PUSH EV DEMAND OR SUPPLY?

Evaluating zero-emissions vehicle policy in Canada

Jonn Axsen
Associate Professor
Sustainable Transportation Action Research Team (START)
Simon Fraser University
Vancouver, Canada

June 22, 2018
World Conference on Transport Research Society (WCTRS), SIG f2:
Transport, Climate Change and Clean Air
Paris, France

SFU

How to get to 30% PEV sales by 2030?

Policies that can induce PEV sales

Demand-focused policy

- Purchase incentives
- Non-monetary incentives (HOV lane, etc.)
- Charger deployment

Supply-focused policy

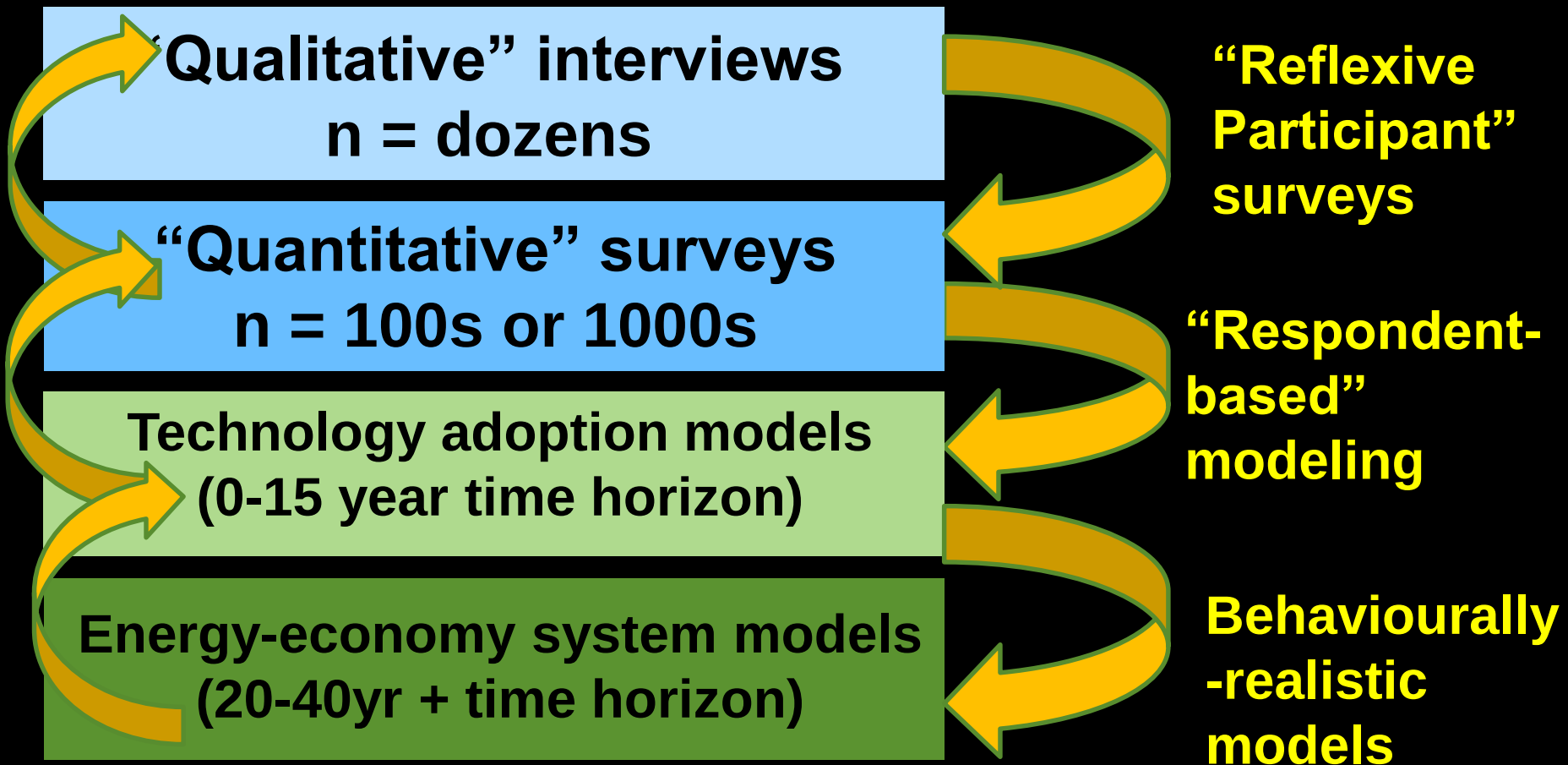
- ZEV mandate (sale requirements)
- Fuel efficiency standards
- Low-carbon fuel standards

Some policy criteria: effective, cost, political acceptability, transformative signal

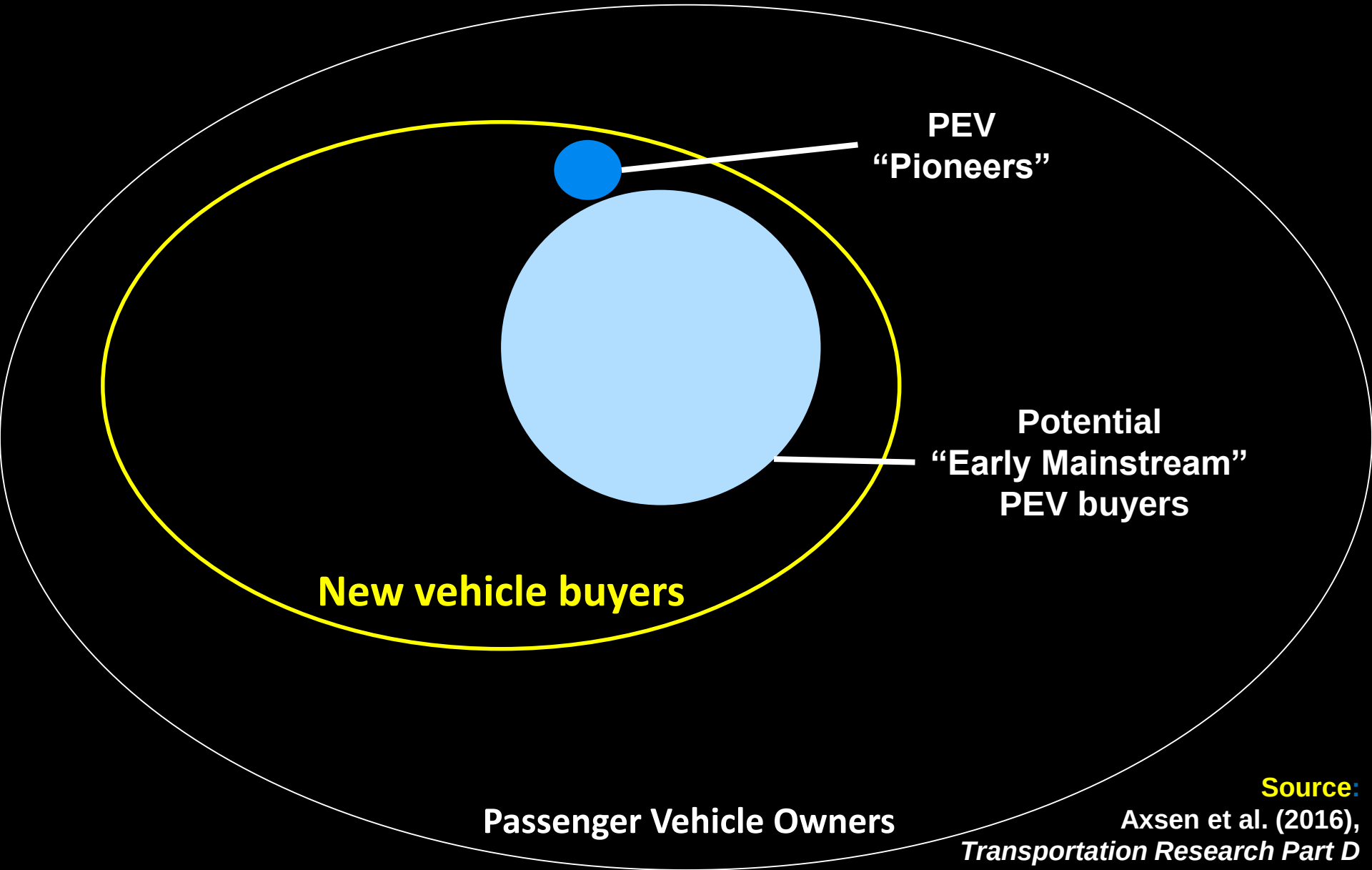
Adapted from: Melton et al. (2017), *Energy Policy*

Some research concepts

A reflexive, multi-method approach



PEV consumer research: "Pioneers" and the "Early Mainstream"



Source:
Axsen et al. (2016),
Transportation Research Part D

What is demand?

Sales: current market share.

Latent demand: demand for a product or service that a consumer cannot satisfy because it is not available, or they do not know that it is available.

Induced demand: an increase in sales due to increases in supply or awareness (or alleviation of other barriers).

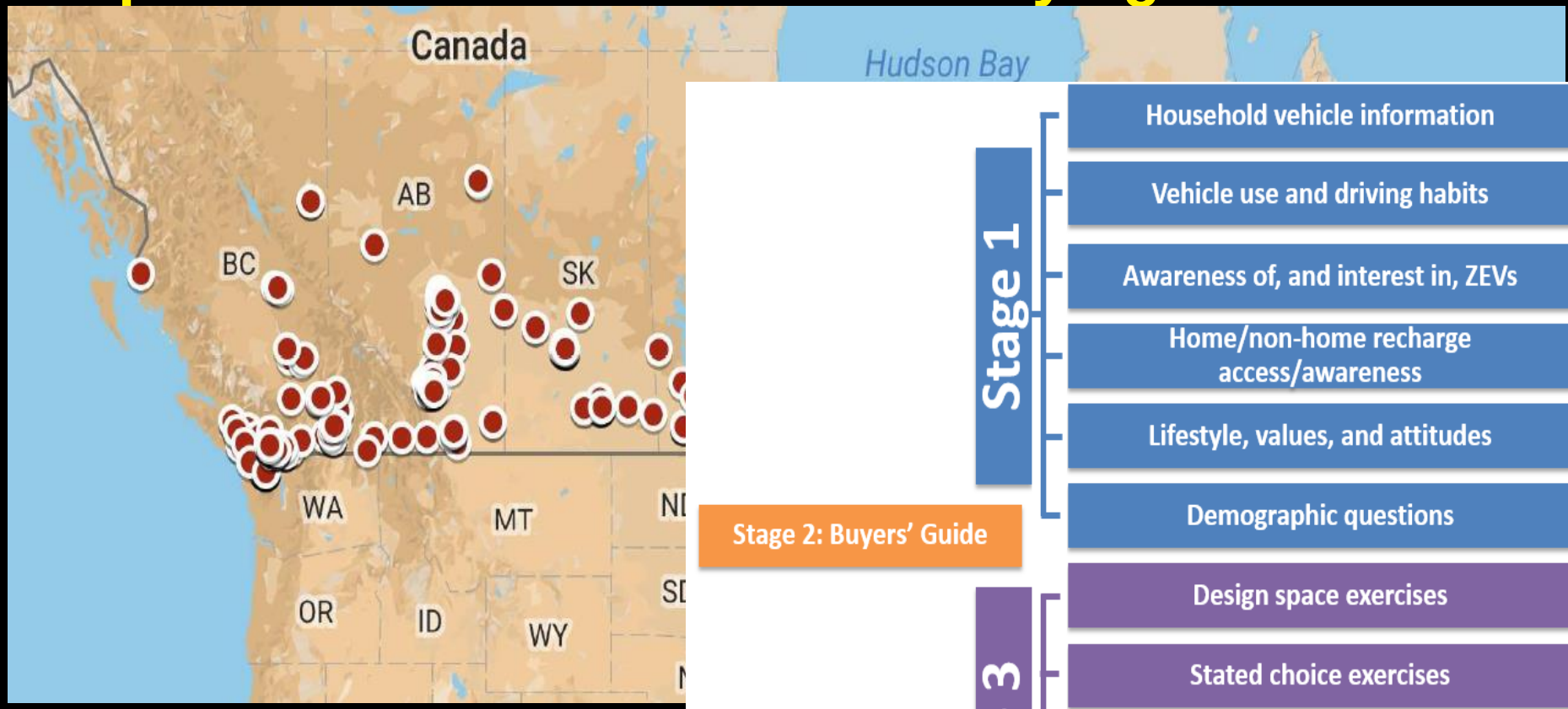
Q1: what is the latent demand for PEVs?

Q2: how can policy push sales towards latent demand?

Source: Long et al. (Under Review), *Transportation Research Part D*

The data

Canadian "Mainstream" Survey (n = 2,123), representative of new vehicle buying households



Stage 1
- Household vehicle information
- Vehicle use and driving habits
- Awareness of, and interest in, ZEVs
- Home/non-home recharge access/awareness
- Lifestyle, values, and attitudes
- Demographic questions

Stage 2: Buyers' Guide

Stage 3
- Design space exercises
- Stated choice exercises
- Perceptions of ZEVs
- Perceptions of vehicle brands (focus on Tesla)
- ZEV interest repeat

Source: Kormos, et al. (Under Review), *Transportation Research Part D*

Method 1: "Design Space" Exercise

Click Here to open the example response that we provide earlier in a new window.

