Conflicting interests in defining an 'optimal' battery size when introducing PHEVs?

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Research question

- How will the choice of objective function influence the optimal battery size?
  - Total Cost of Ownership savings for the users
  - Electric drive fraction of the car fleet
  - Number of PHEVs sold
- How are the results affected by:
  - Costs of converting HEV to PHEV
  - Subsidies

The database

- 445 privately driven Swedish cars
- Car model 2002 and younger
- GPS installed for 1-2 months
- March 2010-Sept 2012
- The cars are conventional gasoline and diesel cars

HEV or PHEV?

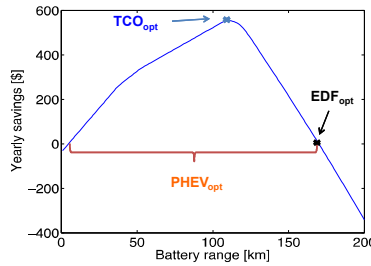
There is a higher investment to buy a PHEV but there is possibility to overcome this investment through cheap mileage.

- A PHEV is chosen if:

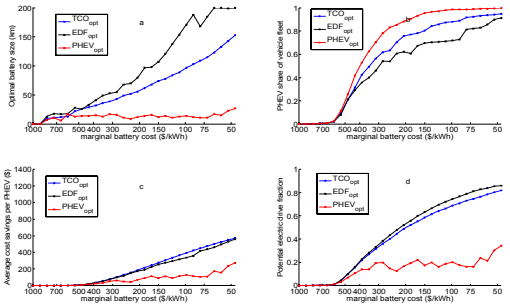
  Savings(AER) > (Battery investment (AER) + C_{fix})

We consider a range of battery costs and two different scenarios of high and low fixed costs (C_{fix})

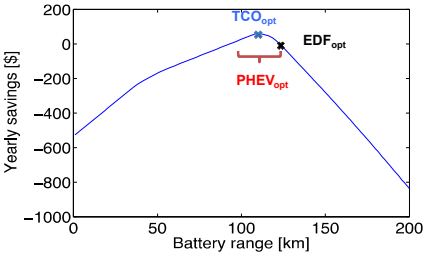
Savings per battery range, when marginal battery cost ~400$/kWh, low C_{fix}(200$), night time charging only



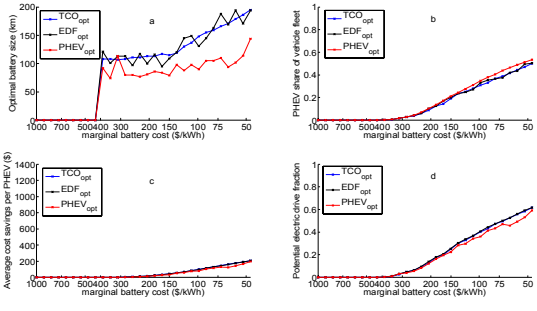
One battery size for the whole fleet, Assuming low C_{fix} (200$)



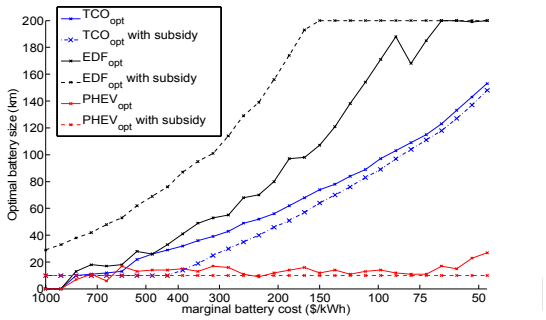
Savings per battery range, when marginal battery cost ~400$/kWh, low C_{fix}(3500$), night time charging only



Assuming high C_{fix} ($3500)



Low C_{fix}, and subsidy of $5000 for 10 km batteries or bigger.



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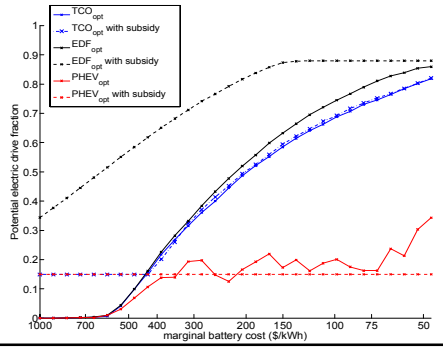


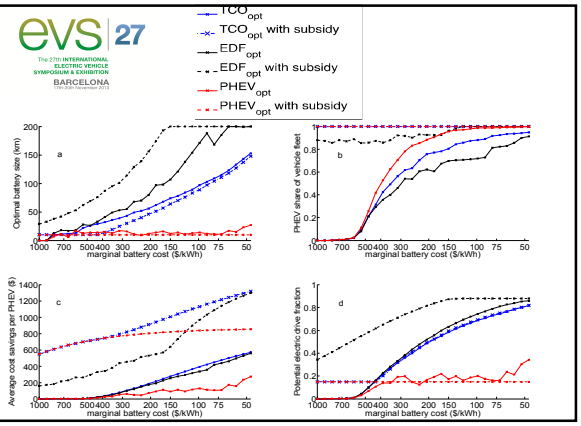
Discussion

- High fixed costs (C_{fix}) may delay introduction of PHEVs
- High share of PHEVs is not necessarily the same as a high share of electric driving
- To reach a high share of electric driving small batteries are not enough.
- Subsidies should be designed with care

Thank you for listening! **Larshenr@chalmers.se**

Car statistics

Parameter	Average for cars in database	Average from vehicle register
Model year	2006.37	
Maximum engine power (kW)	98.2	99.5
Cylinder volume (cm^3)	1819	1812
Curb weight (kg)	1456	1457
Fuel use (liter/100km)	7.22	7.26
CO_2 emission (g CO_2/km)	176	177



Methodology

Shift to PHEV when TCO is lower than corresponding HEV

Costs included:

- Annuitized battery investment costs
- Yearly fuel and electricity costs

$$marginal\ savings = d_{e,l}(AER) * (p_f e_f - p_e e_e)$$
$$marginal\ cost = \alpha\, \beta^{-1}\, c\, e_e$$

- There is also an annualized investment cost besides battery: c_{fix}

Methodology

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- Annuitized battery investment costs
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Marginal annual distance driven on electricity

Fuel and electricity prices

$$marginal\ savings = d_{e,l}(AER) * (p_f e_f - p_e e_e)$$
$$marginal\ cost = \alpha\, \beta^{-1}\, c\, e_e$$

Specific energy use

- There is also an annualized investment cost besides battery: c_{fix}

Methodology

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$$\text{marginal savings} = d_{e,i}(AER) * (p_f e_f - p_e e_e)$$

$$\text{marginal cost} = \alpha\, \beta^{-1}\, c\, e_e$$

Annuity; Depth of discharge; Marginal battery cost

- There is also an annualized investment cost besides battery: C_{fix}

Parameters

Parameter	Value
Specific fuel use, e_f	0.45 kWh/km
Specific electricity use, e_e	0.15 kWh/km
Fuel price, p_f	0.2 $/kWh
Electricity price, p_e	0.2 $/kWh
Annuity, α	0.15 yr^{-1}
Depth of discharge, β	0.7
C_{fix}-low	$200
C_{fix}-high	$3500