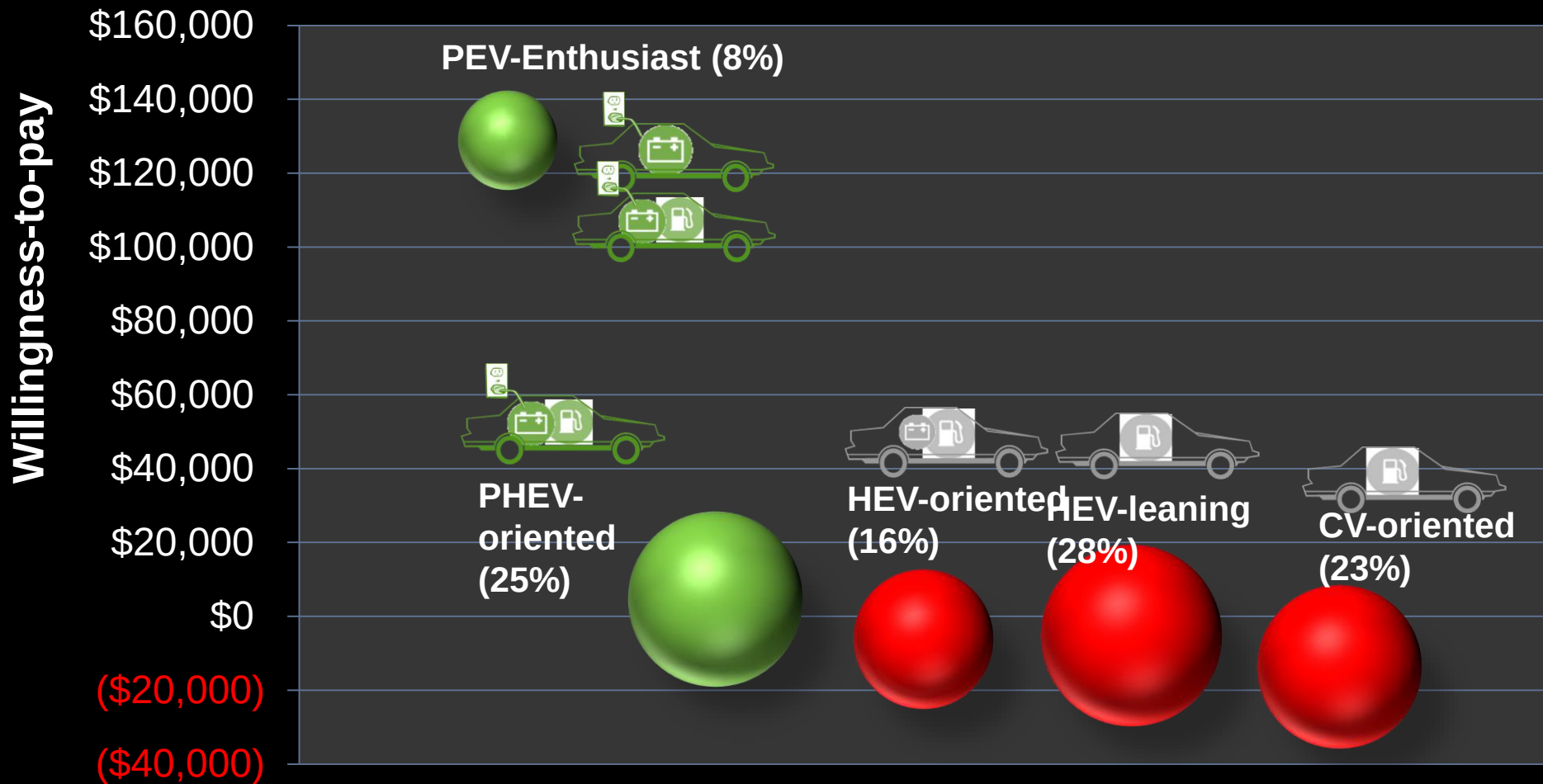


Canadian PEV market



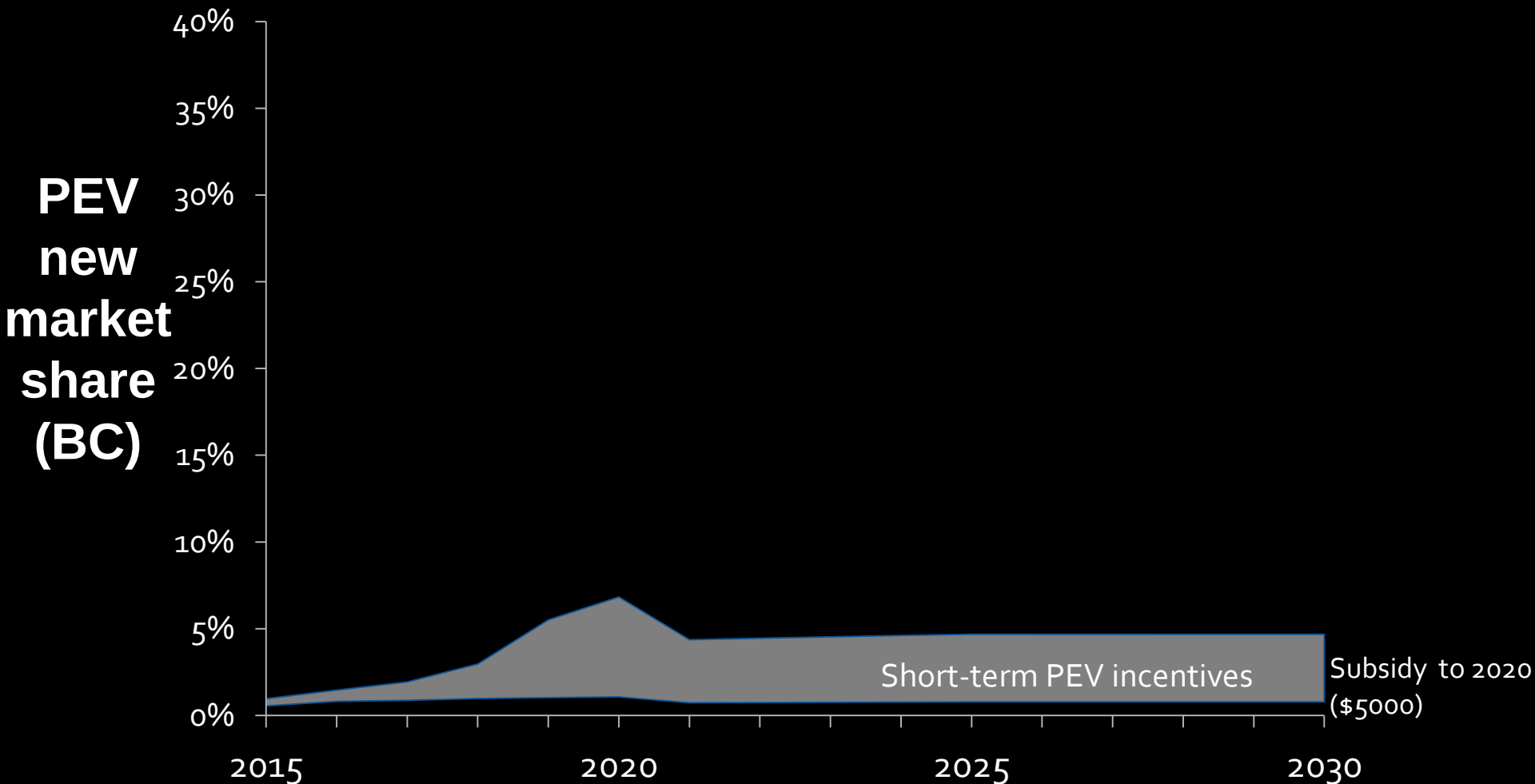
Assessing Policy:

