How Drive Cycle Affects Hybrid Fuel Economy and Vehicle Cost Effectiveness

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CALSTART Data Collection

- CALSTART collected data from Class 8 hybrid beverage delivery trucks
  - Over 420 HVIP orders have been in this Class vehicle
  - CEC sponsored CalHEAT program
  - Vehicles operated in Los Angeles from Santa Monica, CA and Downtown LA
- Four vehicles for long term performance evaluation:
  - Conventional Freightliner
  - Eaton Hybrid Freightliner (280 hp)
  - Eaton Hybrid Freightliner (325 hp)
  - Eaton Hybrid Kenworth (325 hp)

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Typical Beverage Vehicle Route

- Average of the 4 Vehicles
  - 650 miles traveled per Month
  - 60 hours of operation per month
  - 115 gallons of fuel used per month

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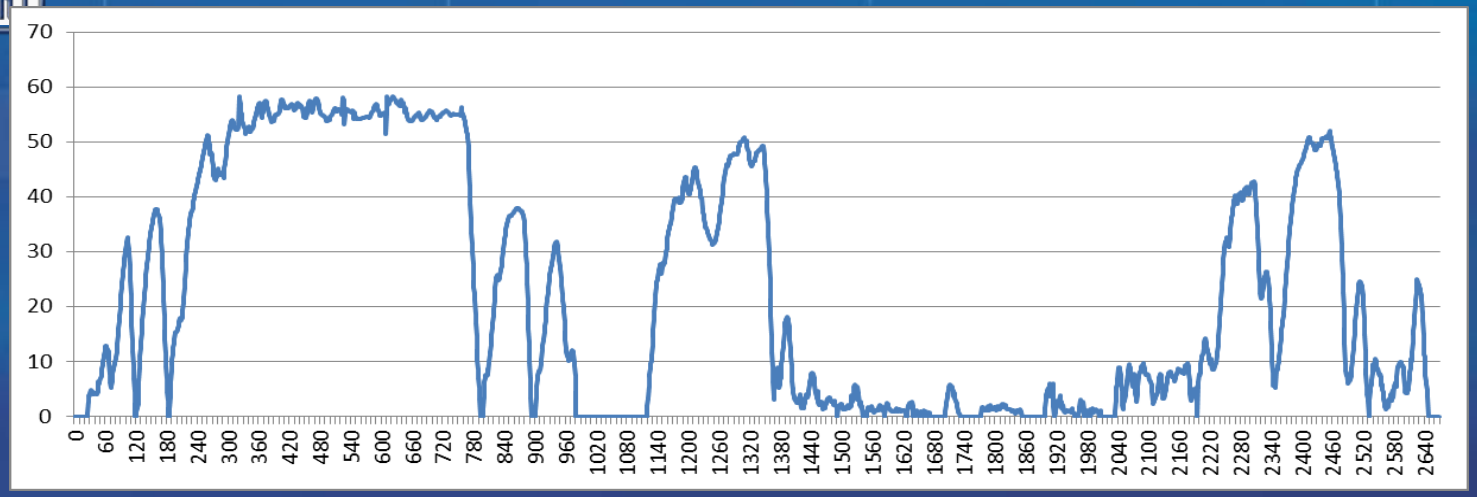
Vehicle Operation Profile/Duty Cycle



- Average fuel economy improvement with hybrids ~ 18%
- Vehicles demonstrated stop and go driving to highway driving; a variety of operational profiles
- Vehicle “microtrips” were developed based on parameters specific to the observed vehicle profile
  - Microtrips - trips made between vehicle stops

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Data Analysis and Operation Modes

- Microtrips were isolated to define vehicle operation modes
- Parameters used to characterize microtrips
  - % Idling
  - % Creep (speed < 10mph)
  - Average Speed
  - Other parameters such as load, altitude, engine speed, throttle position are also considered but not stressed here
- The microtrip data collected on the vehicles were separated into 3 operation modes based on speed, creep, and idling percentages.
  1. Local/Urban Delivery - Low speeds with high idling %
  2. Regional Delivery – Medium average speeds with mixed idling %
  3. Over the Road Delivery - High speed with low idling %

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CalHEAT Truck Categories and their Duty Cycles

Class 7/8 Tractors

Over the Road

- Younger Trucks; High Annual VMT
- Mostly higher average speed, highway driving

Short Haul/ Regional

- Between cities; Drayage; Day Cabs
- Average VMT, Medium Average speeds

Class 3-8 Vocational Work Trucks

Urban

- Cargo, freight, delivery collection
- Lower VMT; Lower Average speed; Lots of stop start