Vehicle type	Driving range	Gasoline fuel use	Refuel/ Home recharge time	Purchase price	I CHOOSE
	→	Gas		$	
 A **conventional** RAM 1500 4X4 FFV	**750 km** gasoline	**15.2** L/100 km	5 mins	**$50000**	Conventional: Please select
 A **hybrid** RAM 1500 4X4 FFV	**750 km** gasoline	**10.2** L/100 km	5 mins	**$51600**	Hybrid: 1st Choice
 A **plug-in hybrid** RAM 1500 4X4 FFV	Electric for the first: Please select your answer	**10.2** L/100 km	Time to fully charge empty battery at home: Please select your answer	**$0**	Plug-in hybrid: Please select
 A **electric only** RAM 1500 4X4 FFV	Electric only for: Please select your answer	None	Time to fully charge empty battery at home: Please select your answer	**$0**	Electric: Please select
 A **hydrogen fuel cell** RAM 1500 4X4 FFV	**500 km** hydrogen	None	5 mins	**$61000**	Hydrogen: 2nd Choice

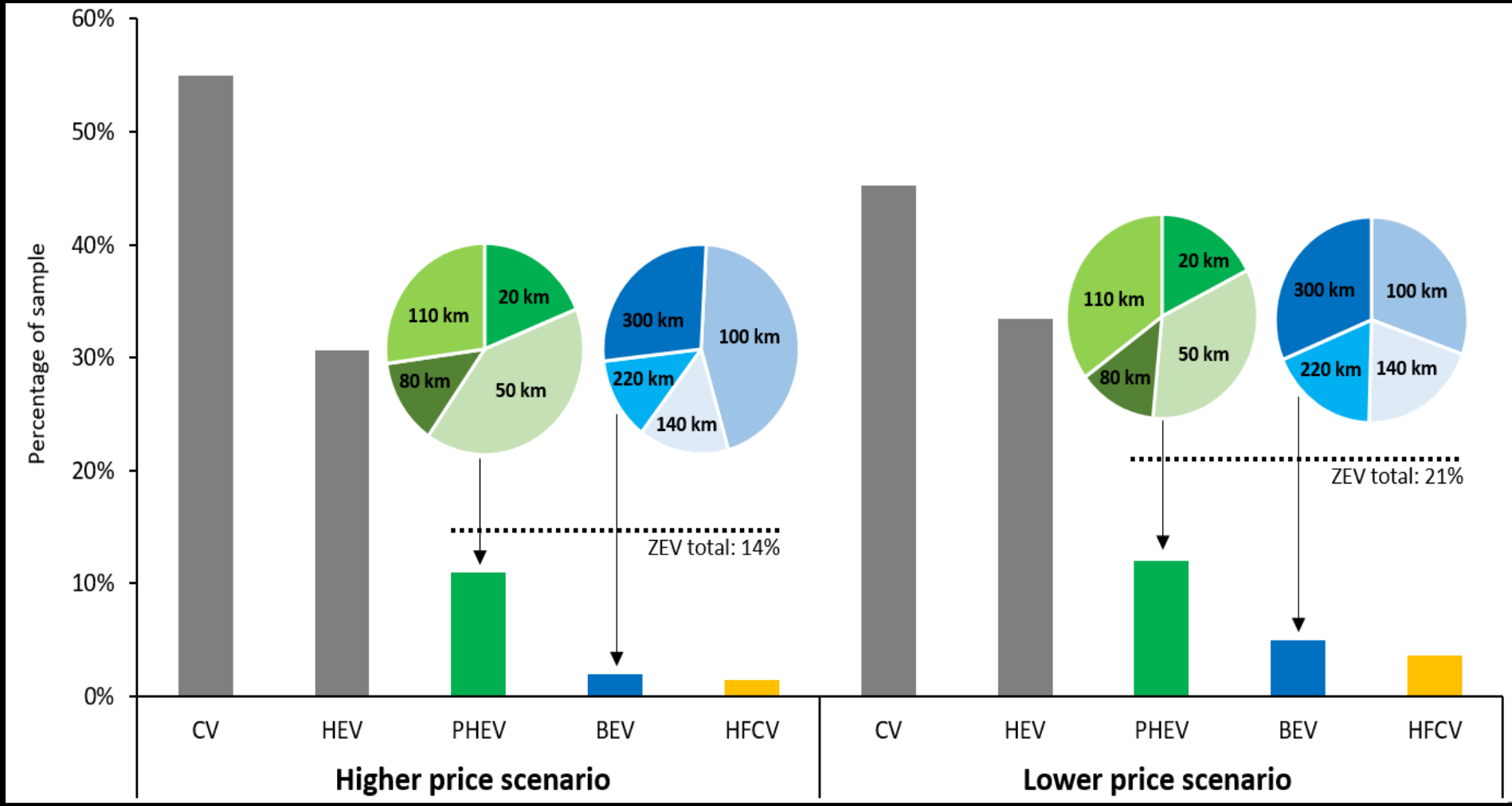
Method 2: Stated choice experiment

Vehicle type	Range	Recharge/ refuel time	Destination recharging or refuelling access		Fuel cost	Purchase price & incentive	I CHOOSE
	→		Level 2	Fast or H_2 refuelling	$	$	
Conventional Honda CIVIC	**650 km** gasoline	5 min.	–	–	**$32** /week	$25,000 - $0 **$25,000**	Conventional
Hybrid Honda CIVIC	**1070 km** gasoline	5 min.	–	–	**$20** /week	$26,380 - $0 **$26,380**	Hybrid
Plug-in hybrid Honda CIVIC	**575 km** First **72 km** electric	Home: **6 hrs.** Work: **–**	**25%** of destinations	–	**$18** /week	$30,180 - $5,000 **$25,180**	Plug-in Hybrid
Electric Only Honda CIVIC	**200 km** electric	Home: **6 hrs.** Work: **–**	**25%** of destinations	**None**	**$10** /week	$38,820 - $5,000 **$33,820**	Electric
Hydrogen fuel cell Honda CIVIC	**350 km** hydrogen	5 min.	–	**20%** of gas stations	**$10** /week	$41,230 - $0 **$41,230**	Hydrogen

Next

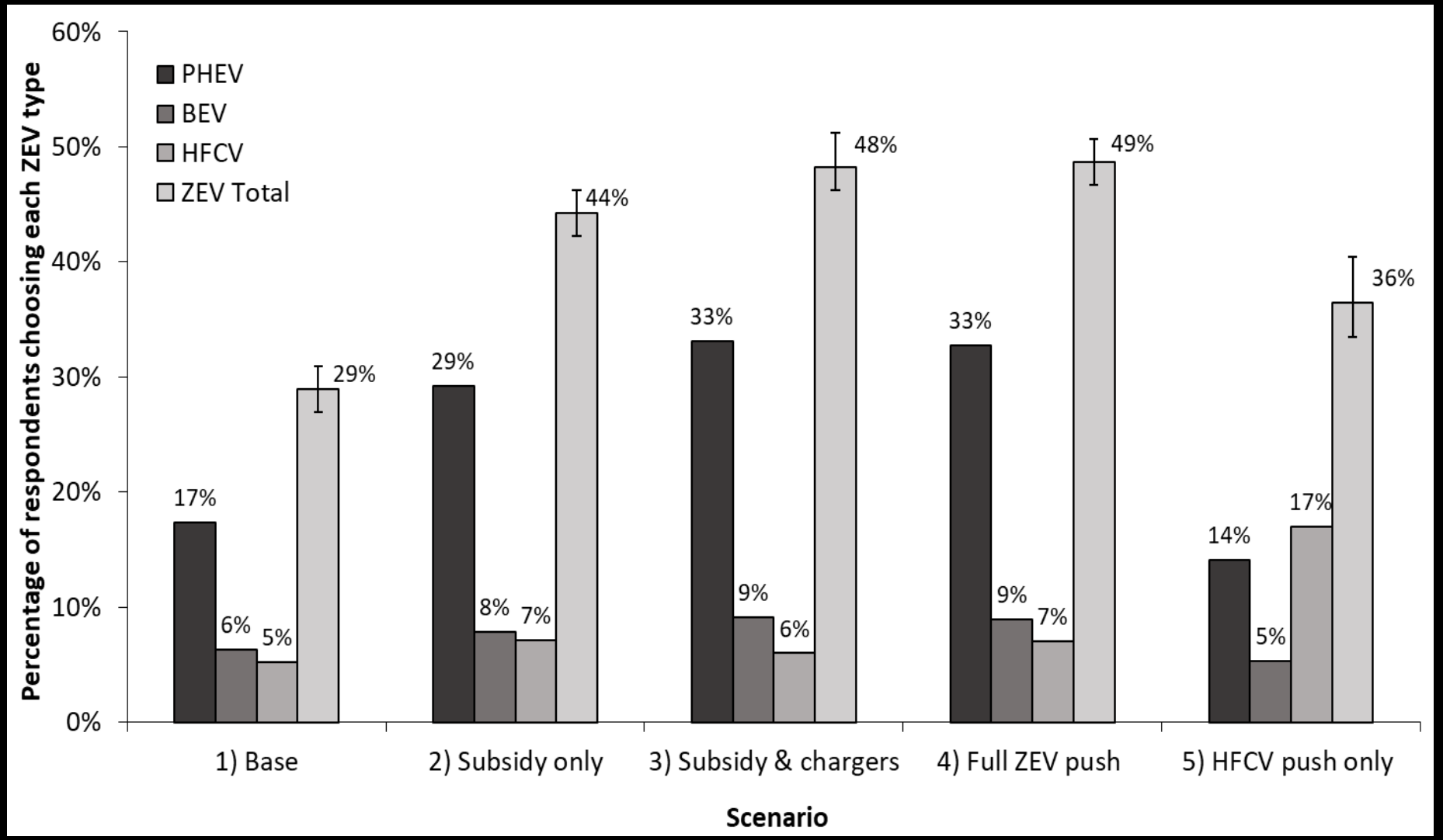
Click HERE to access the Vehicle Buyers' Guide

Design space results: 14-21% design some sort of ZEV, mostly PHEV



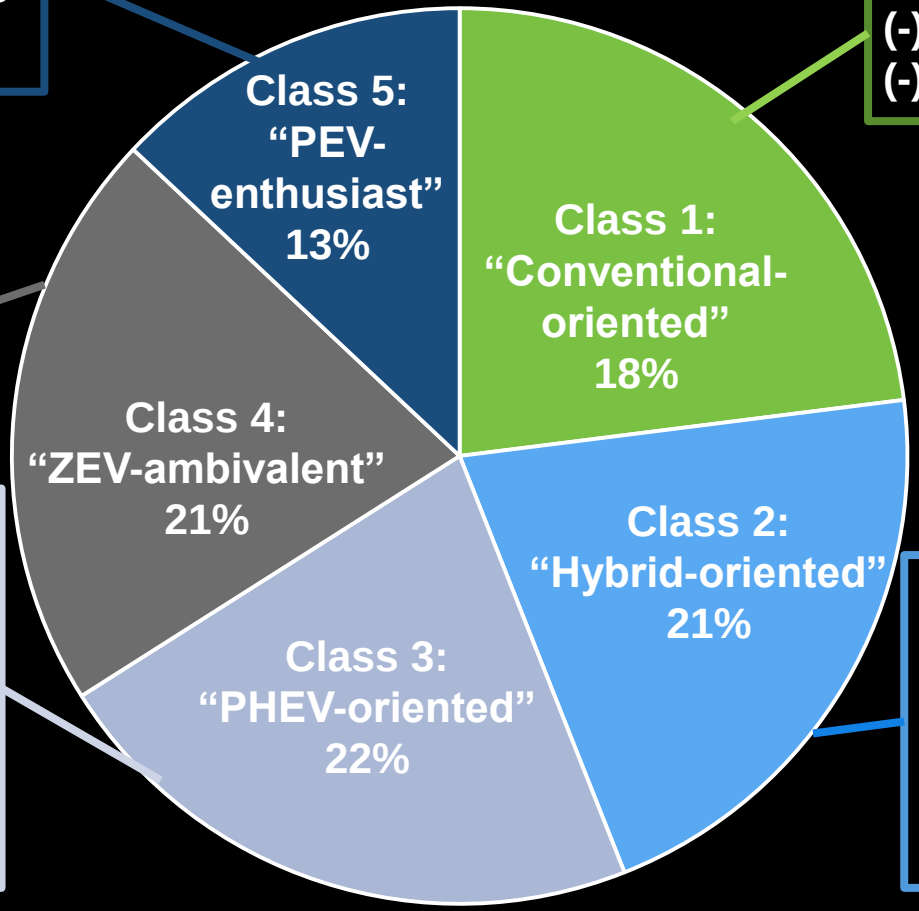
Source: Long et al. (Under Review), *Transportation Research Part D*

Stated choice model: latent demand around 30%, up to 50% with policy



Source: Kormos et al. (Under Review), *Transportation Research Part D*

Latent class model: Segmenting respondents by PEV preference



(+) Hybrid
(++) PHEVs and BEVs
- Not sensitive to attributes
- Environmental lifestyle

(-) Hybrid
(-) PHEV and BEVs
(-) Hydrogen

(+) Hybrid
(+/-) PHEV and BEVs
(+/-) Hydrogen
- Environmental lifestyle

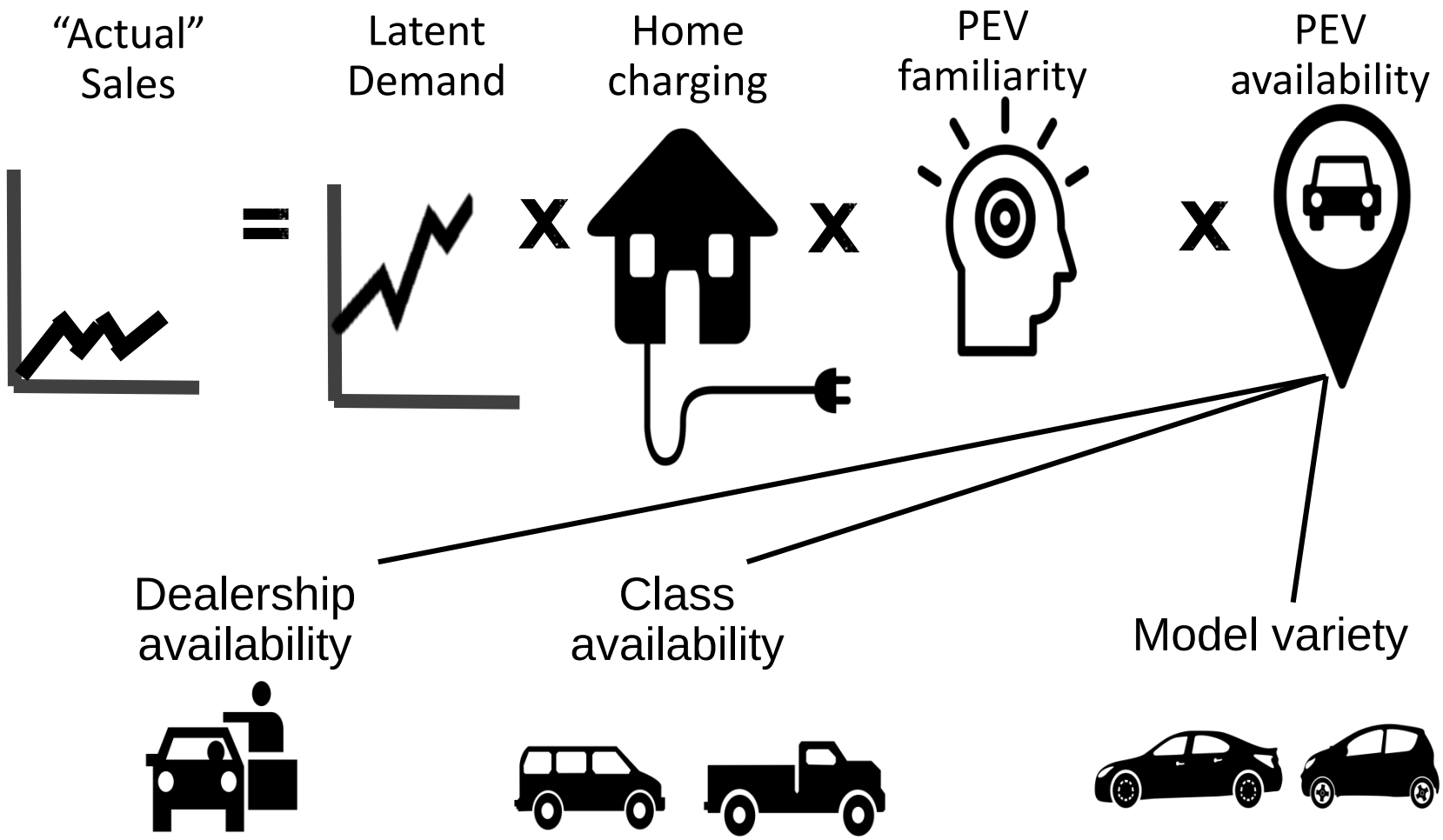
(+) Hybrid
(+) PHEVs
(-) BEVs
(+/-) Hydrogen
- Fuel cost sensitive
- Charger availability
- Environmental concern