Just over 1/3 of Mainstream buyers value PEVs

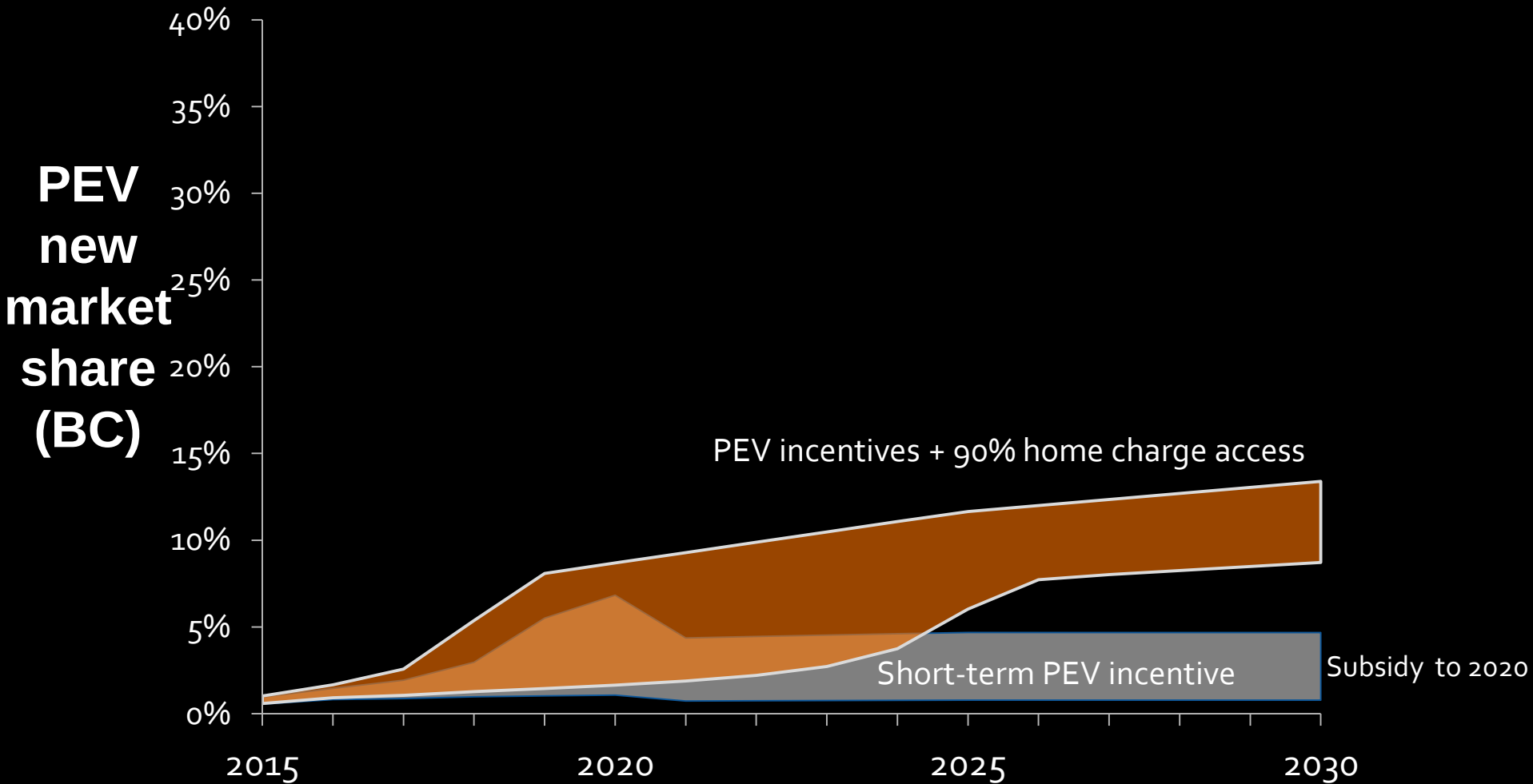


Source: Axsen et al. (2015), *Energy Economics*

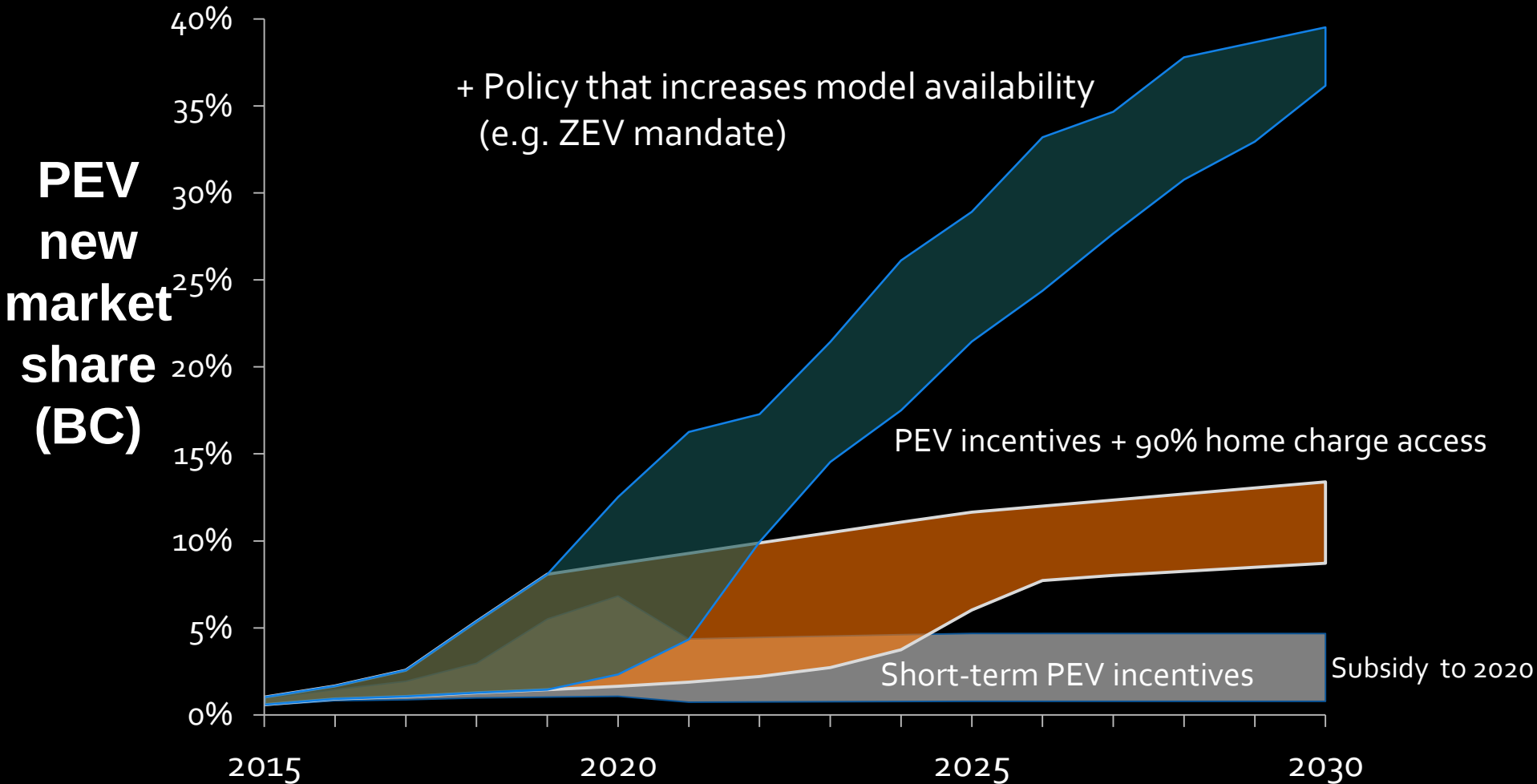
Short-term PEV incentives yield moderate improvement in demand



More charging access improves demand, but only gets us so far



Greater model availability (50+ models) gets us closer to PEV SUCCESS



Constraints model has 4 key components

$$CD_{i,j} = UD_{i,j} * HC_i * PF_{i,j} * PA_{i,j}$$

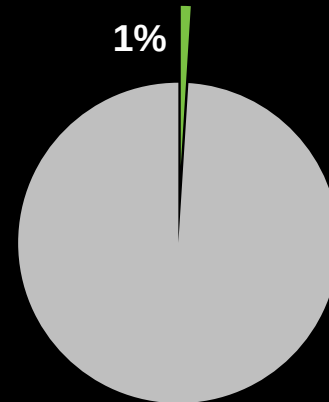
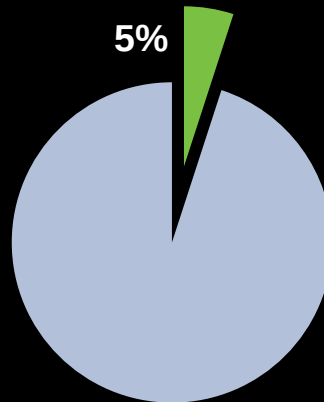
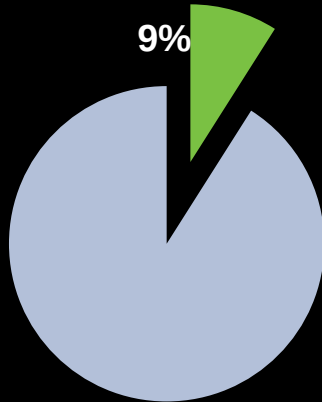
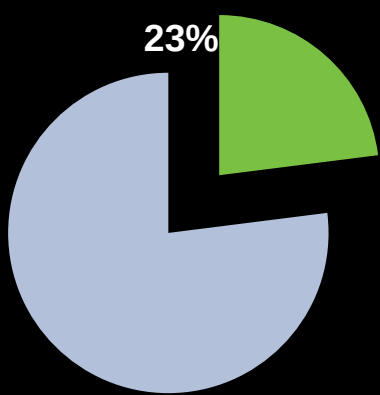
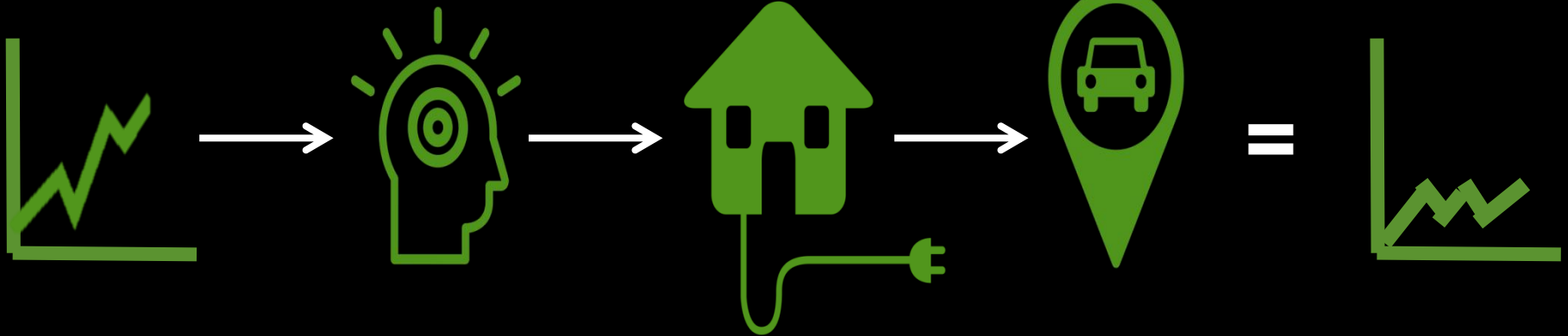
Unconstrained
Demand

Are they
familiar
with PEVs

Do they have
home
charging

Can they buy
one and do
they have
choice?

