What ZEV policies are “best” for Canada?

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Sustainable Pathways for Canada’s On-road Transportation Sector
Ottawa
Overarching policy goals

1. Deep de-carbonization (relative to 2007):
   - 2030: 40% cut
   - 2040: 60% cut
   - 2050: 80% cut

2. ZEV sales goals
   - 2030: 30% ZEV sales
   - 2040: 100% ZEV sales
We need strong policies -- which ones?

Demand-focused policy

- Purchase incentives
- Non-monetary incentives (HOV lane, etc.)
- Charger deployment (home, work, public)
- Information campaigns

Supply-focused policy

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

Adapted from: Melton et al. (2017), Energy Policy
Policy package: Three priority policies

- CAFE standards (g/km)
- ZEV mandate (vehicle sales)
- Low-carbon fuel standard (g/MJ)
The START research program
The START approach: multi-method

- Qualitative interviews
  - n = dozens
- “Quantitative” surveys
  - n = 100s or 1000s
- Technology adoption models
  - (0-15 year time horizon)
- Energy-economy system models
  - (20-40yr + time horizon)

“Reflexive Participant” surveys
“Respondent-based” modeling
Behaviourally-realistic models
More details provided in articles and reports
Study #1:
The case for a ZEV mandate
(REPAC 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)

"Actual" Sales = Stated Preference × Home charging × PEV familiarity × PEV availability

- Dealership availability
- Class availability
- Model variety

Source: Wolinetz & Axsen (2017), *Technological Forecasting & Social Change*
Current policies don’t get past 10% new market share...

Source: Axsen & Wolinetz (2018), *Transportation Research Part D*
$6000 / PEV subsidy until 2021...

Source: Axsen & Wolinetz (2018), *Transportation Research Part D*
$6000 / PEV subsidy until 2025…

Source: Axsen & Wolinetz (2018), Transportation Research Part D
$6000 / PEV subsidy until 2030…
Can achieve 2030 target, but highly uncertain and expensive

Source: Axsen & Wolinetz (2018), Transportation Research Part D
2030 ZEV mandate targets can be achieved (via increased model availability, variety and Intra-firm cross-price subsidies)

Source: Axsen & Wolinetz (2018), Transportation Research Part D
Study #2:
LCFS policy interactions
(CIMS model)
Passenger vehicles: LCFS has little additive impact, ZEV mandate pushes PEVs

*(Strong CAFE, ZEV mandate, carbon price)*

Source: Lepitzki and Axsen (2018), *Energy Policy*
Heavy-duty: LCFS is additive to ZEV mandate and efficiency standards

Source: Lepitzki and Axsen (2018), Energy Policy

Ambitious Policies

(Strong CAFE, ZEV mandate, carbon price)
Study #3:
Citizen acceptance of policy
(2019 survey, n = 1,552)
2013 survey: supply-focused climate policies are more acceptable, strong taxes are not
2019: Policy awareness is high for carbon price, lower for supply-focused policy

British Columbia: “This policy is in place in my region”

<table>
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<th>Policy</th>
<th>In place</th>
<th>Not in place</th>
<th>I don't know</th>
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<td>Carbon tax</td>
<td>72%</td>
<td>3%</td>
<td>25%</td>
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<td>LCFS</td>
<td>19%</td>
<td>6%</td>
<td>75%</td>
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<td>CAFE</td>
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<td>50%</td>
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<td>*ZEV mandate</td>
<td>11%</td>
<td>8%</td>
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<tr>
<td>ZEV subsidies</td>
<td>42%</td>
<td>4%</td>
<td>54%</td>
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ZEV mandate: awareness is low in all regions, even California (2019)
Canada-wide policy support (2019, n = 1552)

**Demand-focused**
- Carbon tax ($150/tonne)
- ZEV subsidy ($6k 10 yrs.)
- HOV lane access for EVs
- Chargers (50% gas)
- EV-ready building codes
- ZEV Info campaigns

**Supply-focused**
- CAFE (60% cut by 2040)
- LCFS (80% cut by 2050)
- ZEV mandate (100% by 2040)

Percentage of respondents (n=1,552)
Conclusions:
ZEV policy priorities
Priorities: The supply-focused policy “Triad”

CAFE standards (g/km)

ZEV mandate (vehicle sales)  Low-carbon fuel standard (g/MJ)

Good “complements”: carbon pricing, purchase incentives, charging infrastructure (home, work, public)
Extra
### Canada’s ZEV Policy Handbook

Sustainable Transportation Action Research Team (START)
Simon Fraser University
December 2017

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<th>Public Support</th>
<th>Policy Simplicity</th>
<th>Transformational Signal</th>
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**Source:** Melton et al. (2017), Canada’s ZEV Policy Handbook
The respondent-based preference and constraint model (REPAC)

**Constrained Demand**

\[
CD_{i,j,k} = \frac{a_{i,j,k} \cdot e^{U_{i,j,k}}}{\sum_j a_{i,k} \cdot e^{U_{i,k}}}
\]

**Utility**

\[
U_{i,j,k,l} = VSC_{j,l} + p_{j,k} \cdot PP_l + f_{j,k} \cdot FC_l + r_j \cdot ER_{j,l} + L2_{j,l}
\]

**Constraints**

\[
a_{i,j,k} = HC_i \cdot PF_{i,j} \cdot PA_{i,j,k}
\]

**Availability**

\[
PF_{i,j,t} = \frac{1}{(1+a \cdot e^{-CD_{t-1} \cdot b})}
\]

\[
PA_{i,j,k} = \frac{2}{(1 + e^{-c \cdot n_{i,j,k}})} - 1
\]

\[
n_{i,j,k} = \sum_m n_{j,k} \cdot d_{i,j,k}
\]

\[
d_{i,j,k,m,t} = \frac{1}{(1+s \cdot e^{-CD_{t-1} \cdot r})}
\]

**Source:** Wolinetz & Axsen (2017), *Technological Forecasting & Social Change*
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)
5. Long-term R&D (more variety, lower costs)
6. Strong signal for stakeholder coordination
7. More local ZEV marketing

Modeled in REPAC

“Sort of” modeled in REPAC as increasing awareness, but not preference change
REPAC lines up well with actual PEV sales in 2015

Latent demand (without constraints)

Constrained only by Home charging

Constrained only by PEV Familiarity

Constrained only by PEV availability

All constraints

% PEV new-market share in Canada, 2015

Source: Axsen & Wolinetz (2018), Transportation Research Part D
What battery cost assumptions?

Battery pack Manufacturing Costs ($CDN dollars)

- **Optimistic**
  - 2015: $350 / kWh
  - 2030: $85 / kWh

- **Medium**
  - 2030: $94 / kWh

- **Pessimistic**
  - 2030: $125 / kWh

Source: Axsen & Wolinetz (Under review)
Incentive-based strategy costs **government** 20-30 times more than ZEV mandate.

*Gov’t Spending on PEV subsidies (millions, undiscounted)*

Both can achieve 30% PEV new market share by 2030.

Source: Axsen and Wolinetz (2018), *Transportation Research Part D*