(+) Hybrid
(-) PHEV and BEVs
(-) Hydrogen
- Fuel cost
- Environmental concern

Source: Kormos et al. (Under Review), *Transportation Research Part D*

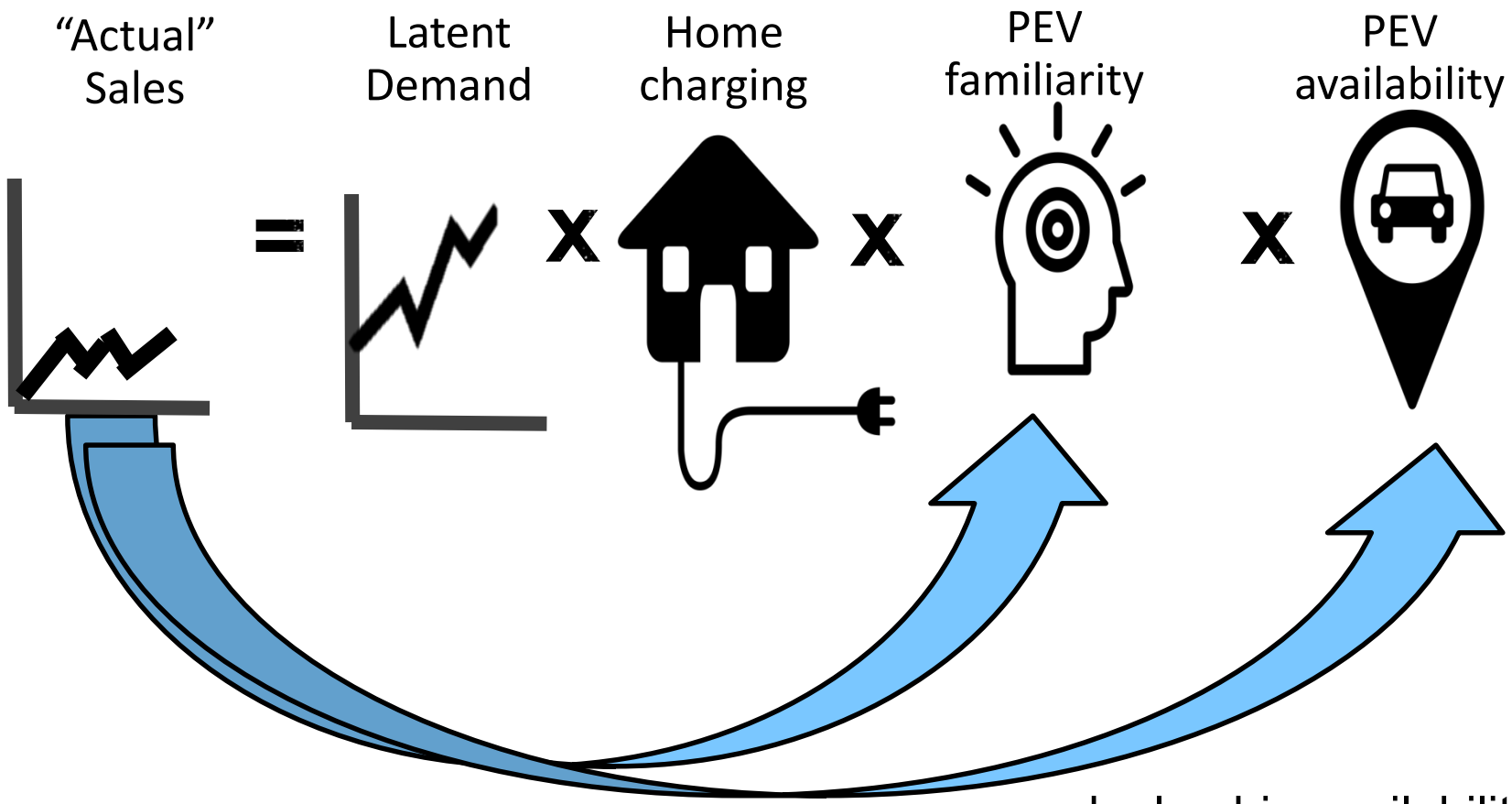
The model

The respondent-based preference and constraint model (REPAC)



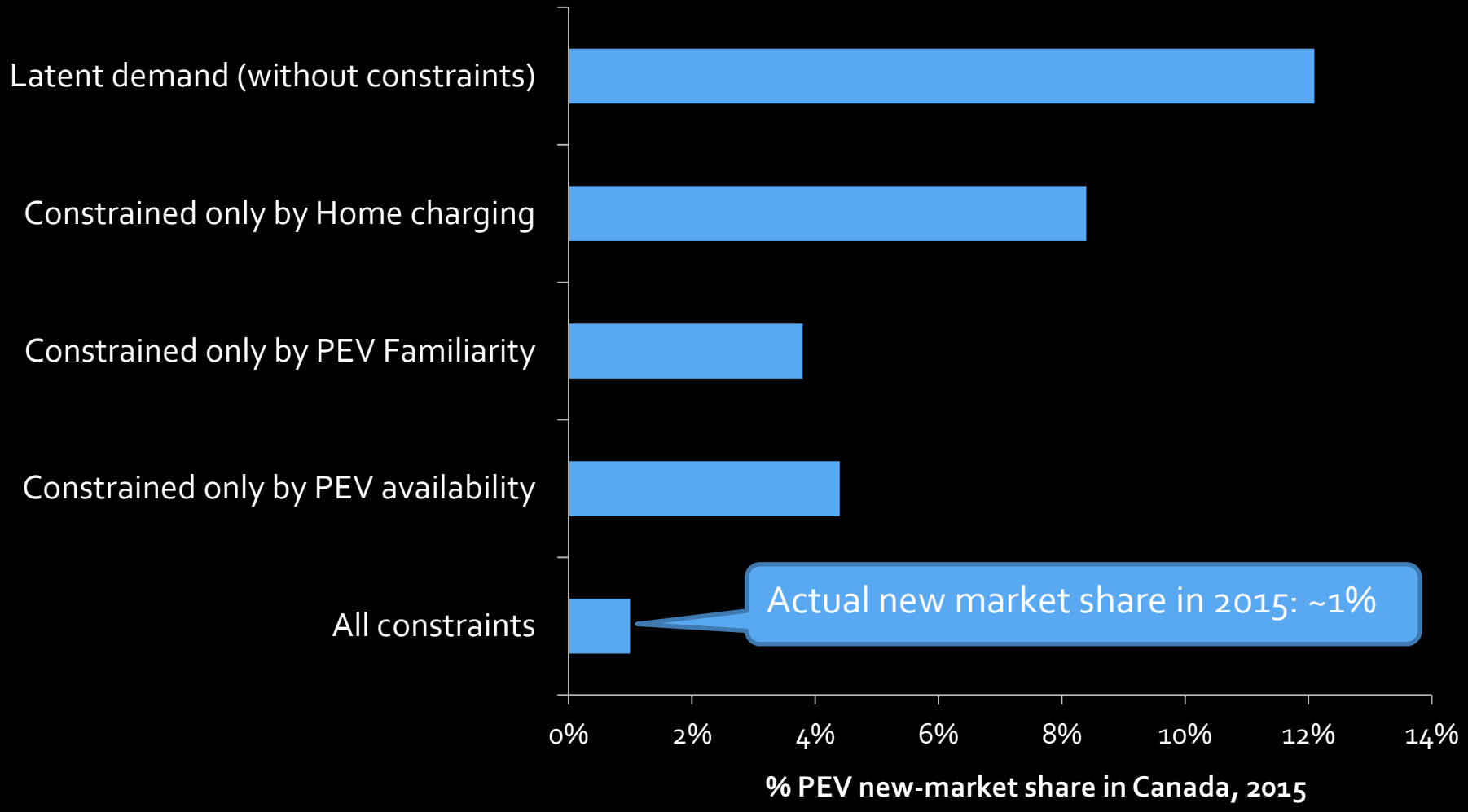
Source: Wolinetz & Axsen (2017), *Technological Forecasting & Social Change*

The respondent-based preference and constraint model (REPAC)



Source: Wolinetz & Axsen (2017), *Technological Forecasting & Social Change*

REPAC lines up well with actual PEV sales in 2015



Source: Wolinetz & Axsen (2017), *Technological Forecasting & Social Change*

Comparing policy packages in Canada

Target: 30% PEV market share by 2030

1) Current policies

- Some purchase incentives, HOV lane access
- Planned charger deployment
- Clean Fuel Standard
- National carbon pricing

2) + Incentive-based approach (demand-focused)

- What is needed for 2030 target?
- Incentives for how long? 2021, 2025, or 2030?

3) + ZEV-mandate approach (supply-focused)

- Require 30% or 40% by 2030
- Automakers comply via:
  - Increased PEV model variety and availability, and
  - internal cross-price subsidies,

Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

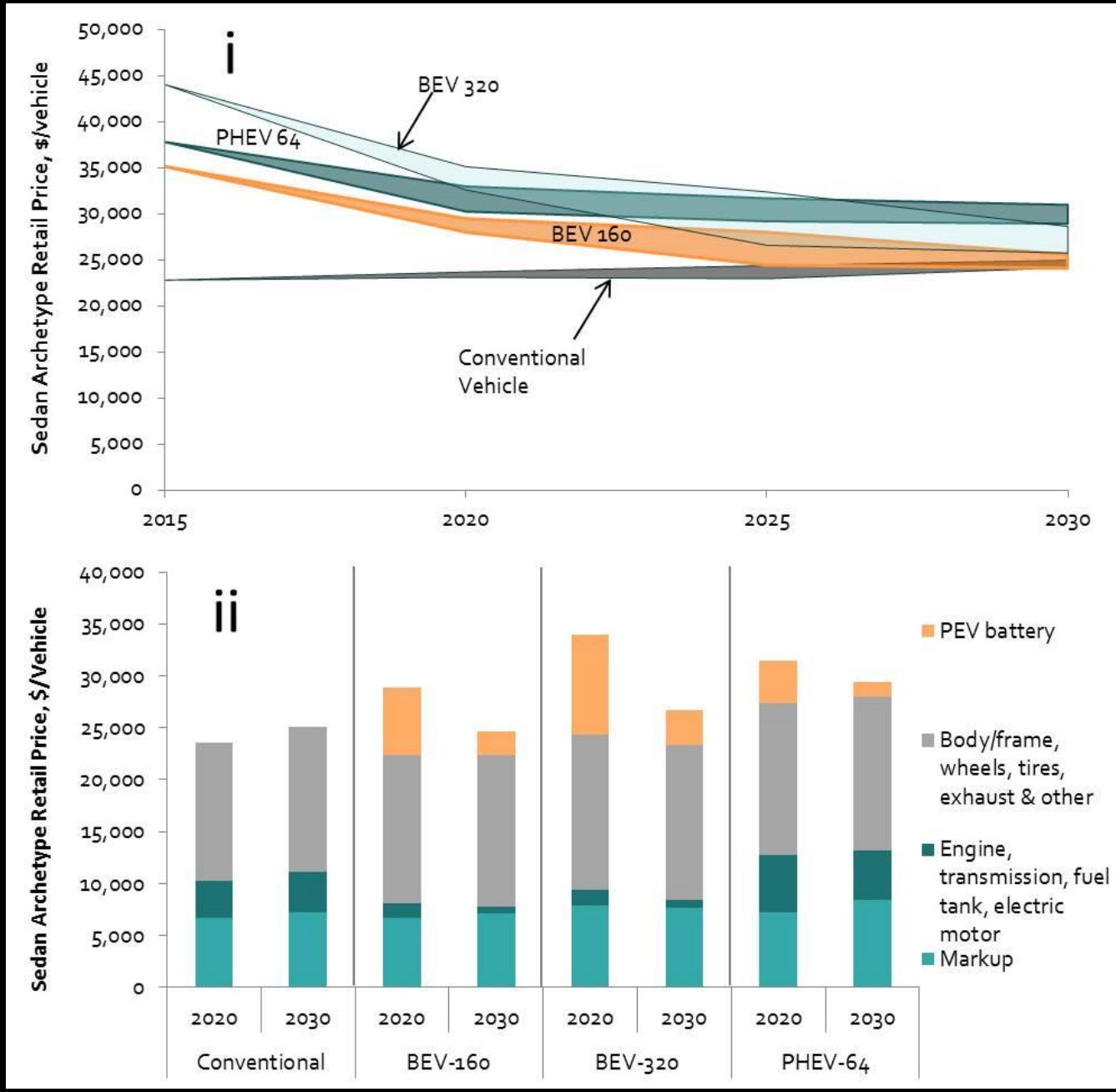
Modeled ZEV purchase prices

2030 battery pack costs (CDN)