Consumer PEV
Demand

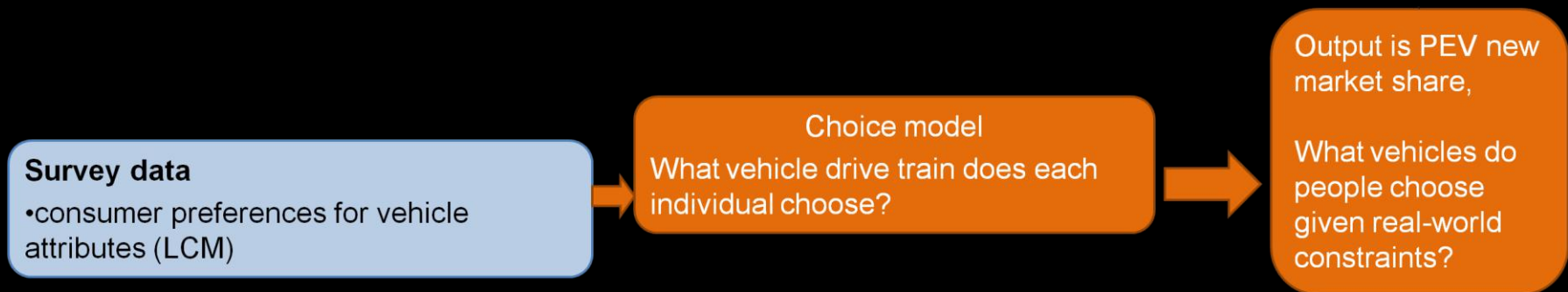


Survey and vehicle data are combined to develop models that forecast future PEV market shares: Respondent-based Preference And Constraint Model (REPAC)

Model Inputs

Model Components

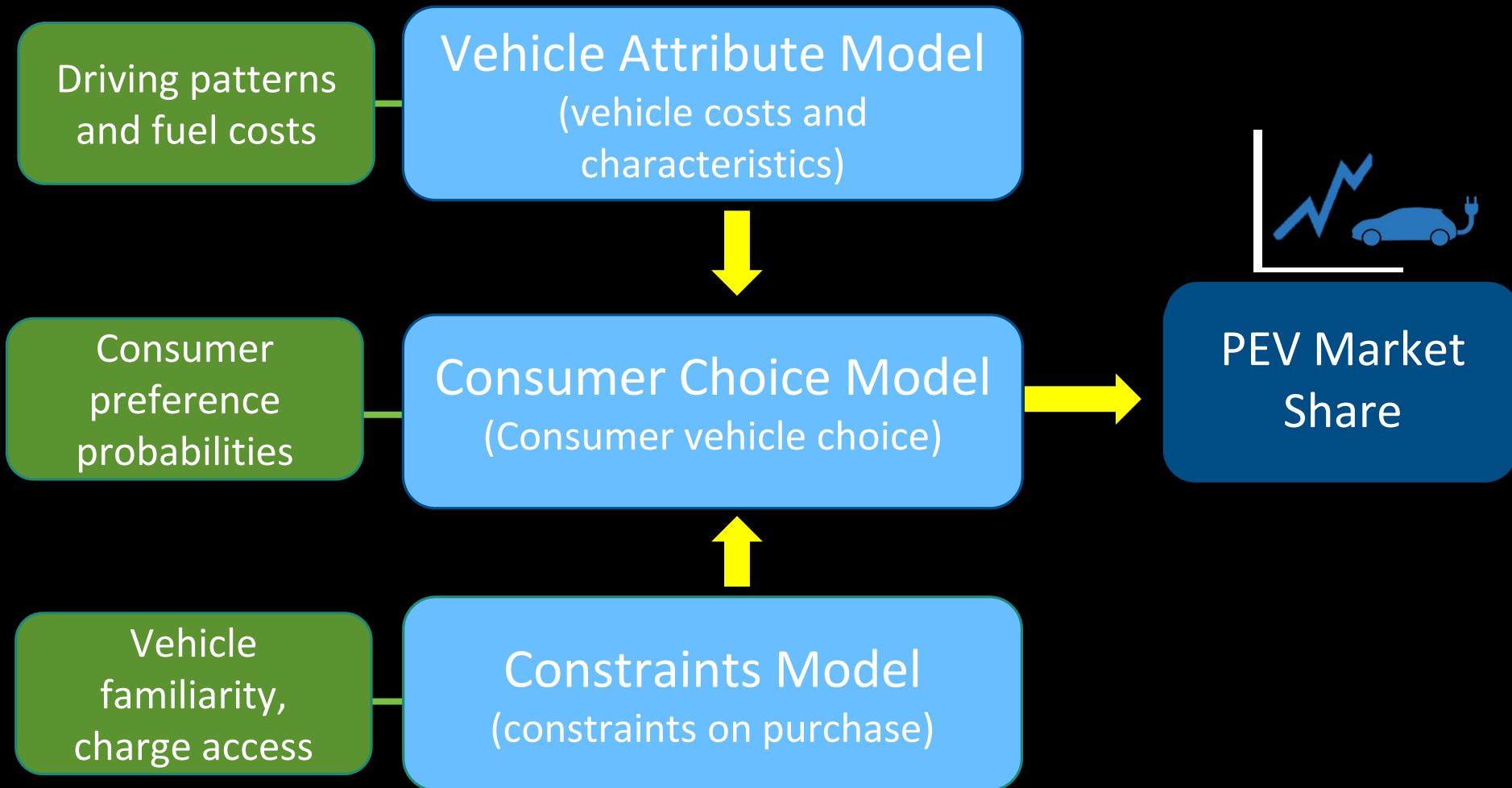
Model Outputs



Agenda

- 1. The Canadian PEV market**
- 2. The Canadian Plug-in Electric Vehicle Study**
- 3. Pioneers and Mainstream buyers in Canada**
- 4. Informing market share forecasts and policy assessment with survey data**

REPAC is informed by consumer survey data



Forecasts of PEVs vary and optimistic

Assessment of these approaches suggests:

- **Vehicle decision not based just on cost and functional constraints**
 - **Other factors considered in vehicle purchase**
- **Consumer and automakers decisions often ignored**
 - **Both important factors and can limit understanding of policy impact**