Rural/ Intracity

- Cargo, freight, delivery collection
- Higher VMT; Higher Avg speed; Combined urban/ highway

Work site support

- Utility trucks, construction, etc.
- Lots of idle time; Lots of PTO use

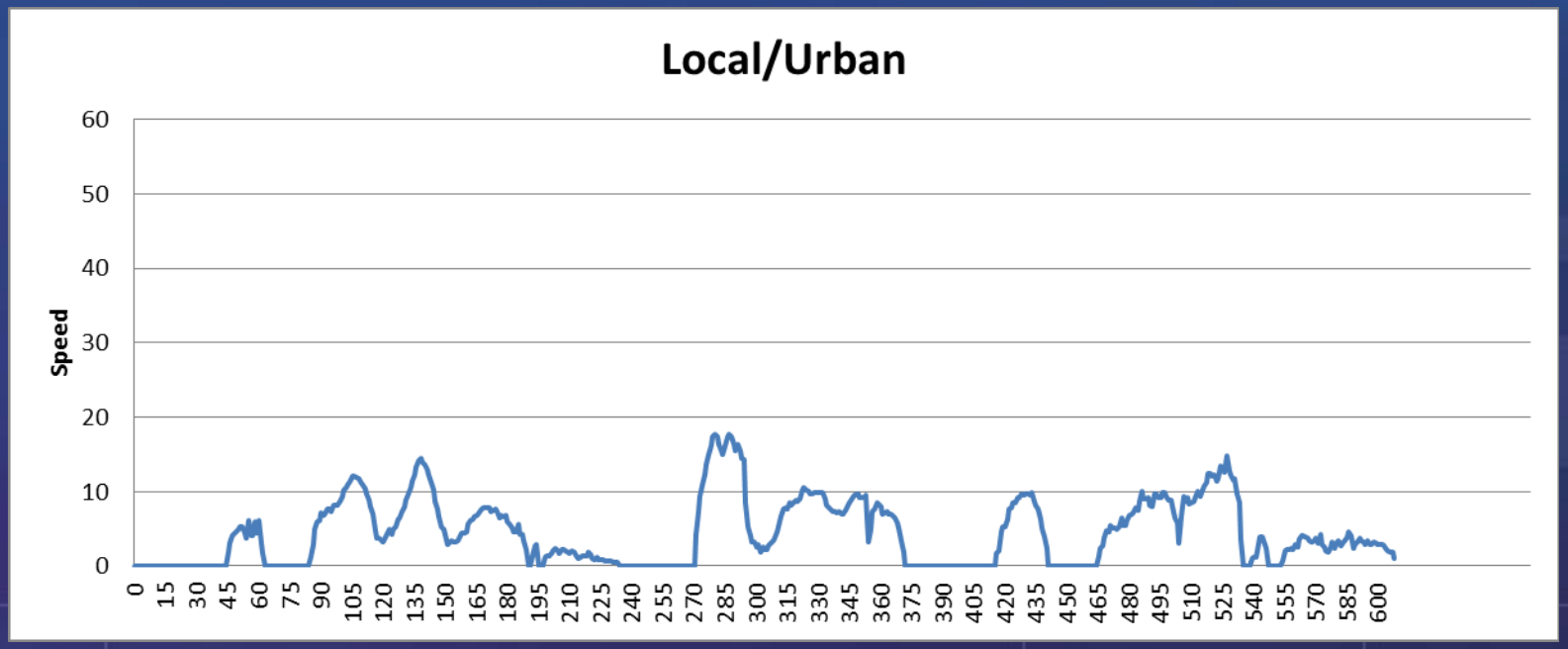
Class 2B/3

Pickups/ Vans

- Commercial use; Automotive OEMs & volumes

1. Local/Urban

- Operational Mode Characteristics
  - Low Average Speed: ~ 8 MPH (including stops)
  - Vehicles idles 48% of the time
  - Vehicle travels in creep mode (<5MPH) 25% of the time
- Observed Hybrid Fuel Economy Benefit: ~40%