High: ~$125/kWh

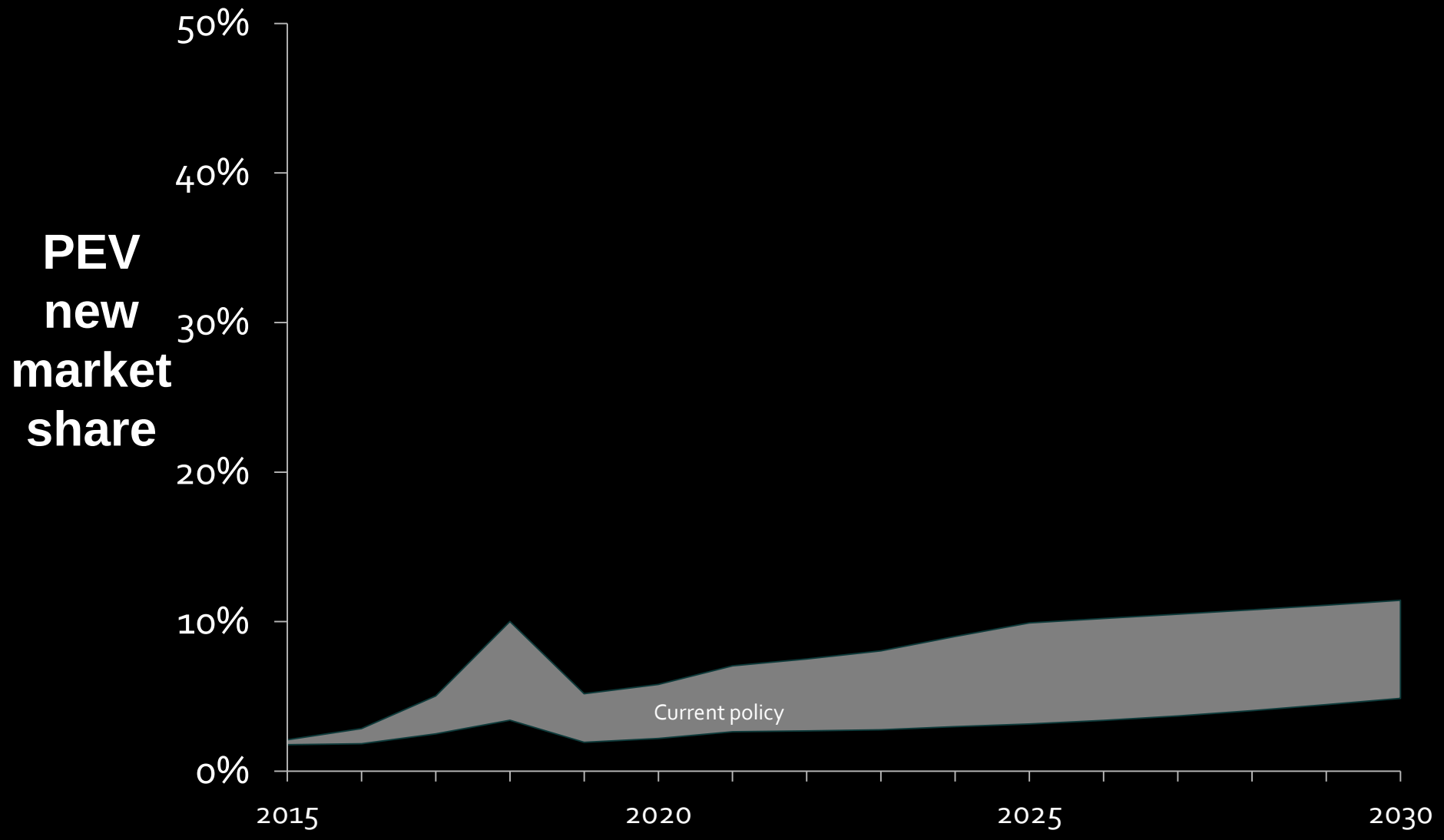
Low: ~ $85/kWh

With increasing OEM markups



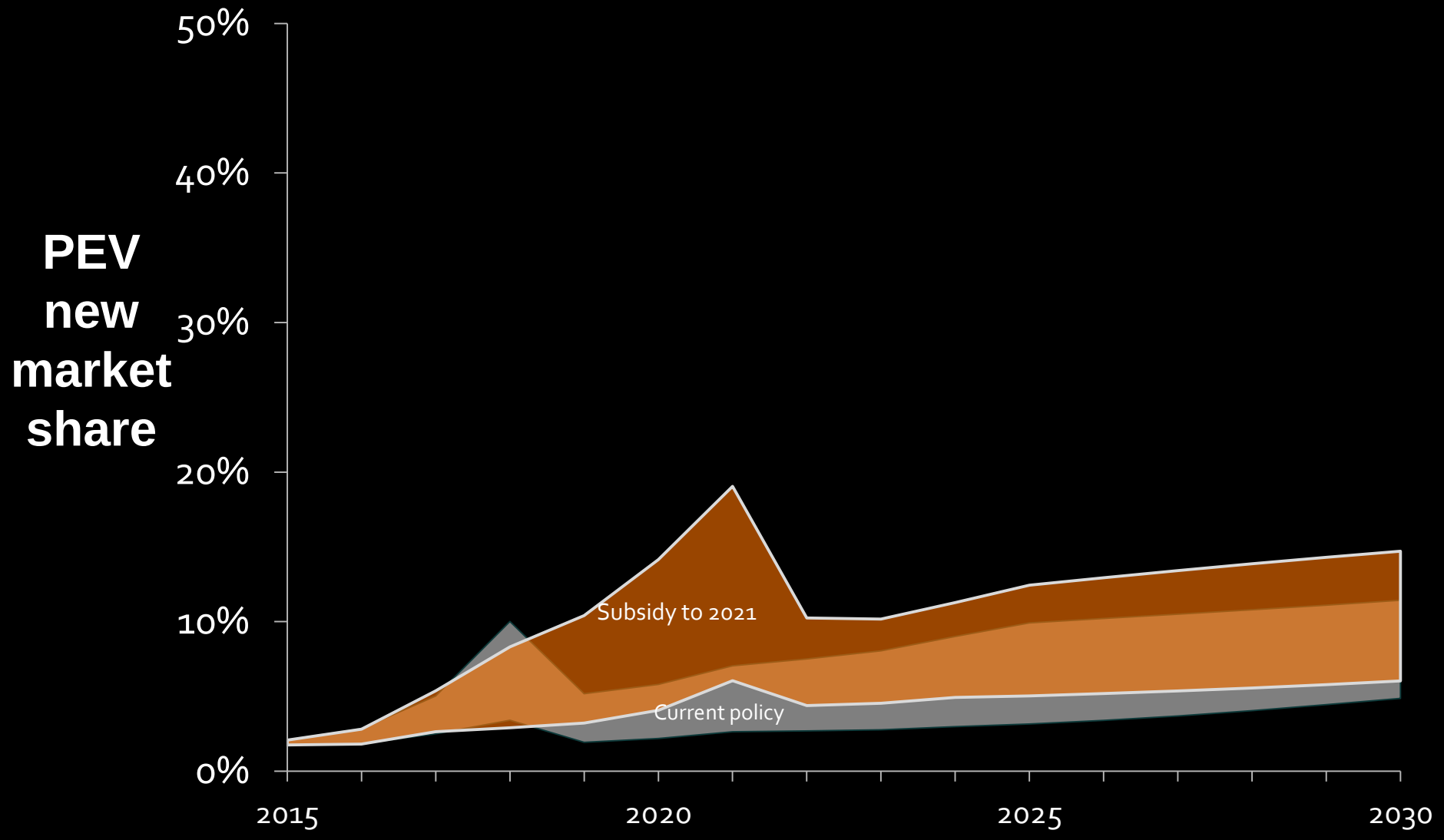
Source: Axsen & Wolinetz (Under review)

Current policies don't get past 10% new market share...



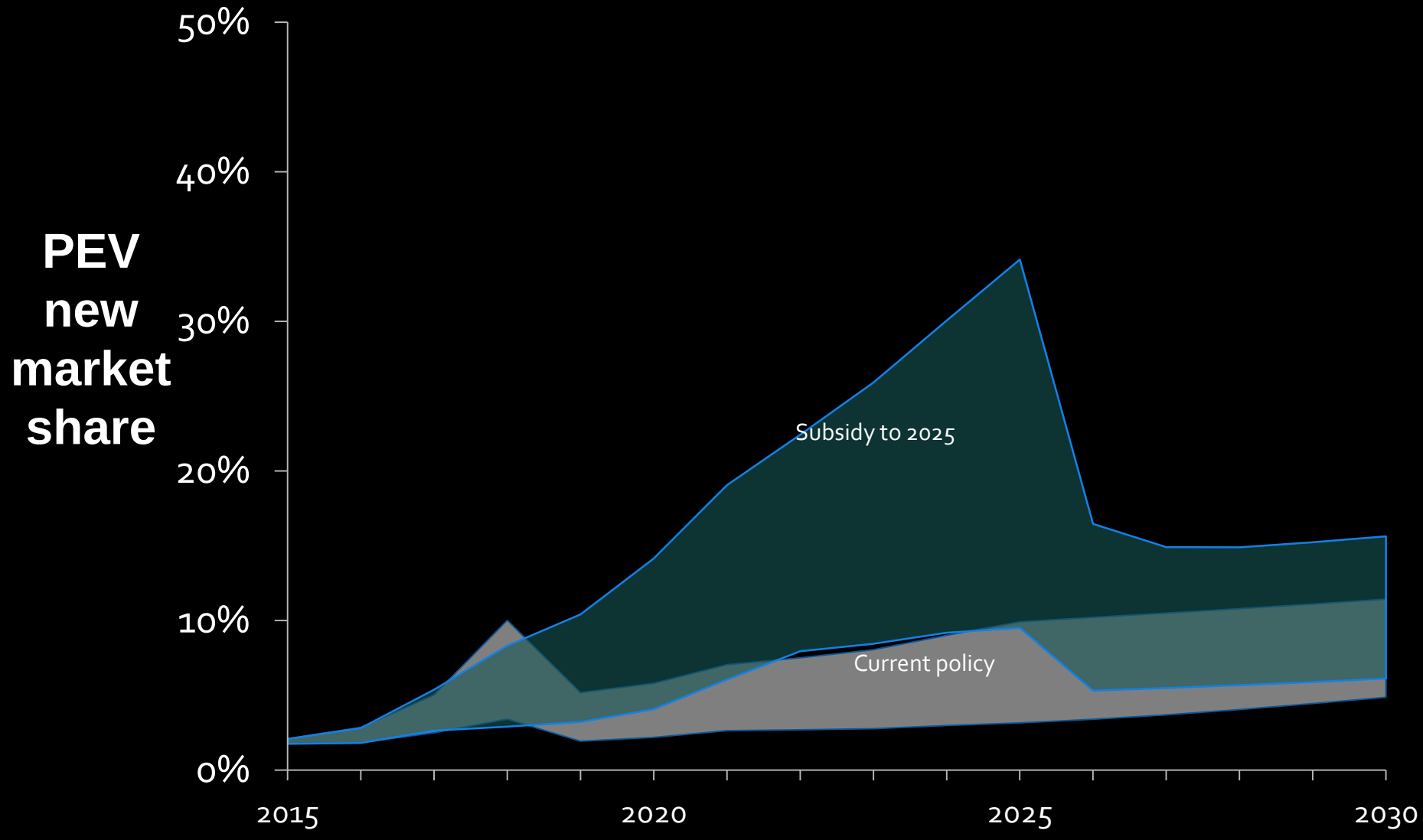
Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

$6000 / PEV subsidy until 2021…



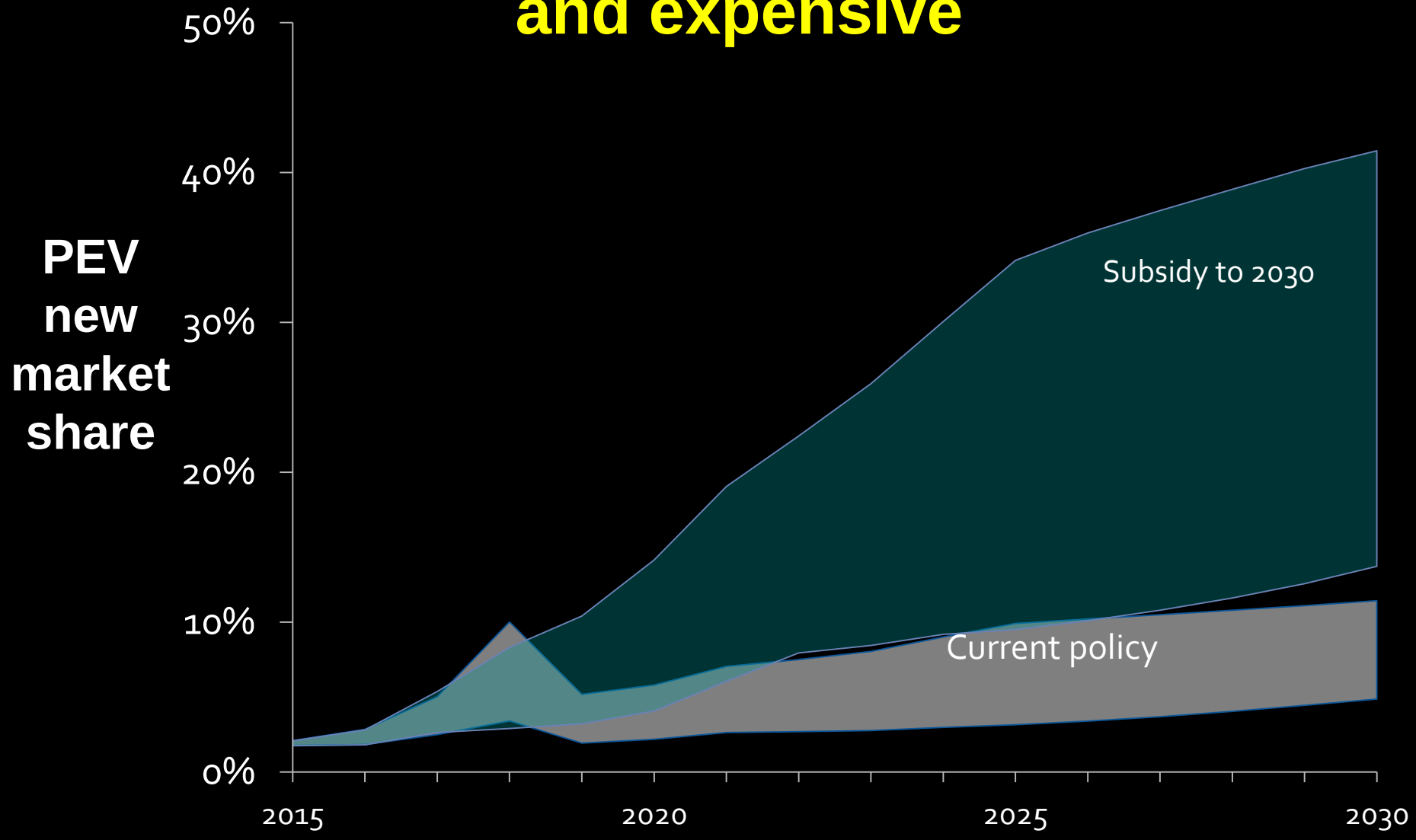
Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