Comparing PEV policies

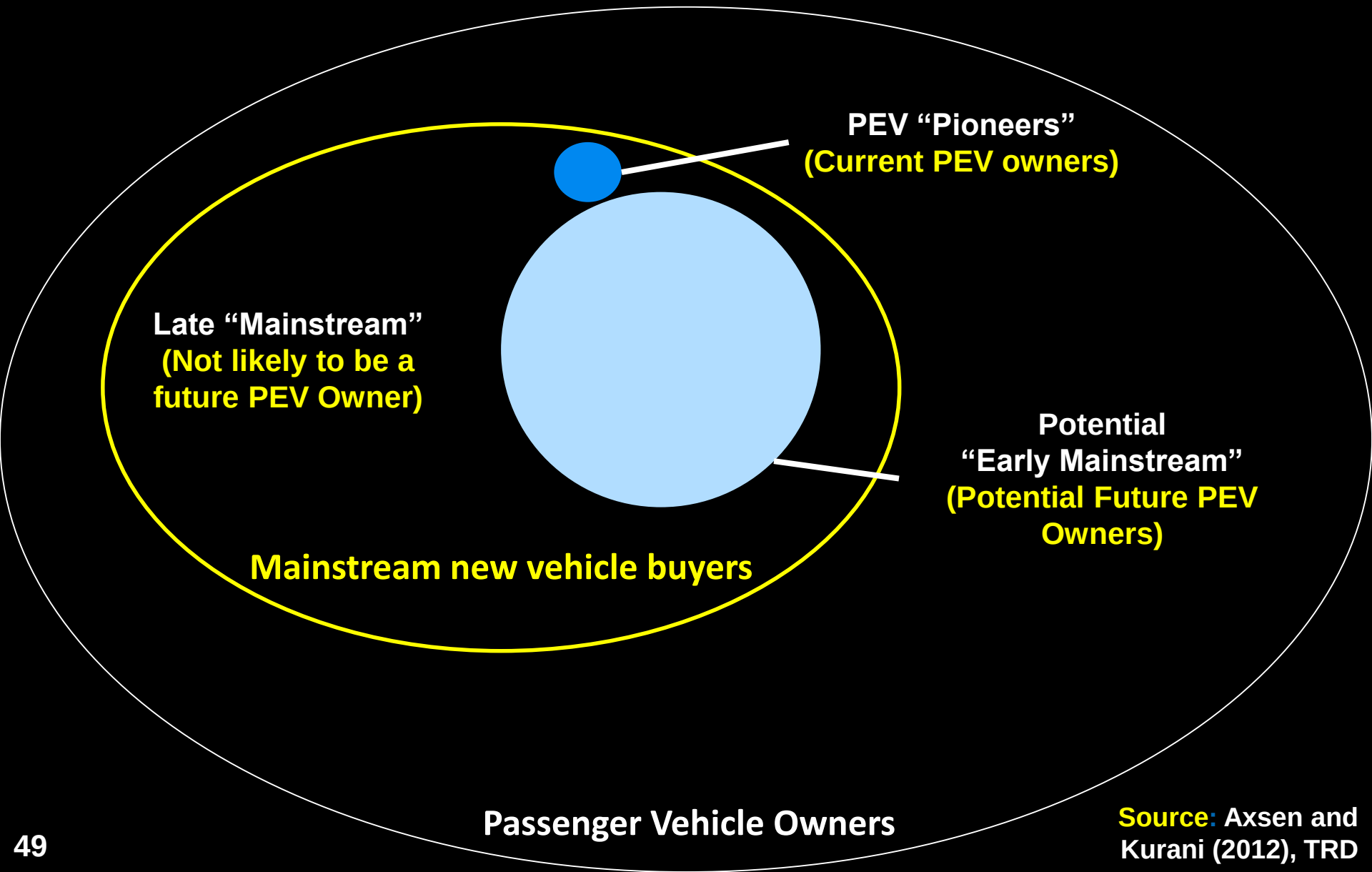
Demand-focused policies

Purchase incentives

Rebates, tax breaks, fee reductions

Supply-focused policies

Our framing of the Canadian PEV market: Now and future



Source: Axsen and
Kurani (2012), TRD

REPAC will guide evaluation of Canada's PEV-readiness in our forthcoming (Summer 2016) policy scan project

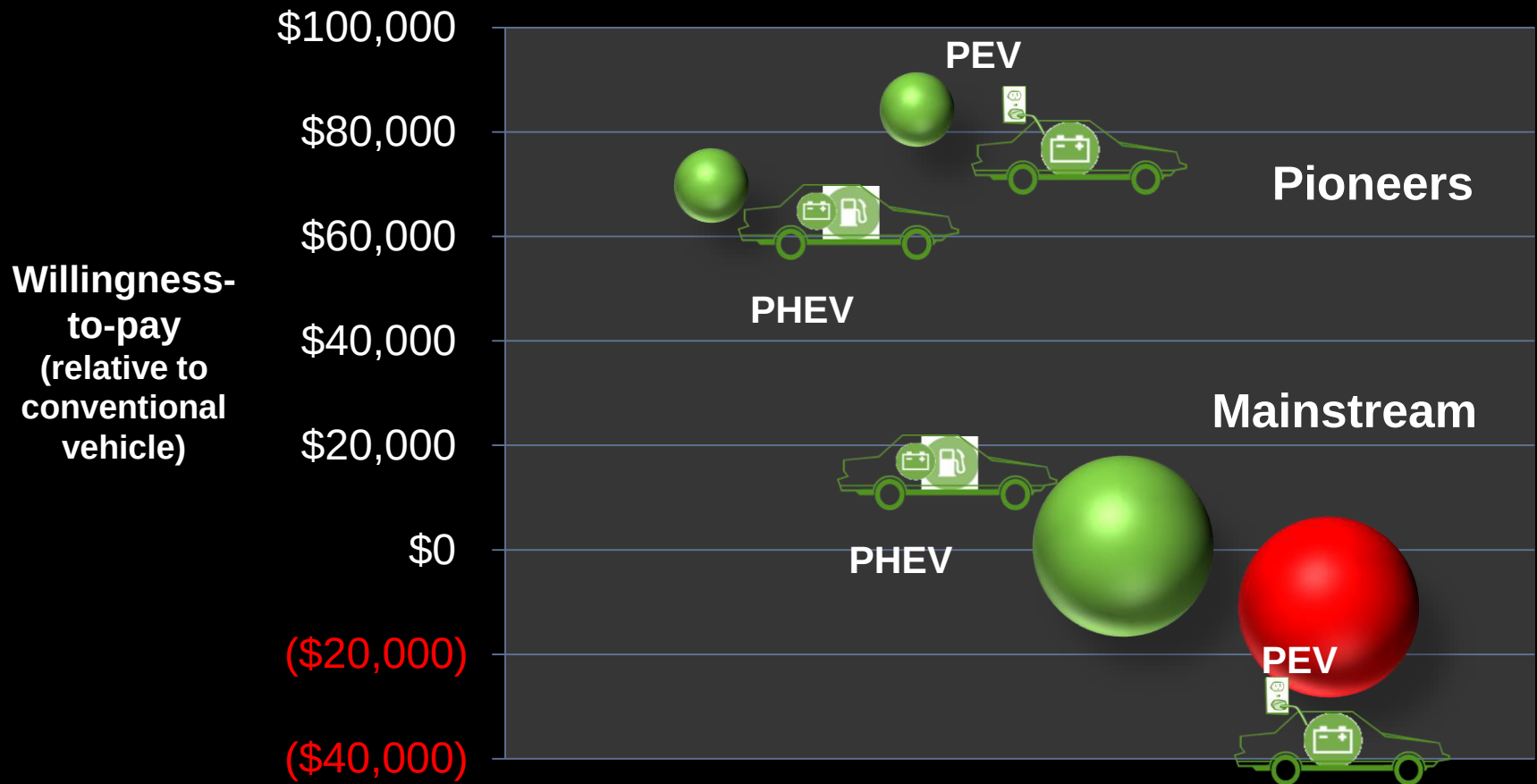
Project Next Steps

1. Define evaluation criteria
2. Determine criteria weighting (modeling and lit review)
3. Assess policy impact (modeling and lit review)
4. Grade provinces' PEV-readiness
5. Provide recommendations

Provincial PEV Report Card [Example]	
British Columbia	D
Alberta	F
Saskatchewan	F
Manitoba	F
Ontario	D
Québec	D
New Brunswick	F
Nova Scotia	F
Prince Edward Island	F
Newfoundland	F
Yukon	F
Northwest Territories	F
Nunuvat	F

Source: Melton and Goldberg
(in-progress)

Pioneers are willing to pay significantly more for PEVs than Mainstream buyers



Responding to critiques of alternative fuel vehicle forecast studies

Al-Alawi and Bradley's (2013) recommendations for a “useful” model:

1. Better represent consumer behaviour:

- Use consumer data (survey, e.g. choice model)
- Represent financial and non-financial motivators

2. Model vehicle supply and actions of automakers

- Availability of PEV models (in dealerships)
- Variety of PEV models
- Vehicle class

3. Model national and subnational policy

- Demand-focused policies (incentives, charging access)
- Supply-focused policies (production requirements)

Extra: Charger

Actual and Potential Charging Patterns

Pioneers report greater daily driving distances than mainstream

*I feel less
“hypocritical”
driving to
experience nature*

*Now I do “not think
twice” about having to
drive to the grocery
store.*

45 km (median)

- Less guilty about enviro. impact
- Saves money; cheaper to drive
- Enjoy driving experience

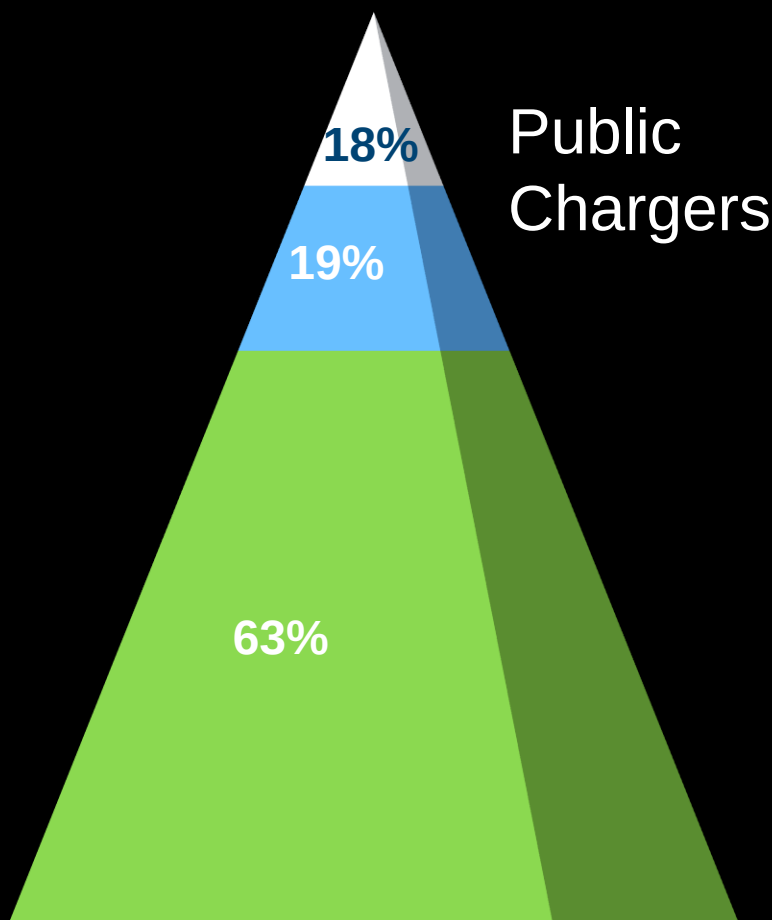
36 km (median)