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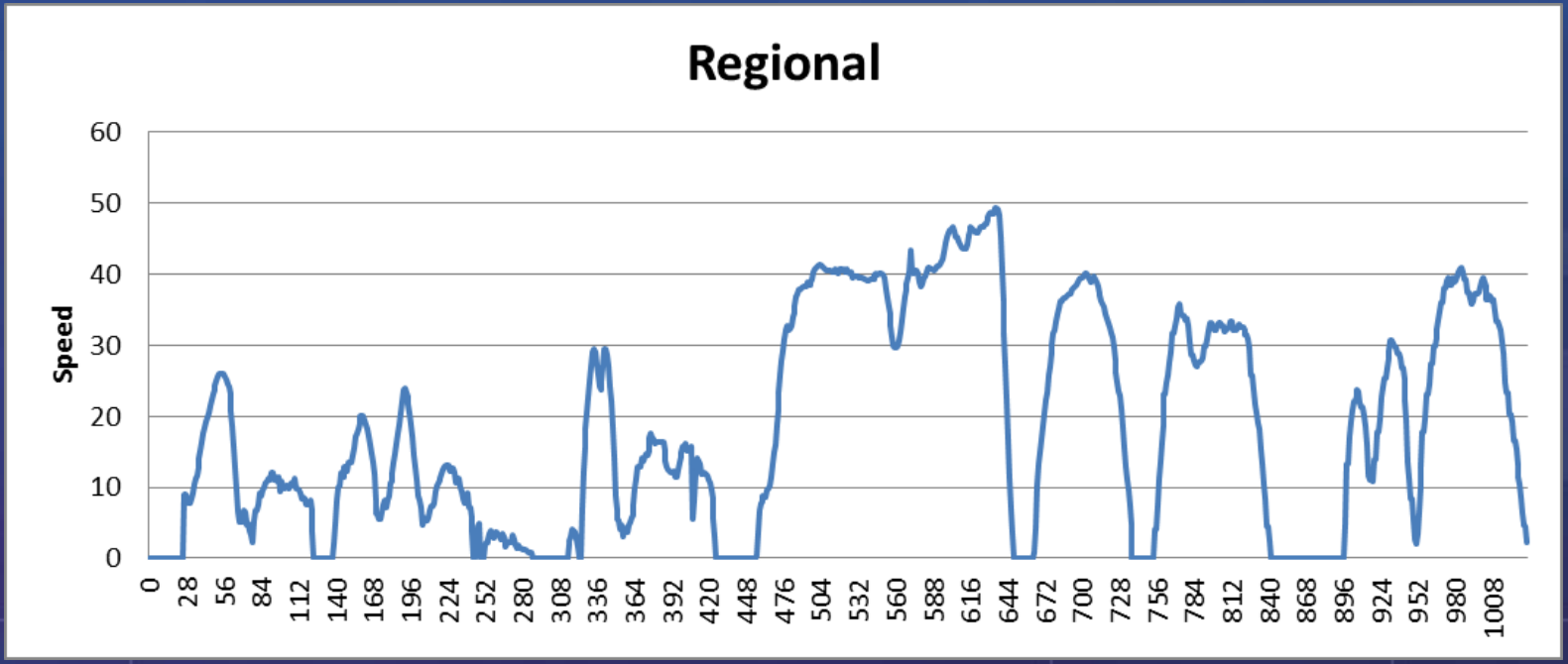
2. Regional

- Operational Mode Characteristics
  - Medium Average Speed: ~ 23 MPH (including stops)
  - Vehicles idles 15% of the time
  - Vehicle travels in creep mode (<5MPH) 14% of the time
- Observed Fuel Economy Benefit: ~20%