$6000 / PEV subsidy until 2025…



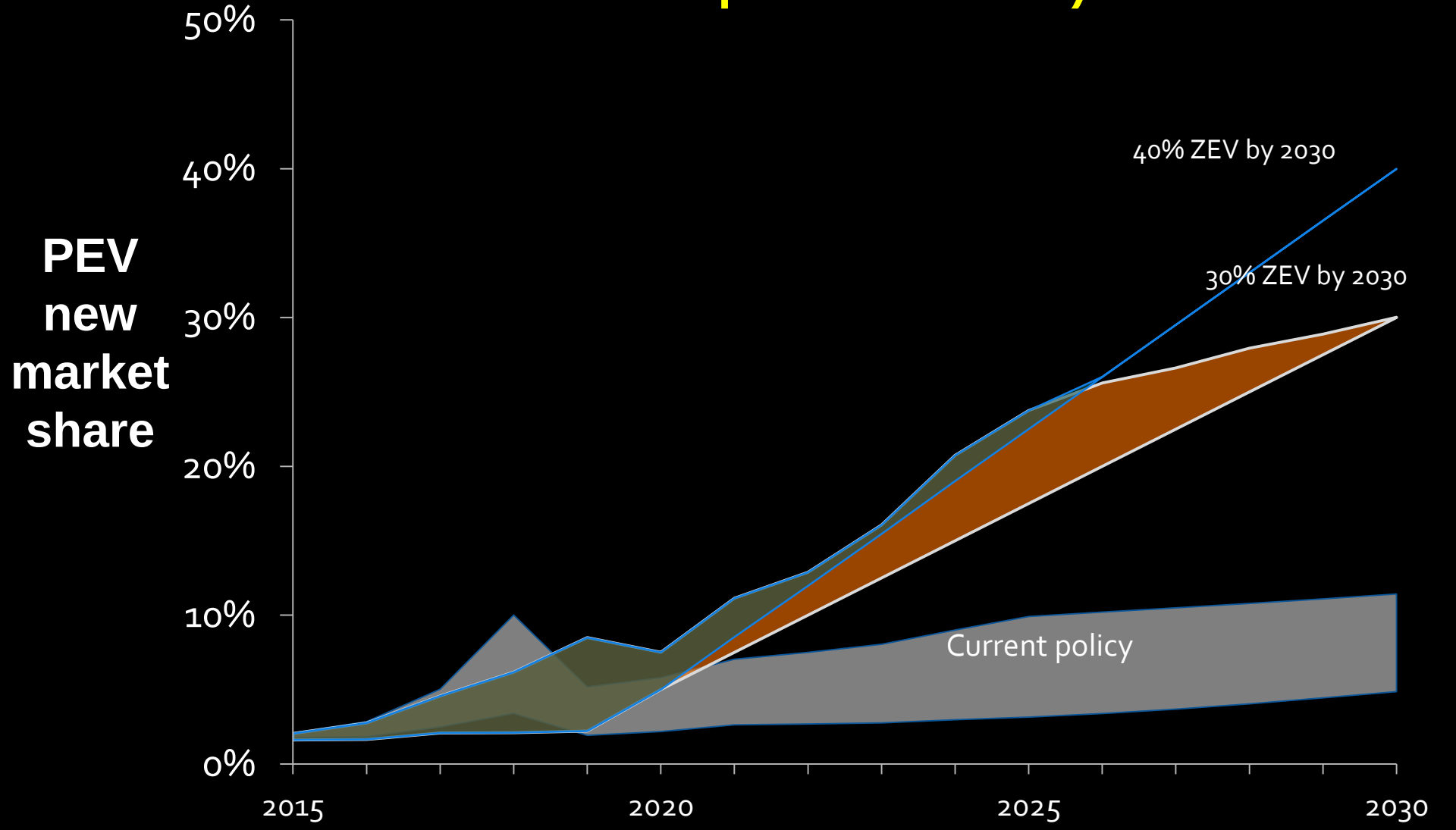
Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

$6000 / PEV subsidy until 2030…
Can achieve 2030 target, but highly uncertain and expensive



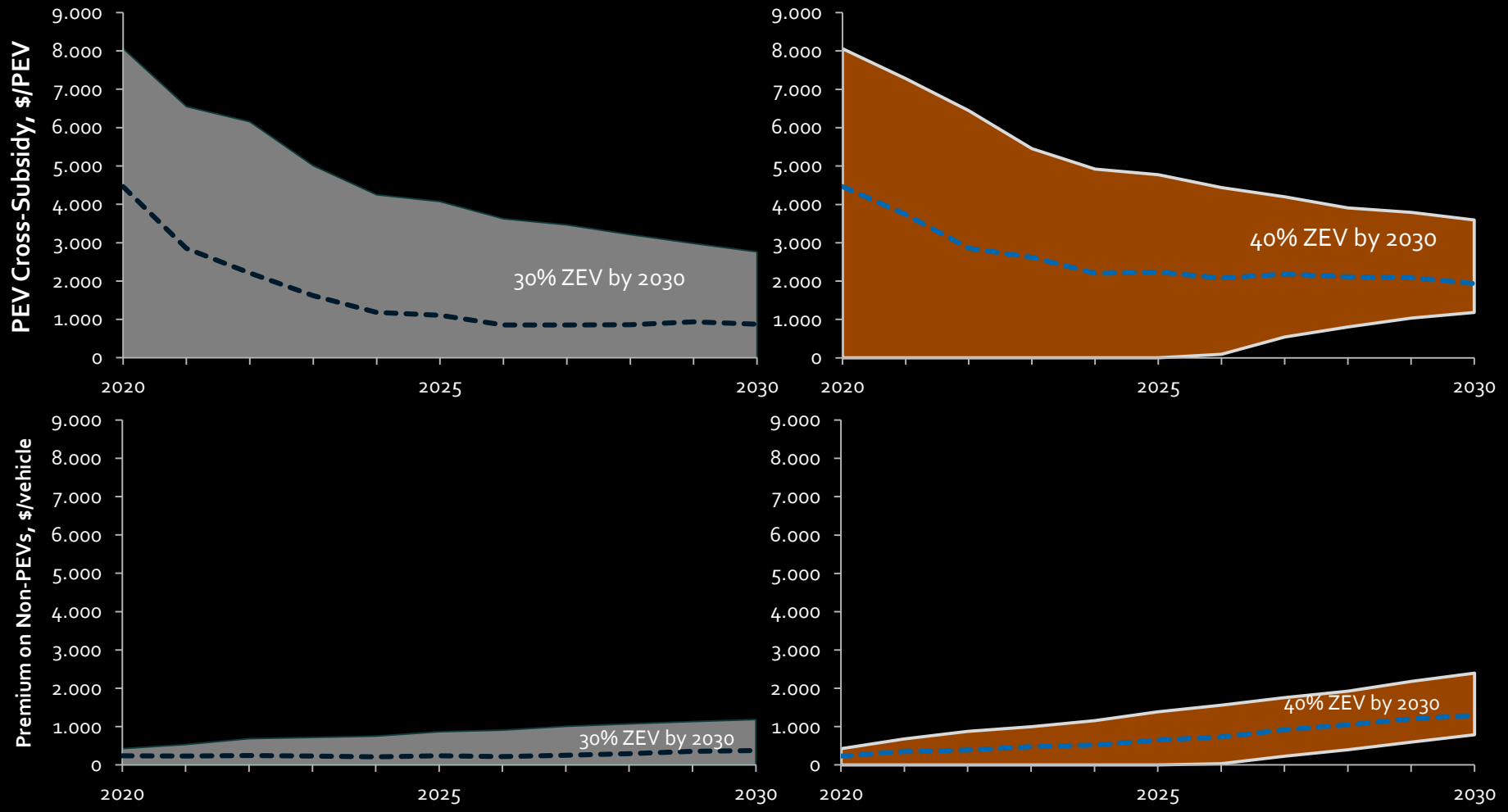
Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

Both ZEV mandate targets can be achieve
(via increased supply and internal cross-price subsidies)



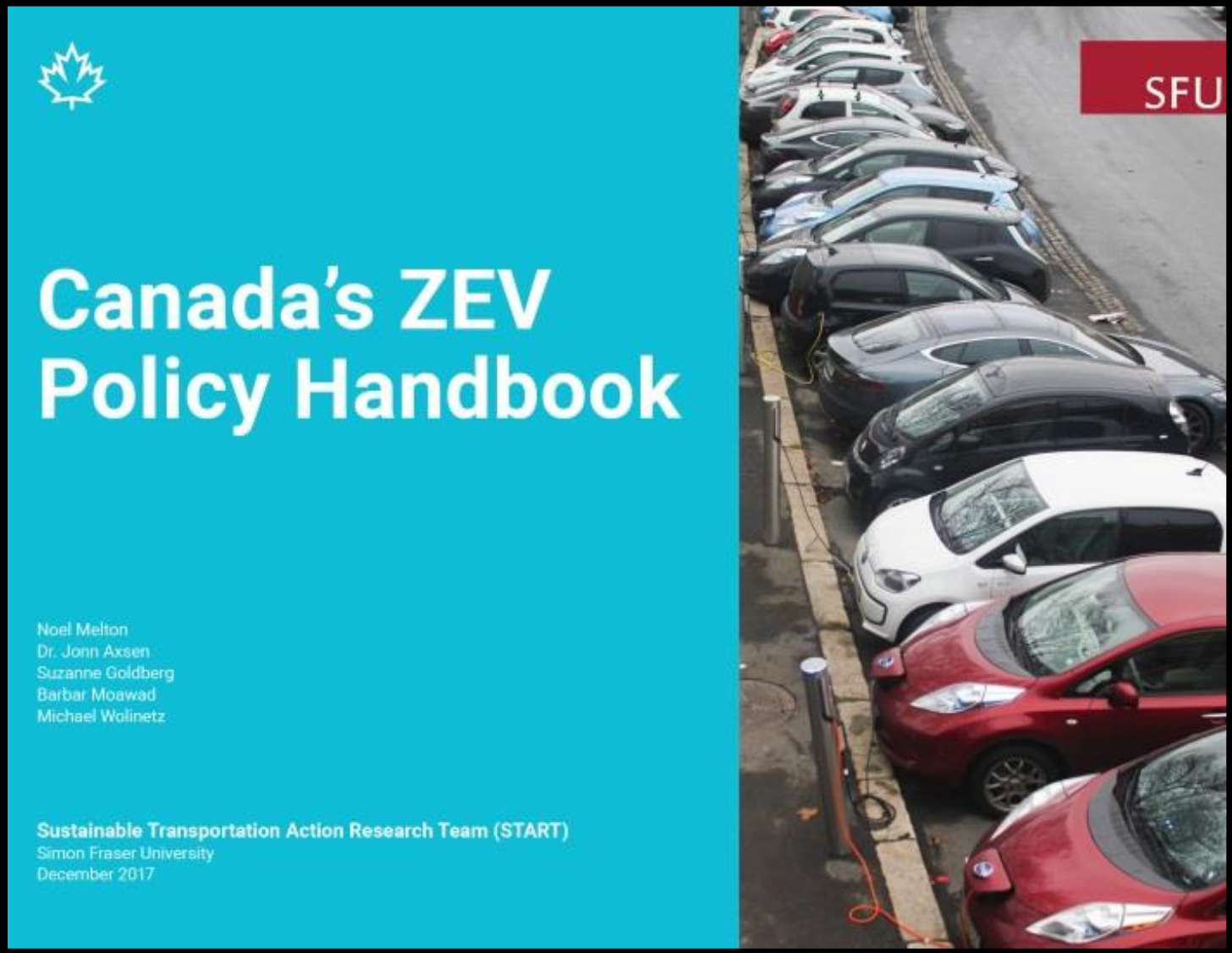
Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

ZEV mandate: cross-price subsidies needed to comply



Source: Axsen & Wolinetz (Under Review), *Transportation Research Part D*

Policymaking is complex and needs multi-criteria evaluation



Source: Melton et al. (2017), Canada`s *ZEV Policy Handbook*

Policymaking is complex: Evaluating three policy packages that could achieve 2030 target

	Effectiveness	Cost Effectiveness	Public Support	Policy Simplicity	Transformational Signal
Demand-focused policy package	5	1	3	4	2
Supply-focused package (ZEV mandate)	5	5	4	2	5
Supply-focused package (vehicle emissions standard)	5	5	4	3	4

Source: Melton et al. (2017), Canada`s *ZEV Policy Handbook*

Key implications

1. **Achievable**: 2030 goals of 30% PEV sales
2. Significant “latent” demand (20% to 40%)
3. But stronger policy needed to induce sales
   - Incentives needed for the long-term (costly)
   - ZEV mandate, puts more onus on automakers
   - Other policy packages possible

Extra

Consumer perceptions are complex: functional, symbolic and societal dimensions

Functional

Symbolic

Private

Societal

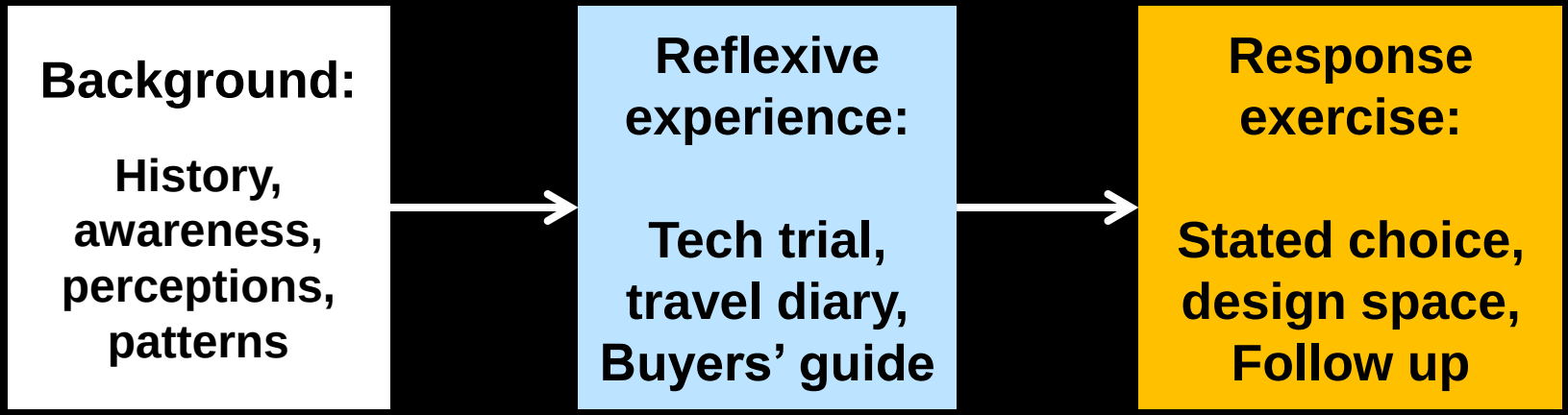
Sources: Axsen and Kurani (2012), *Environment and Planning A*
Axsen, Orlebar & Skippon (2013), *Ecological Economics*