Source: Cairns (forthcoming), Axsen, Goldberg et al. (2015)

Most charging occurs at home when the average duration of a charge is longer

Modeled after EPRI's charging pyramid



- Individual locations used infrequently
 - 9/13 interviewed household's use was rare
 - Weak link between awareness of charger and Mainstream PEV interest

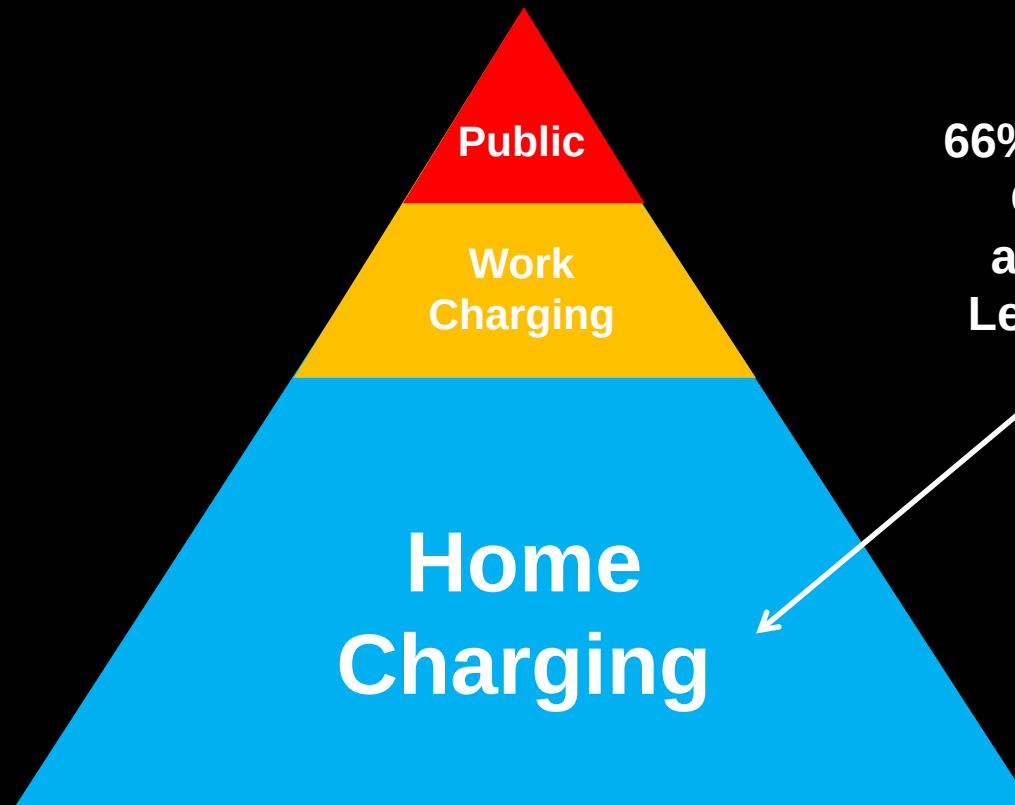
"n" charging events = 831

Charging is only one issue...

Level 1: Regular outlet (1-2 kW)

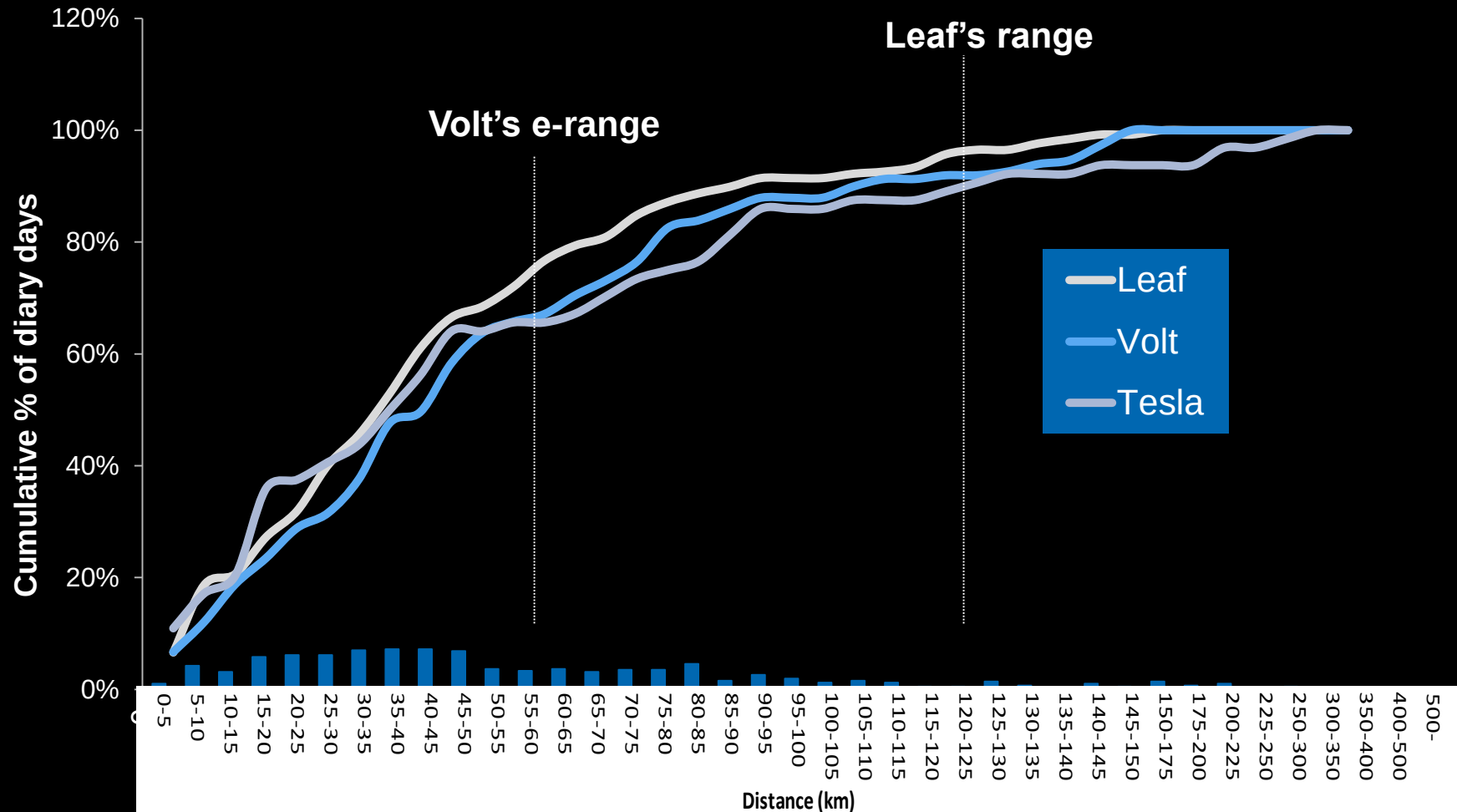
Level 2: Your dryer outlet (3-6 kW)

Level 3: Fast charging (20-200 kW)