Perspectives on the “mainstream” consumer

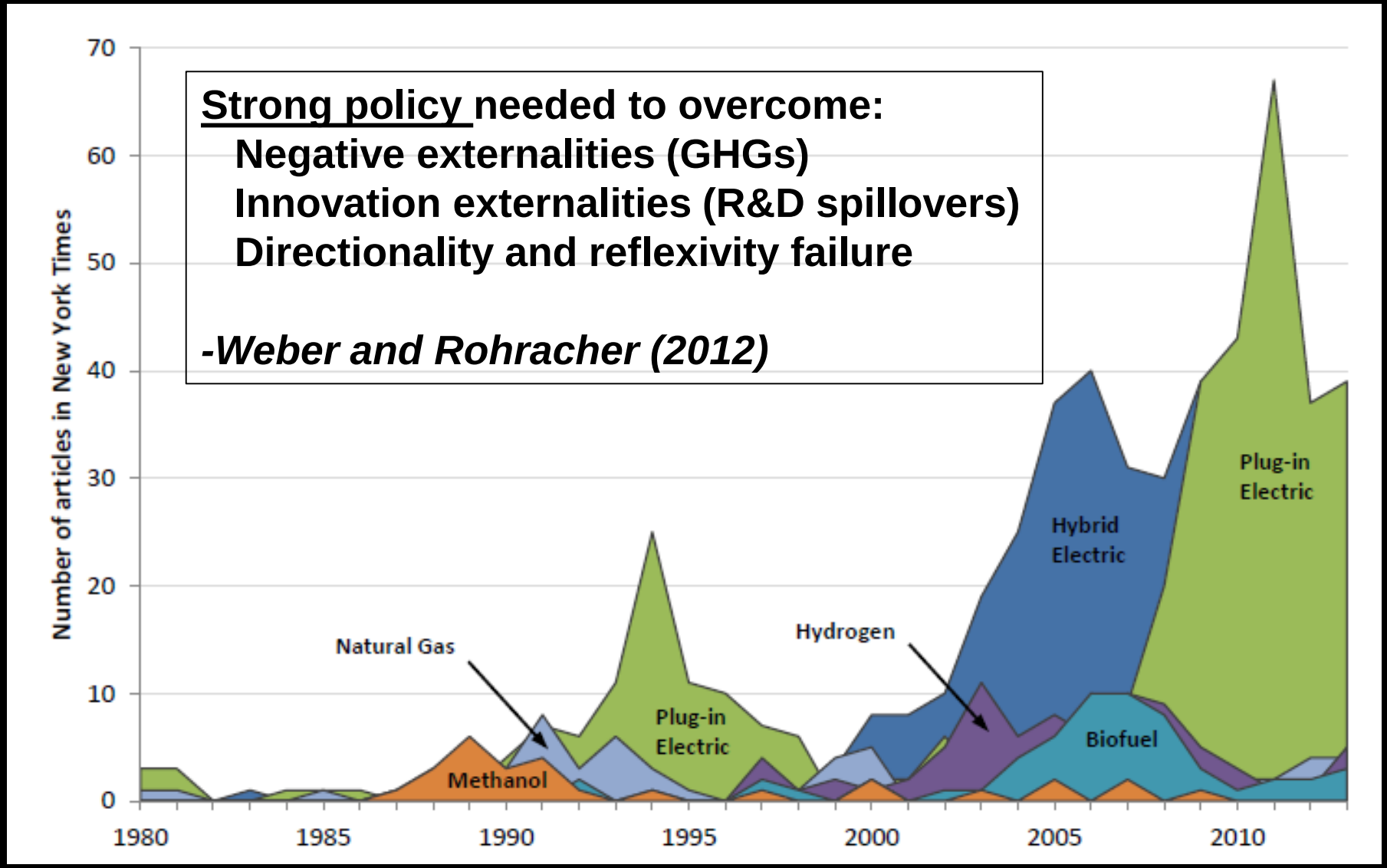
The “Rational Actor”….

The “Reflexive Participant”…

The “Reflexive Participant Approach”: Three elements

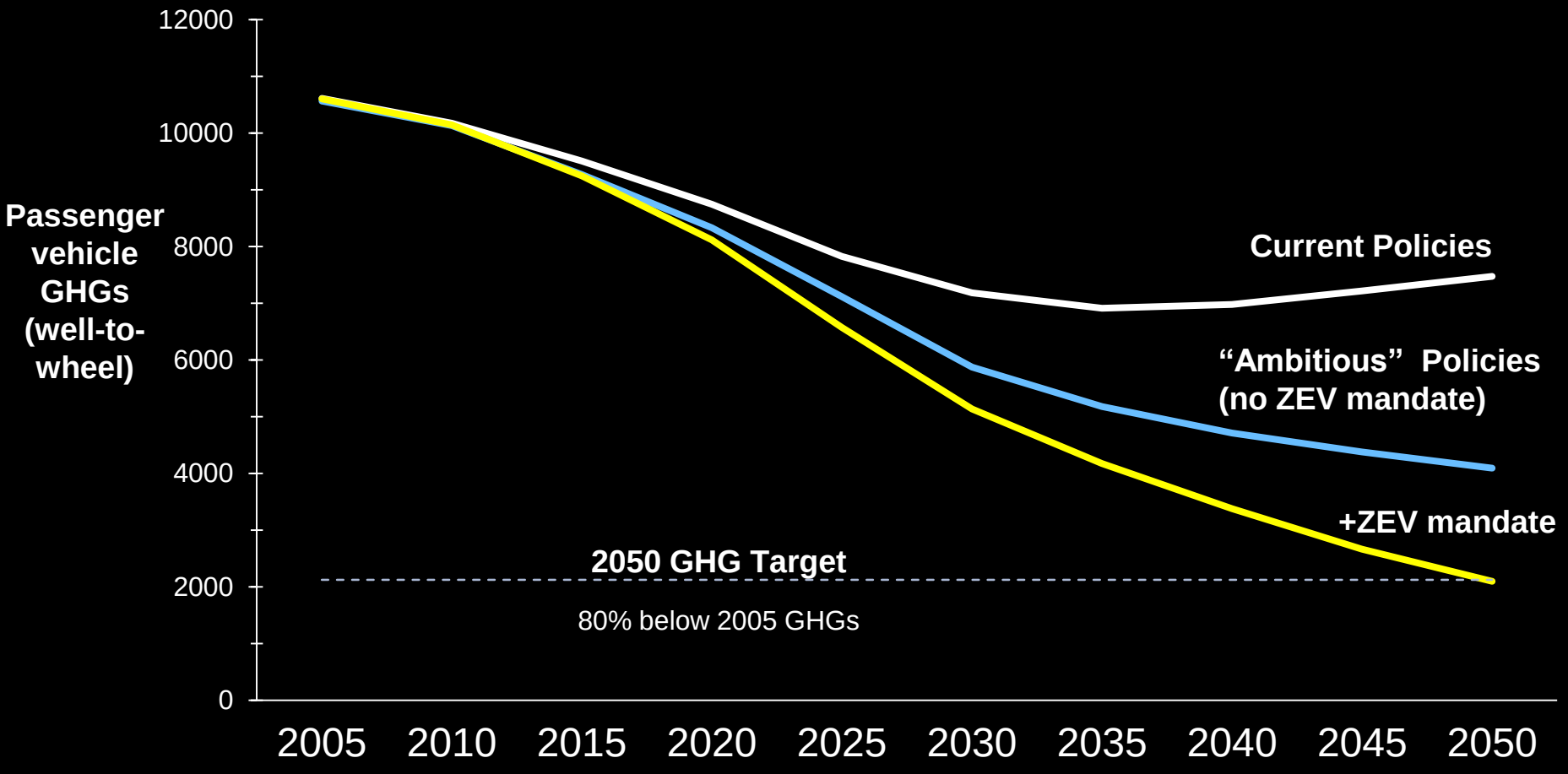


Beware of the "Hype & Disappointment" cycles for alternative fuels (New York Times 1980-2013)



Source: Melton, Axsen & Sperling (2016), *Nature Energy*

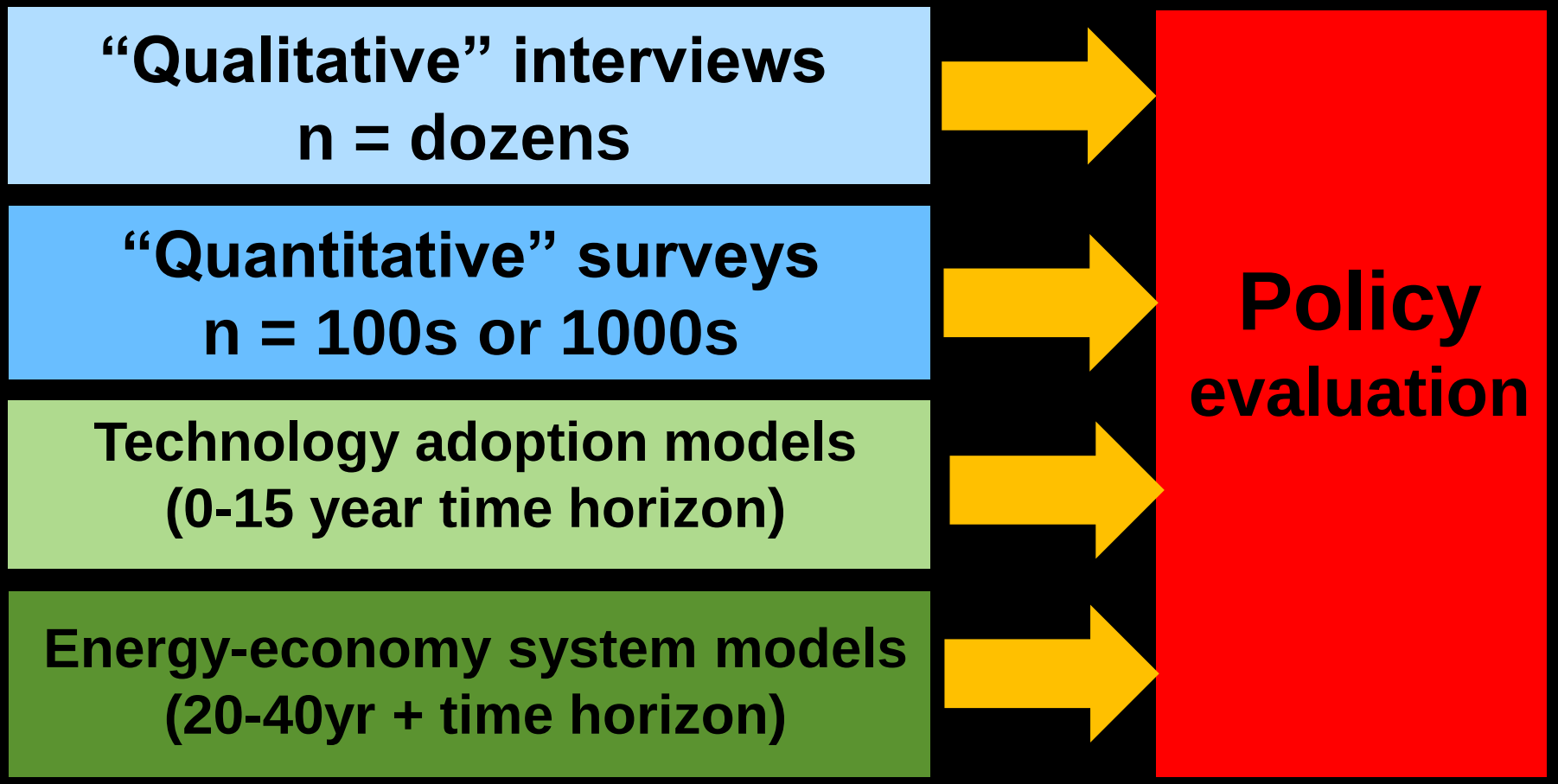
Long-term modeling suggests that PEVs can play an important role in GHG mitigation



"Ambitious" Policies		
	Carbon Tax: $30/t 2015 to $120/t 2050 ZEV Subsidies: $5000 in 2015 and 2020	LCFS: 20% less GHG intensive w/ biofuels CAFE: 60% less fuel intensive by 2050

Source: Sykes and Axsen (2017), *Energy Policy*

6) From research to policy evaluation



Canada's Electric Vehicle Policy Report Card

Dr. Jonn Axsen
Suzanne Goldberg
Noel Melton

Sustainable Transportation Action Research Team
Simon Fraser University
November 2016

Energy Policy 107 (2017) 381–393

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Evaluating plug-in electric vehicle policies in the context of long-term greenhouse gas reduction goals: Comparing 10 Canadian provinces using the "PEV policy report card"

Noel Melton[a,b,*], Jonn Axsen[b], Suzanne Goldberg[b]

METCALF FOUNDATION

Social Sciences and Humanities Research Council of Canada
Conseil de recherches en sciences humaines du Canada
Canada

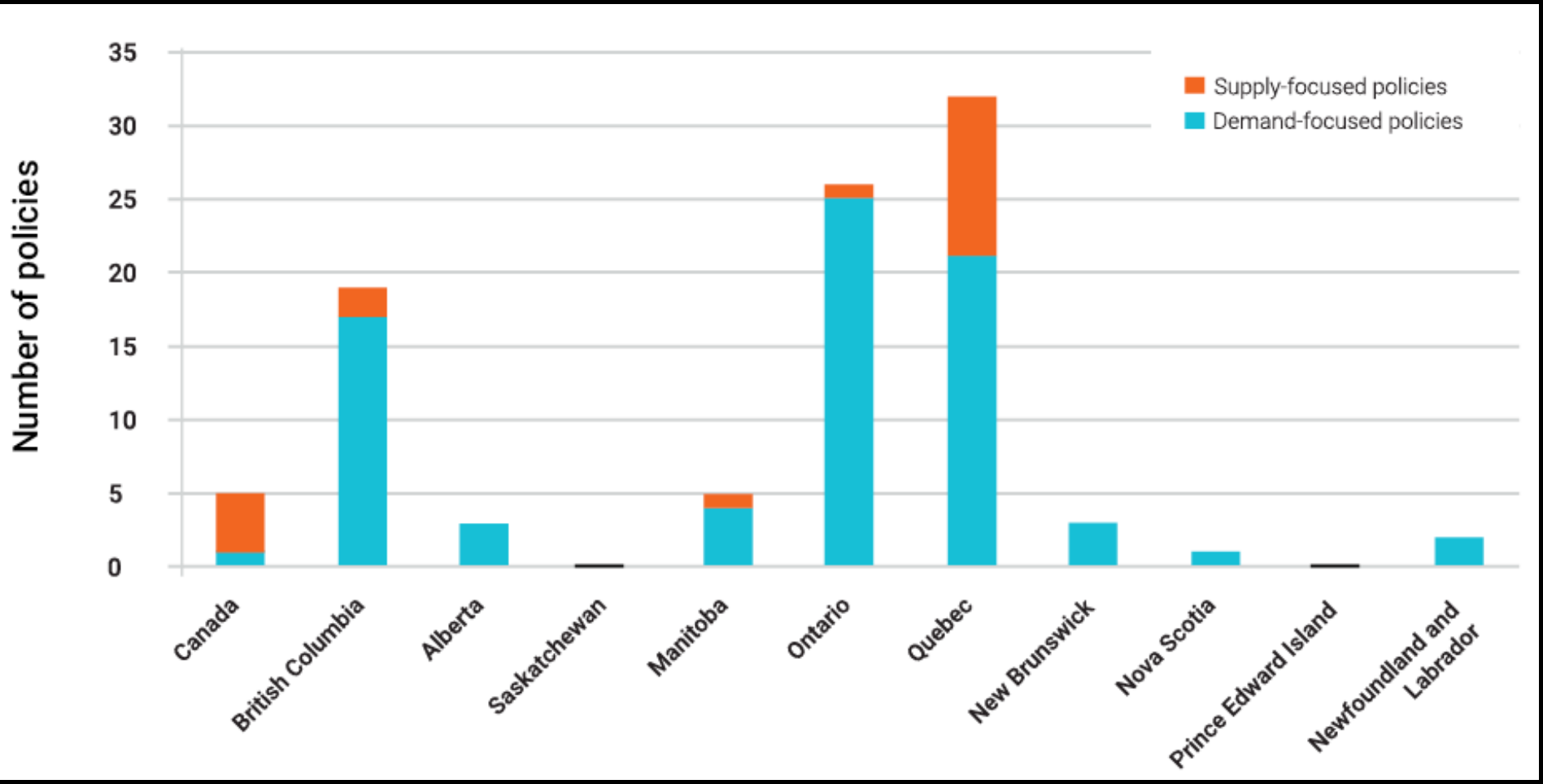
Policy Goal:

To achieve long-term GHG mitigation targets, PEVs reach 40% of new vehicle market share by 2040 (IEA scenario) – that is an "A"

1	2	3
		
Identify electric vehicle supportive policies	Evaluate the effectiveness of each policy	Assign letter grades to each province (based on the effectiveness of their policies)

Adapted from: Axsen et al. (2017), *Energy Policy*

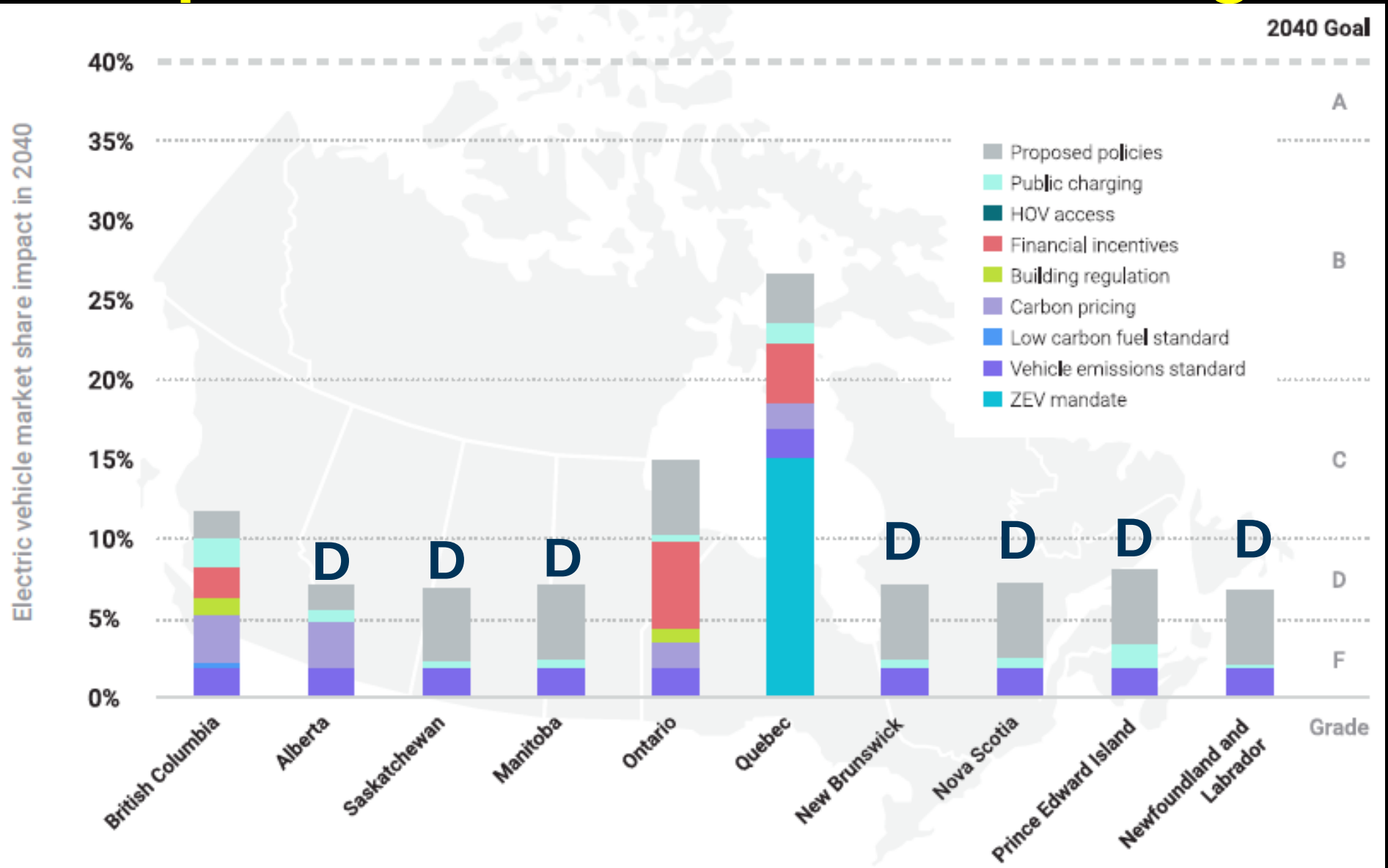
Many PEV-supportive polices (62 active), mostly demand-focused



Policy	Policy Benchmark (i.e. maximum stringency and duration)	Estimated 2040 electric vehicle market share impact
Demand-side policies		
Financial incentives	$12,000 per vehicle for 15 years.	10%
HOV lane access	100% of congested highways have HOV lane access for PEVs.	1%
Public charging deployment	One public charger for every two gas stations (sufficient charger density to alleviate range anxiety).	3%
Building regulations	100% of population has level 2 home charging access.	8%
Carbon Price	Carbon price on track to meet $150/tonne CO2e by 2030.	15%
Supply-side policy		
ZEV mandate	California's ZEV mandate (requiring 9 to 21% electric vehicle sales by 2025).	15%
Vehicle emissions standards	Vehicle emissions standards with electric vehicle credits reaching 98g CO2e/100 km by 2025.	2%
Low Carbon Fuel standards	Low carbon fuel standard requiring a 10% reduction in carbon intensity by 2020, with electric vehicle credits.	0.3%

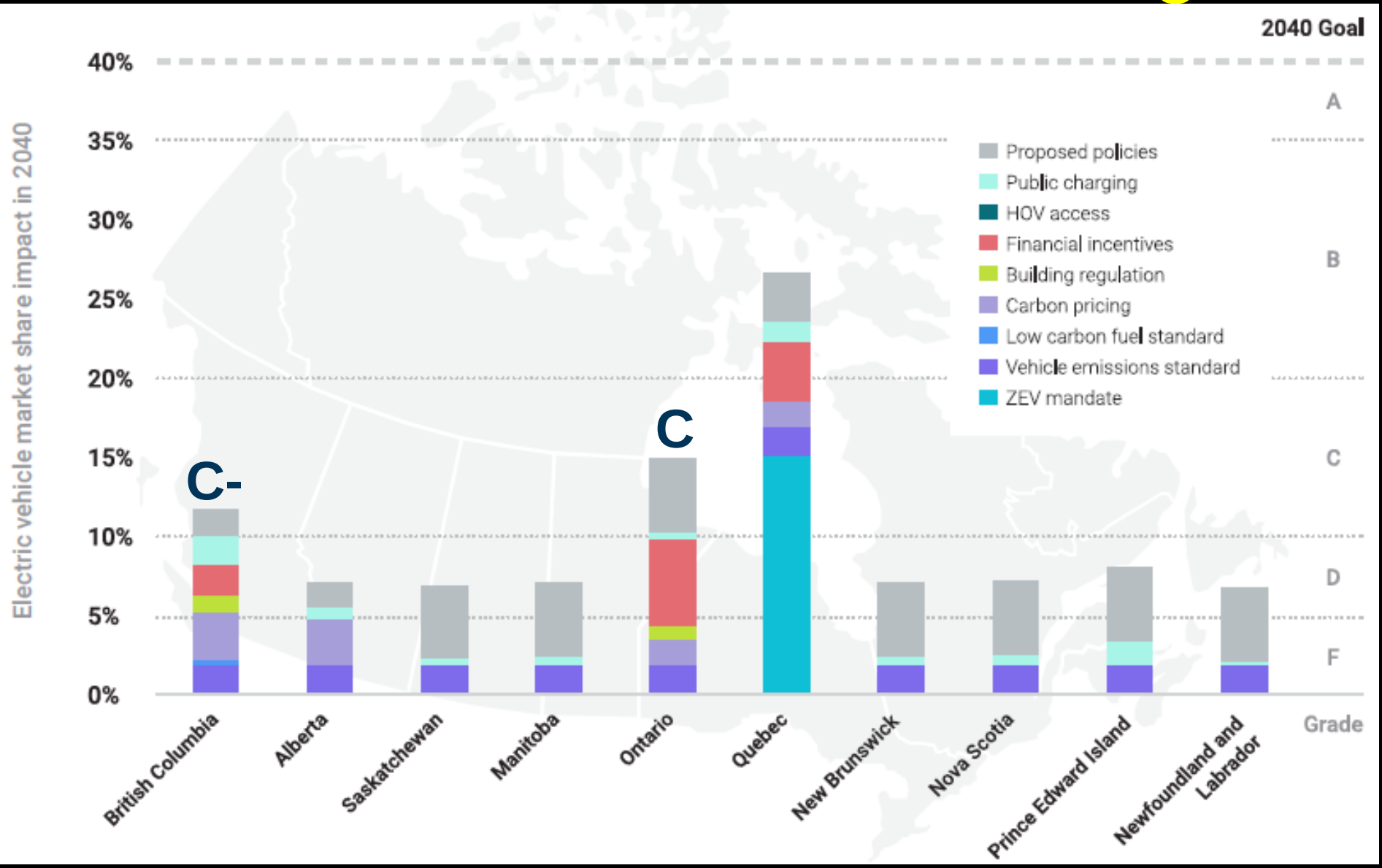
Grade	Estimated market share in 2040	Policy performance
A	35%+	**Excellent performance:** Initiatives are likely to meet or exceed target
B	20–35%	**Moderate performance:** Initiatives are likely to boost the adoption of electric vehicles but not achieve target
C	10–20%	**Marginal performance:** Initiatives are likely to achieve relatively limited adoption of electric vehicles
D	5–10%	**Poor performance:** Initiatives are likely to achieve relatively limited adoption of electric vehicles
F	0–5%	**Unsatisfactory performance:** Initiatives, if any, are likely to induce only marginal adoption of electric vehicles

Grades across Canada….
7 provinces in the “D” or “F” range



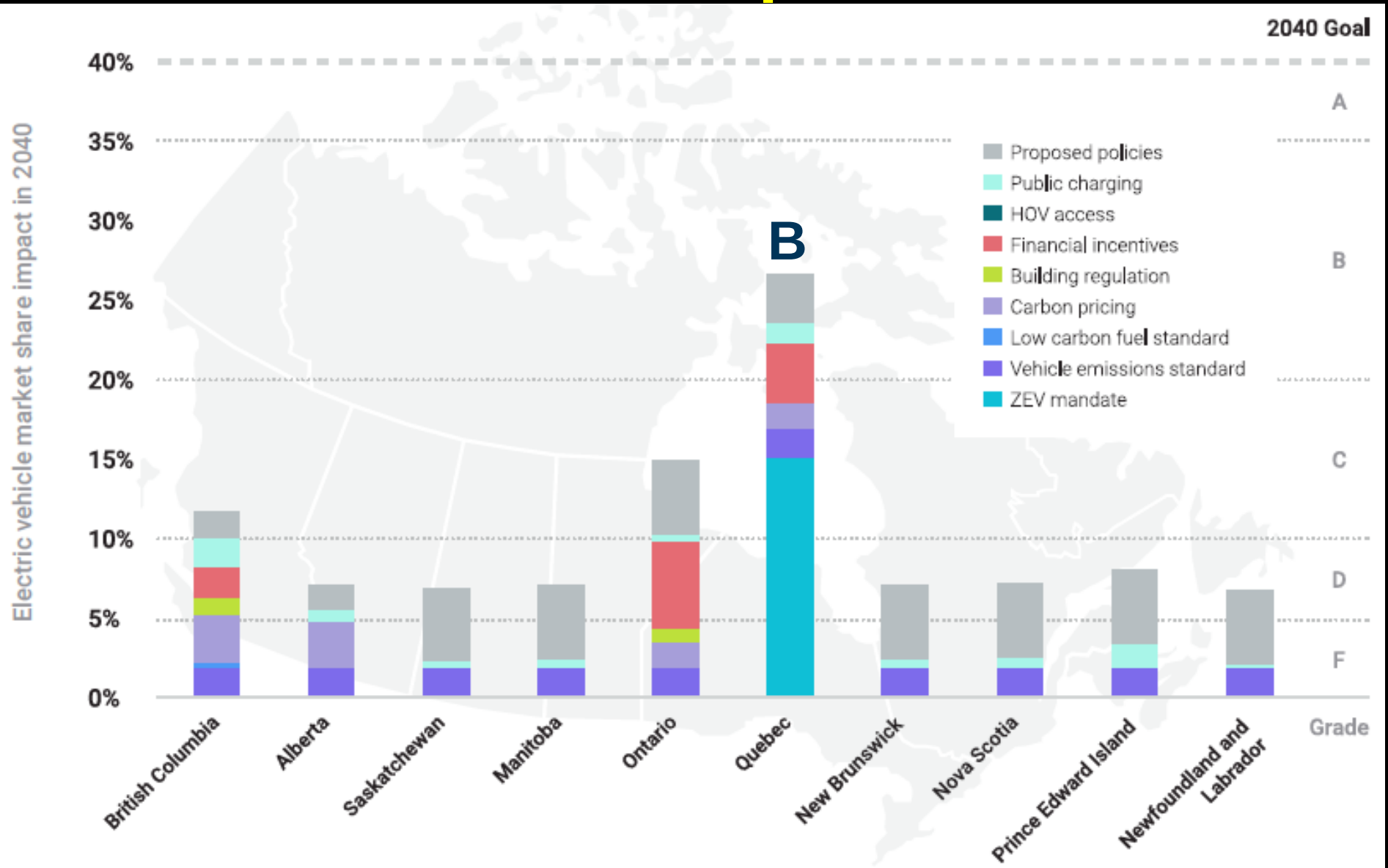
Adapted from: Axsen et al. (2017), *Energy Policy*