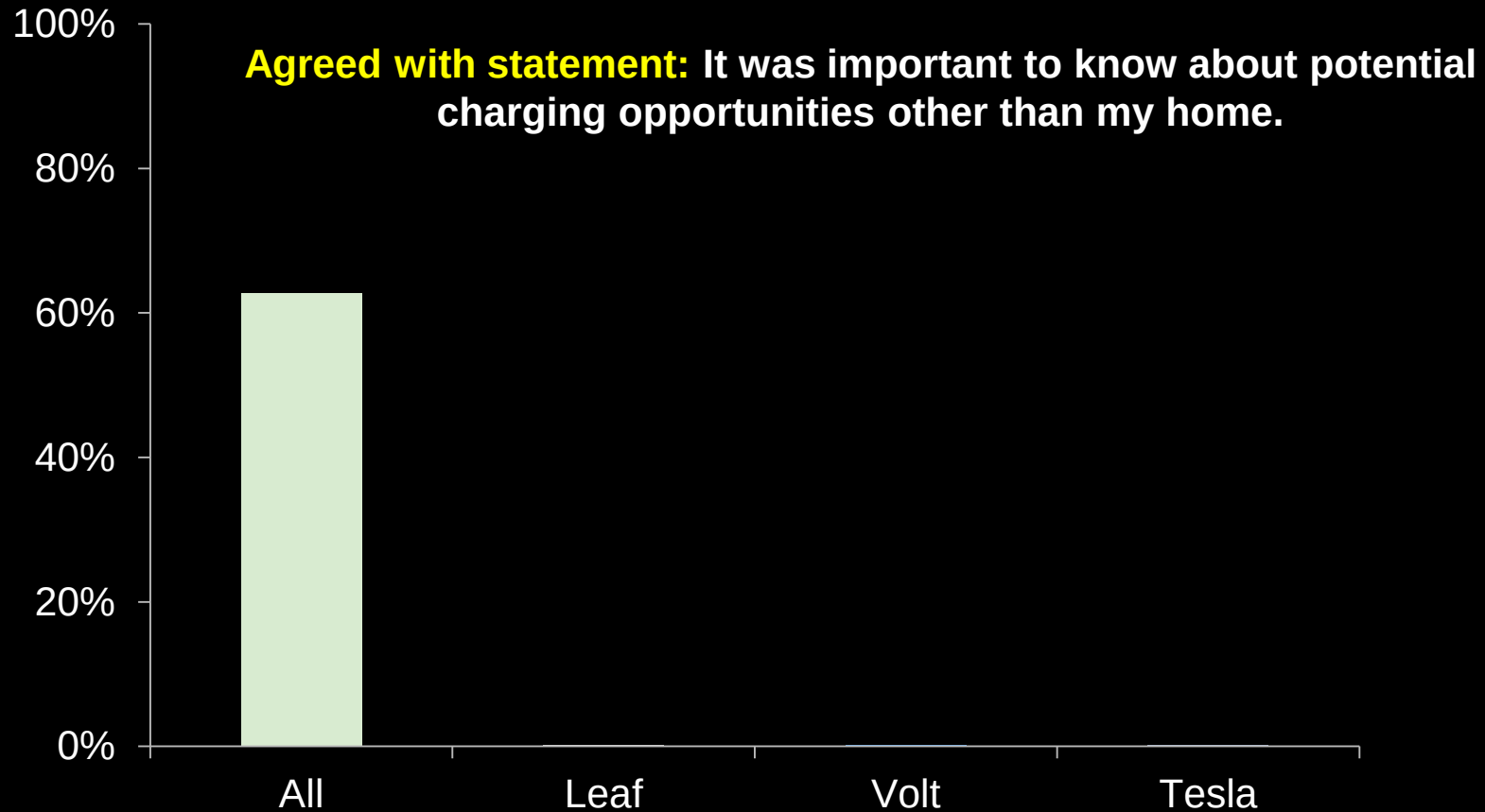
66% of Canadian
Car buyers
already have
Level 1 access

Over 60% drive on average no further than the range of a Volt during the day



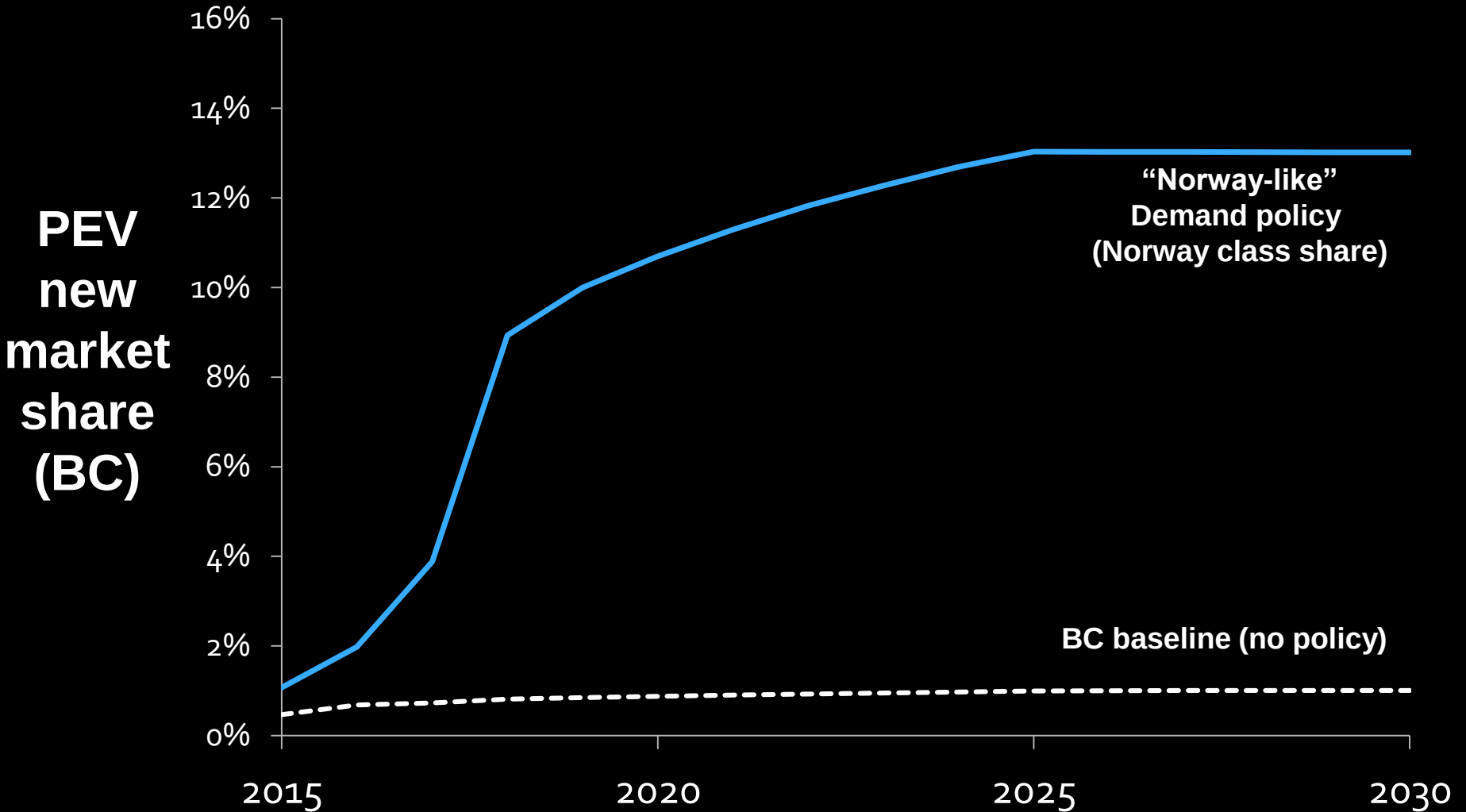
"n" diary days= 257(Leaf); 149 (Volt);

Pre-purchase knowledge of chargers was important for some (varied by model)