Grades across Canada….
Ontario and BC in the “C” range



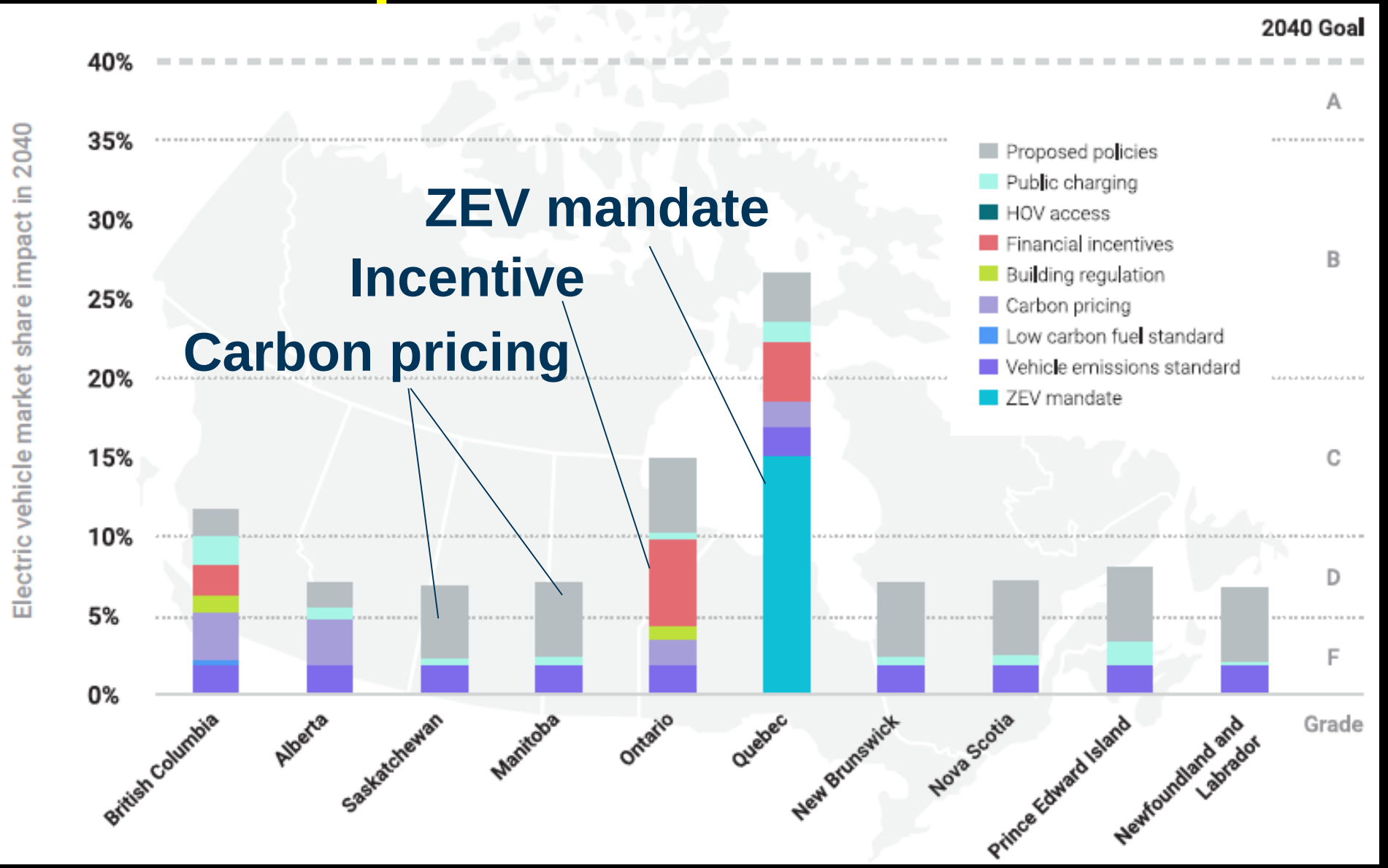
Adapted from: Axsen et al. (2017), *Energy Policy*

Grades across Canada….
Quebec is our inspiration at “B”



Adapted from: Axsen et al. (2017), *Energy Policy*

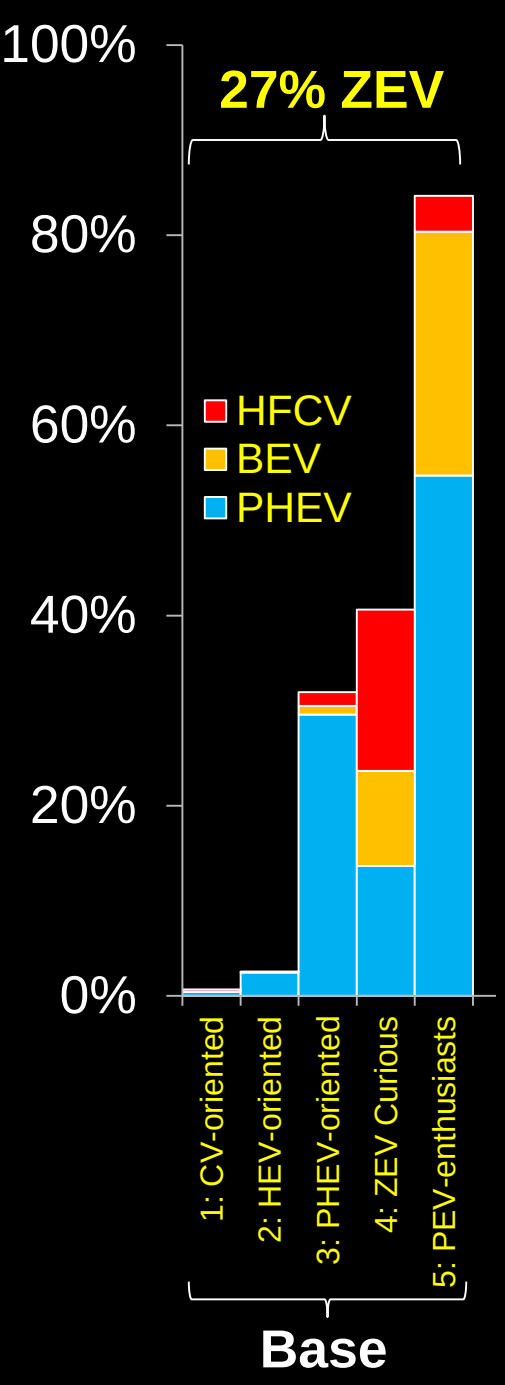
What are the most effectives climate policies in Canada?



Adapted from: Axsen et al. (2017), *Energy Policy*

World-leading policy can raise all grades

Province	Current policies*	Current + proposed*
Canada	C–	C
British Columbia	C–	C–
Alberta	D	D
Saskatchewan	F	D
Manitoba	F	D
Ontario	C–	C
Quebec	B–	B
New Brunswick	F	D
Nova Scotia	F	D
Prince Edward Island	F	D
Newfoundland and Labrador	F	D


100%
80%
60%
40%
20%
0%
27% ZEV
HFCV
BEV
PHEV
1: CV-oriented
2: HEV-oriented
3: PHEV-oriented
4: ZEV Curious
5: PEV-enthusiasts
Base

Latent-class choice model (LCM)

TABLE 5 Results for 5-Segment Latent Class Model (Canadian-wide sample, n=2124)

Segment name	CV-oriented		HEV-oriented		PHEV-oriented		ZEV-curious		PEV-enthusiast	
Percentage of respondents in segment	**23%**		**21%**		**22%**		**21%**		**13%**	
Latent Class Model										
Measure of vehicle interest (s)										
HEV	-2.87	***	1.48	*	1.30	***	0.653	*	1.07	*
PHEV	-4.92	***	-1.47	***	0.567	**	-0.603	**	2.63	*
BEV	-8.93	***	-5.32	***	-2.90	***	0.0782		1.89	*
HFCV	-4.94	***	-4.19	***	-2.39	***	0.0842		-1.11	
Measure of preferences (coefficients)										
PHEV range (km)	0.001450		-0.000832		0.00263		0.00350	*	0.000578	
BEV range (km)	0.00598		0.00513		0.00265		-0.00277	***	0.00101	
HFCV range (km)	0.000252		0.00227		0.00220	**	0.000335		0.00150	
Vehicle price (CAD$)	-0.000154	***	-0.000292	***	-0.000290	***	-0.000032	***	-0.000012	***
Fuel cost (CAD$/week)	-0.000225		-0.0133	***	-0.0160	***	0.000069		-0.000105	
Incentive value (CAD$)	0.000129	***	0.000133	*	0.000296	***	0.000079	*	0.000096	***
Home charging (Level 1 or 2)	-0.127		-0.249		0.650	***	-0.0172		-0.0422	
Workplace charging (Level 1 or 2)	-0.281		0.165		0.0519		0.117		0.188	
Public charging (% of destinations)	0.0120		0.00565		0.00260		0.00425		0.00194	
DC fast charging (access on major highways)	0.808		0.177		0.314	***	0.162		-0.240	
Hydrogen station availability (% of gas stations)	0.0171		0.0205		0.0156	**	0.00121		0.011	
Implied willingness-to-pay[a,b]										
Valuation of vehicle type ($ CAD)										
HEV (all else held constant)	$ (18,675)		$ 5,052		$ 4,476		$ 20,598		$ 87,981	
PHEV-60km (all else held constant)	$ (31,977)		$ (5,028)		$ 1,951		$ (12,396)		$ 215,907	
+ home charging					$ 4,188					
+ DC fast charging					$ 3,034					
BEV-220km (all else held constant)	$ (58,104)		$ (18,188)		$ (9,991)				$ 154,796	
+ home charging					$ (7,755)					
+ DC fast charging					$ (8,909)					
HFCV-500km (all else held constant)	$ (32,107)		$ (14,335)		$ (4,443)					
10% gas stations					$ (3,904)					
50% gas stations					$ (1,750)					
100% gas stations					$ 943					
Valuation of vehicle type ($ CAD)										
PHEV range (per km)							$ 110			
BEV range (per km)							$ (87)			
HFCV range (per km)					$ 8					
Fuel cost savings(per year)			$ 2,373		$ 2,876					
Incentive value (per $1000 incentive)	$ 838		$ 454		$ 1,019		$ 2,494		$ 7,897	
Home charging (of Level 1 or 2)					$ 2,237					
Workplace charging (of Level 1 or 2)										
Public charging (per % of destinations)										
DC fast charging (for access on major highways)					$ 1,082					
Hydrogen stations (per % of gas stations)					$ 54					

Note the difficulty of modeling supply-focused policy (e.g. ZEV mandate)

A ZEV mandate can induce a variety of compliance strategies:

1. **Increase ZEV availability in that region**
2. **More ZEV-ready dealerships**
3. **New ZEV makers emerge (e.g. Tesla)**
4. **Internal cross-subsides (cheaper ZEVs)**

Modeled in REPAC

5. **Long-term R&D (more variety, lower costs)**
6. **Strong signal for stakeholder coordination**
7. **More local ZEV marketing**

"Sort of" modeled in REPAC as increasing awareness, but not preference change

California's (and Quebec's) ZEV Mandate

- Sales requirement: "the most direct policy change any state can take to ensure increased PEV deployment"
- California now: ZEVs ~15% of new market share by 2025
- Credits differ by vehicle (PHEV, EV, Fuel Cell)
- Credits can be traded among automakers (noncompliance = $5k per ZEV credit)

Note: Tesla earned $139 million in Q3 2016 by selling ZEV credits!

What might happen with a ZEV mandate?

A variety of potential actions….

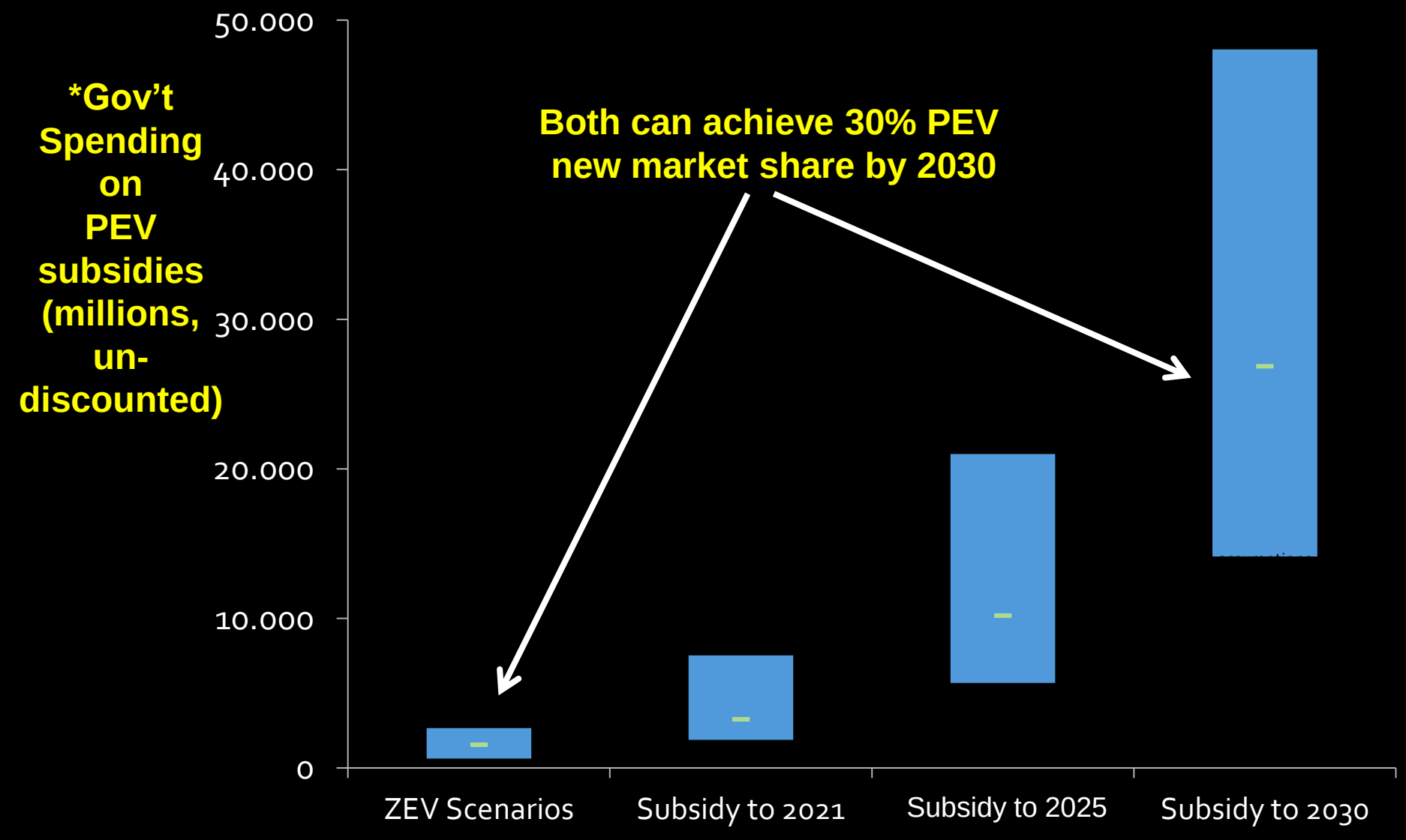
For a small region (e.g. Quebec):

1. More EV models available (bigger inventory, less wait time)
2. More dealerships become EV-ready (training, etc.)
3. EVs become more affordable (pricing changes)
4. More local marketing

For the world:

5. Automakers channel more funds into R&D for EVs
6. New EV automakers can emerge (e.g. Tesla)
7. More, cheaper EV models in the long-term
8. Strong signal for various stakeholders to transition (direction)

Multiple ways to push electric vehicles, but subsidies cost* 20-30 times more than ZEV mandate



Source: Axsen and Wolinetz (Under review), *Transportation Research Part D*