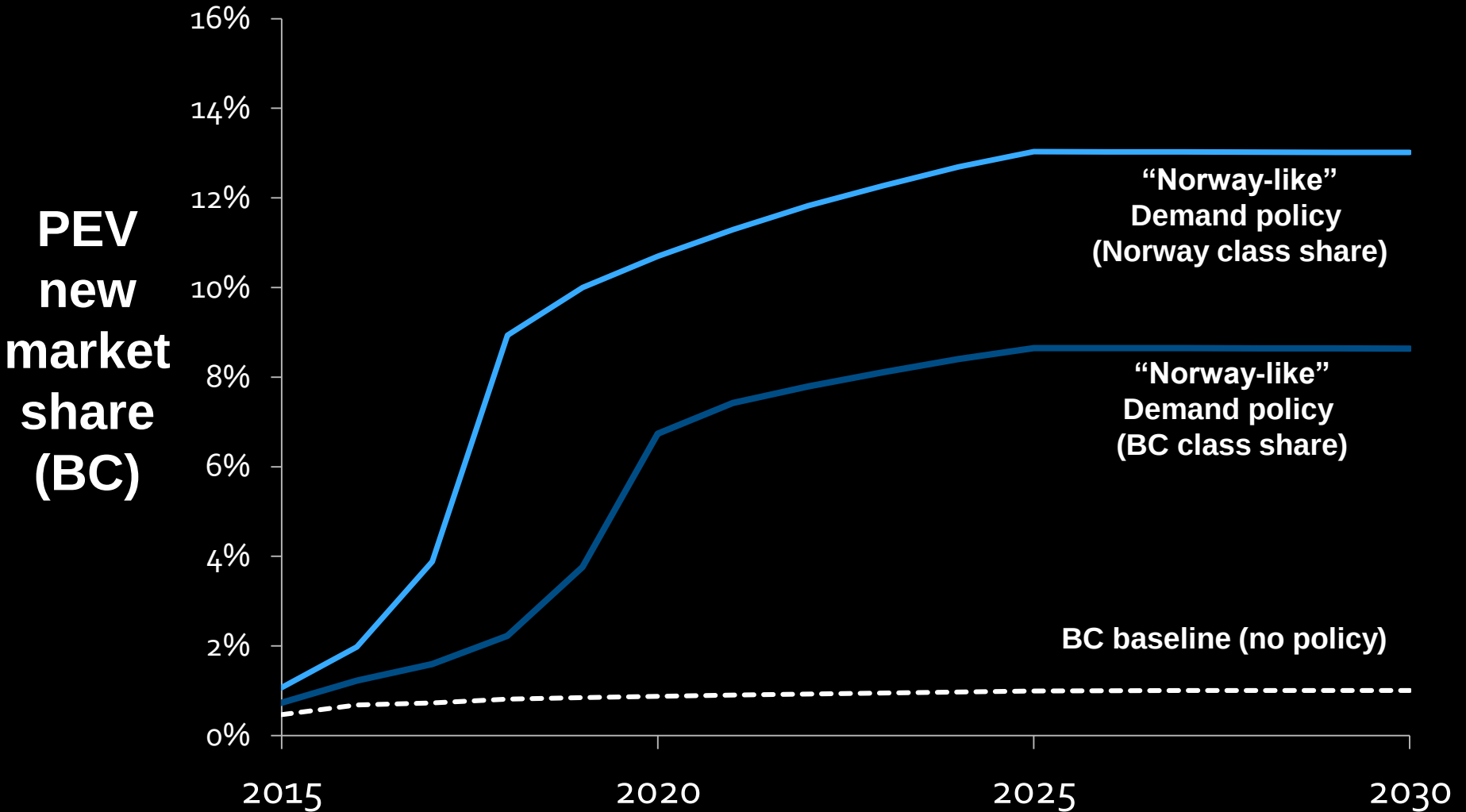


Extras: REPAC

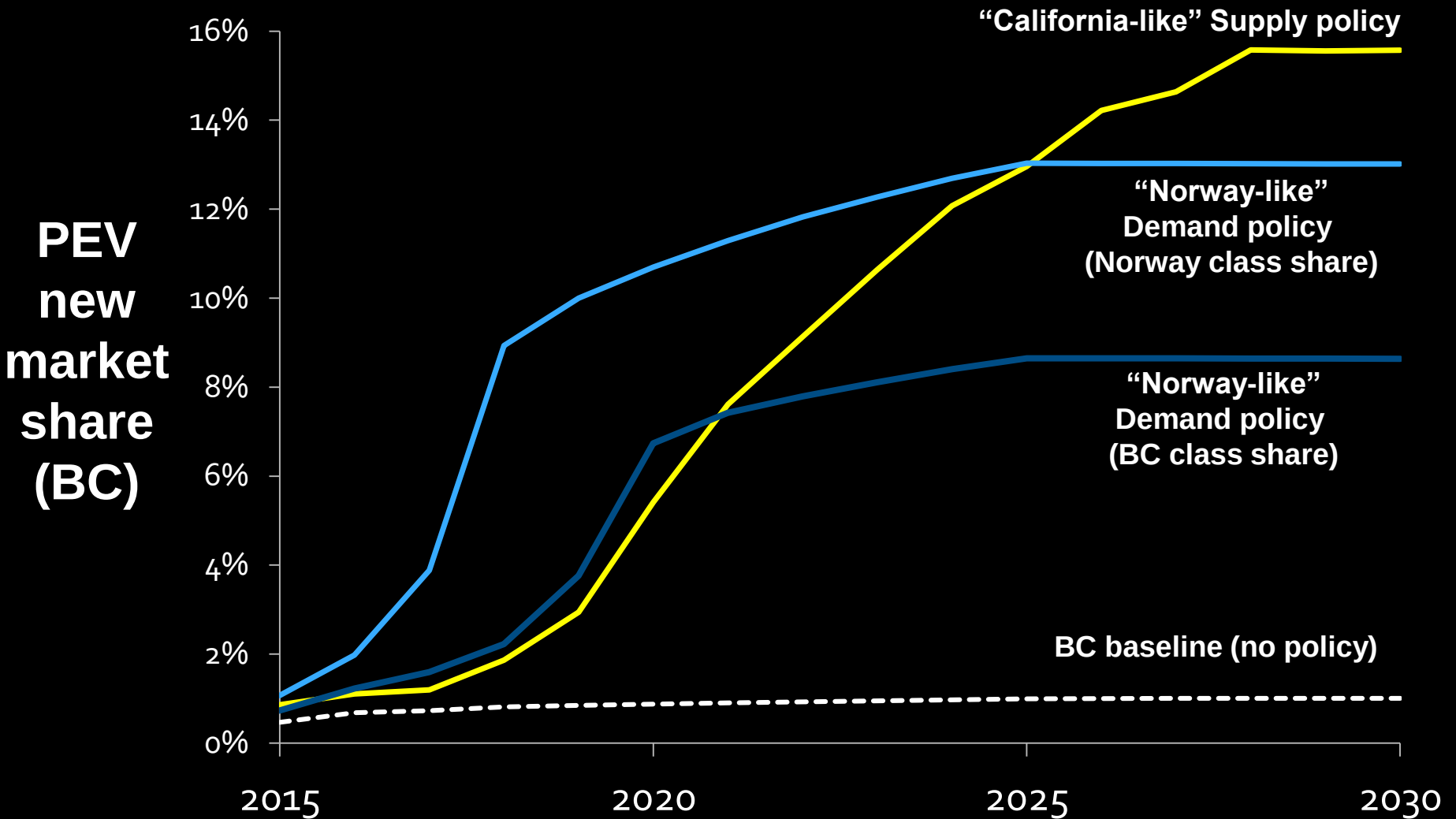
Comparing “Norway-like” and “California-like” policies in Canada via REPAC



Comparing “Norway-like” and “California-like” policies in Canada via REPAC



Comparing “Norway-like” and “California-like” policies in Canada via REPAC



Pioneer and Mainstream interest in Utility Controlled Charging

Utility controlled charging (UCC) of PEVs

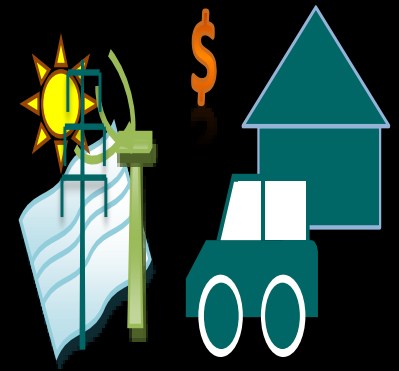
When an electric utility somehow controls the charging of PEVs. Can be timing, charging rate, and discharge.

Benefits:

- Facilitate deployment of intermittent renewables
- General load management, cost reduction
- Subsidize PEV market?

Attributes:

- Monthly electricity bill
- % of renewables
- User inconvenience (Guaranteed minimum charge)

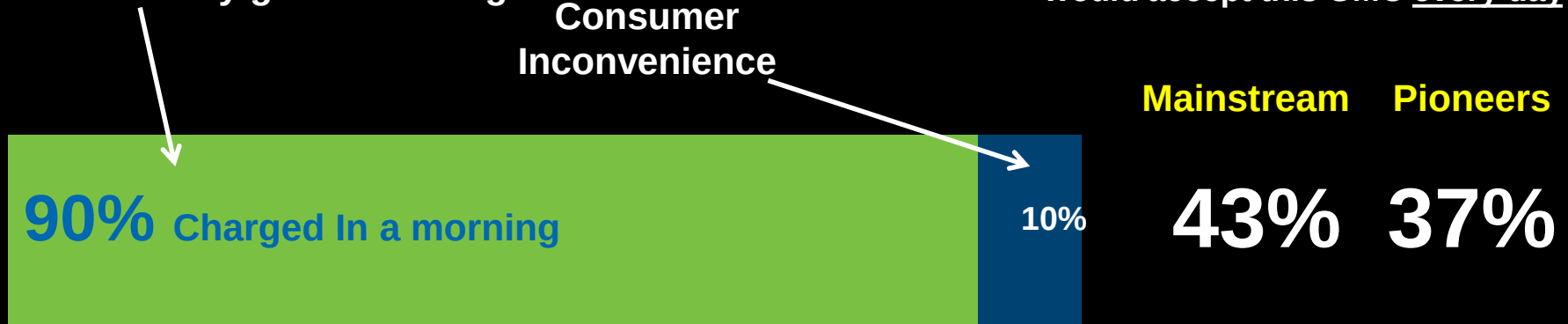


Acceptance of guaranteed minimum charge (GMC) is identical for Pioneers and Mainstream

The absolute minimal level of charge that you would wake up to on any given morning.

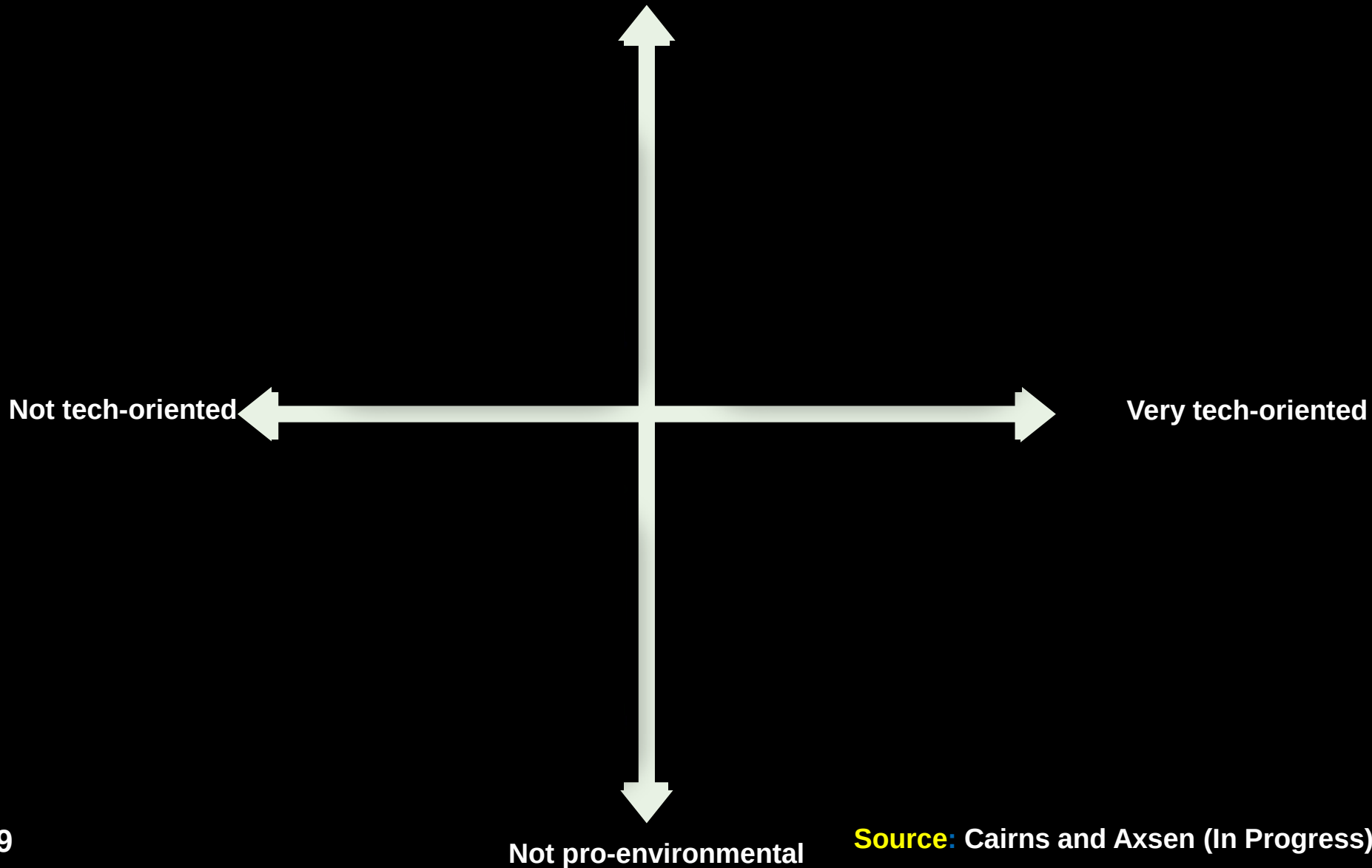
Consumer Inconvenience

Percentage of respondents that would accept this GMC every day



Extras: Misc

Early electric vehicle buyers have different motivations



Source: Cairns and Axsen (In Progress)

Methods used in the study

Surveys

- Knowledge, awareness, perceptions
- Attitudes, values, lifestyle
- Design space exercises
- Discrete choice experiment
- Diaries (driving, charging, social interactions)

Semi-structured interviews

- Narrative analysis
- Content analysis

Quantitative modeling and analysis

- Statistical analysis (regression, choice, cluster, latent class)
- Technology forecast (scenario)
- Policy analysis

Further research and ideas

Ongoing work

- Modeling the “value” of PEV-grid integration (e.g. \$/Tonne of GHG abatement)
- Effects of incentive systems and charging infrastructure on controlled charging efforts.

Future research ideas

- Other proxies for “charge inconvenience”, e.g. minimum charge for emergency use
- Pioneers vs. Mainstream “social influence” and learning of new technology
- Better quantifying perceptions and valuation of UCC for PHEV vs. BEV drivers
- UCC trial project: Mainstream interaction with UCC and “smart charging”
- Applications to fleet drivers

Mainstream knowledge and understanding (interviews)

Table 20: Households categorized by knowledge of vehicle technology (n=22)

Category of electric-drive vehicle knowledge	Households	Knowledge of vehicle type		
		Hybrid-electric vehicles (HEV)	Plug-in hybrid vehicles (PHEV)	Battery electric vehicles (BEV)
Basic knowledge	Fay The Mathews Andreas The Chens Lei Violet Veronica The Parks The Morrettis Christine Al The Dimirovics Margaret Clair	Experience, but low familiarity	Not aware that this type of vehicle exists	No experience, but aware that this type of vehicle exists
Moderate knowledge	The Youngs Sandra Omar Kevin The Nicolovs	Experience and familiarity		
High knowledge	Daryl Liz The Fengs		Experience and familiarity	

Extra: GHG and Electric

Figure 40: Emissions Intensity of plug-in electric vehicles, g CO₂e/km (using average annual emissions factors for electricity from Environment Canada, 2014)

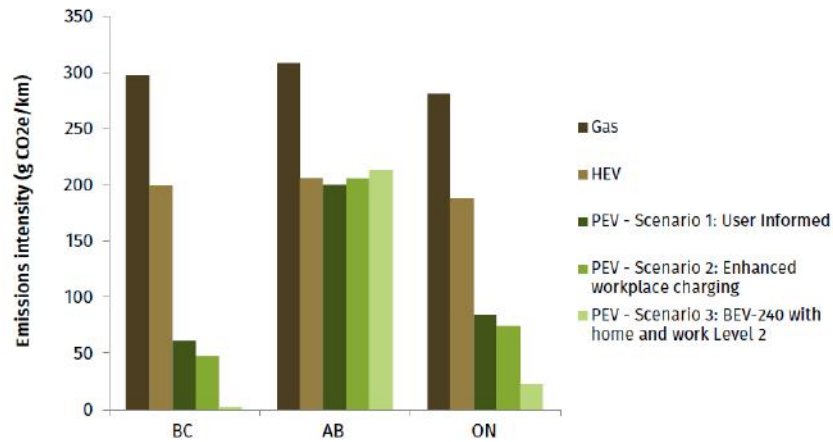
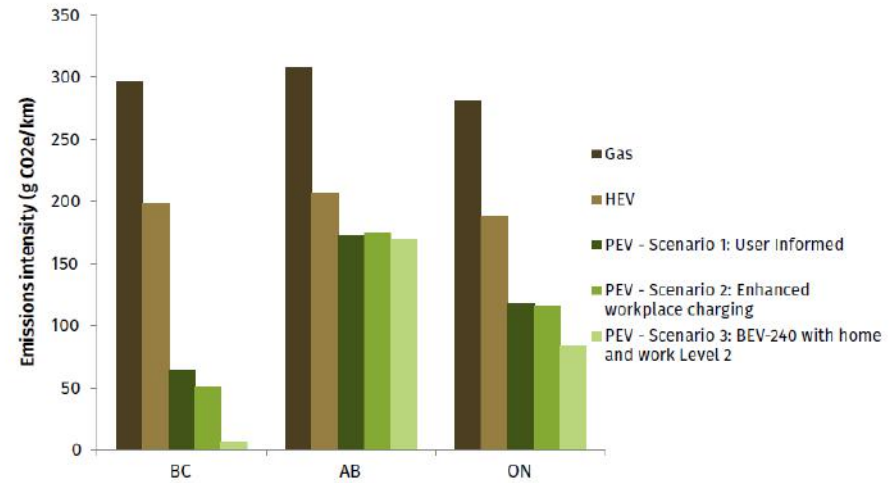
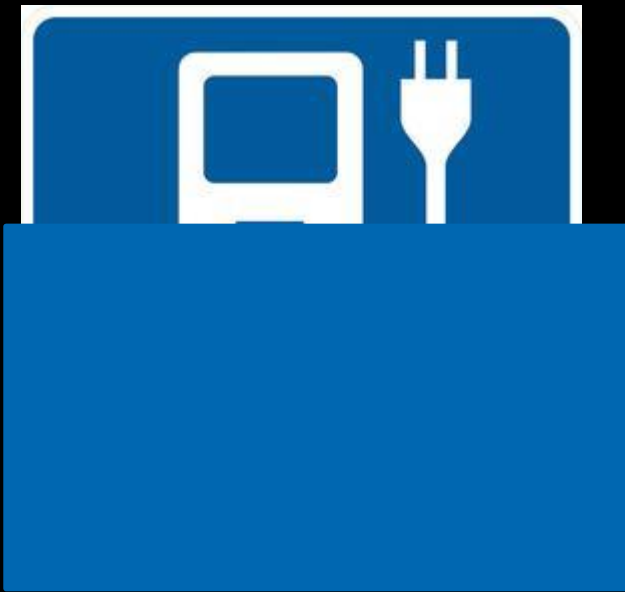


Figure 39: Emissions intensity of plug-in electric vehicles, g CO₂e/km (using hourly marginal emissions factors for electricity, including trade)



PEV owners are more aware of public chargers



Before buying their PEV...

86% were aware of at least one

Only 30% of Mainstream owners were aware of at least one public charger

We find public charger awareness is a weak predictor of PEV interest



Home charging access is a significant predictor of Mainstream PEV interest