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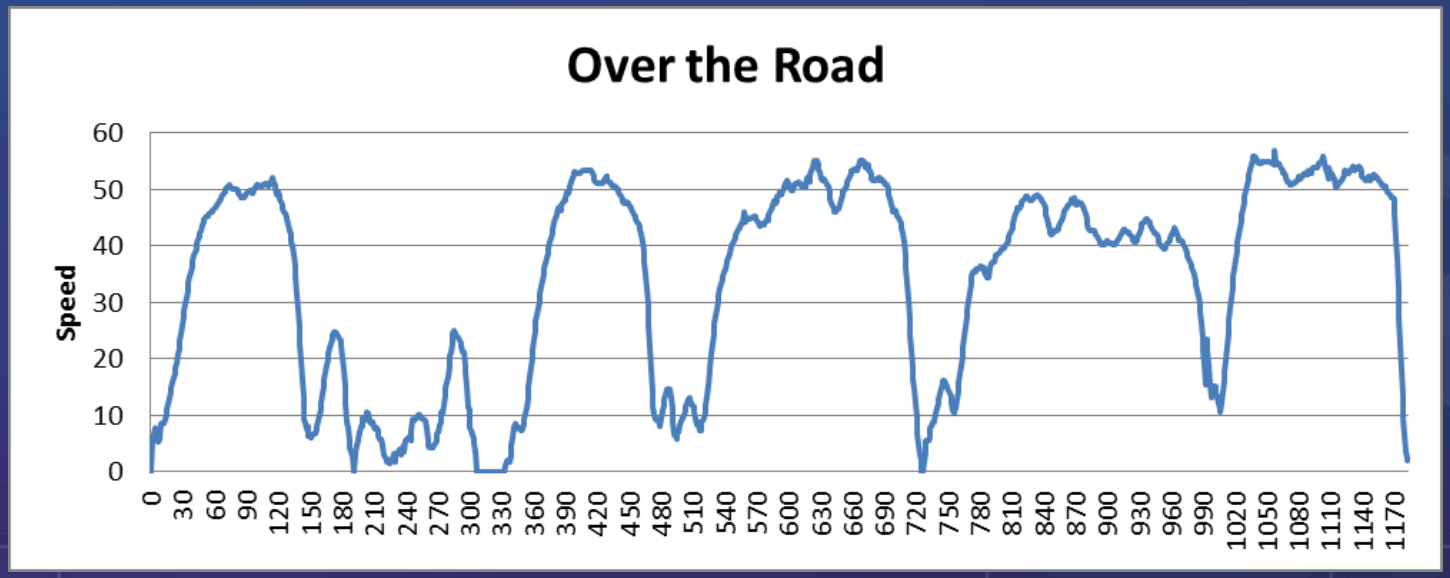
3. Over the Road

- Operational Mode Characteristics
  - Higher Average Speed: ~ 38 MPH (including stops)
  - Vehicles idles 5% of the time
  - Vehicle travels in creep mode (<5MPH) 3% of the time
- Observed Fuel Economy Benefit: ~13%



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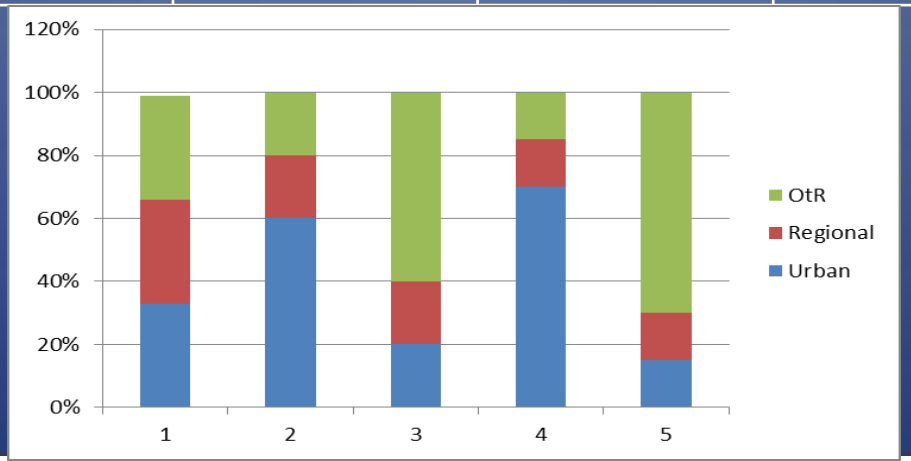
Sample Duty Cycles

- Fuel Consumption is dependent on Duty Cycle
- Overall Vehicle Duty Cycle will be a mixture of the 3 operational categories

	Urban	Regional	OTR	% Benefit
1	33%	33%	33%	24%
2	60%	20%	20%	31%
3	20%	20%	60%	20%
4	70%	15%	15%	33%
5	15%	15%	70%	18%



Business Case Assumptions

- Class 8 Hybrid Electric Tractor
  - Hybrid system incremental cost: **$45,000**
  - Maintenance costs decreased by **10%**
  - **10-year lifetime** – 5 days/week – 50 weeks/year
- California Diesel Prices as of 02/27/2012
  - **$4.410** per gallon
  - Fuel Escalation Rate at **3% per year**
- HVIP Incentive at **$25,000**
- Discount Rate for Net Present Value (NPV) at **7%**

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Hybrid System Benefits

- Local / Urban Delivery: 50 miles/day – 6 MPG
  - Hybrid system fuel economy improvement **~40%**
- Regional Delivery: 150 miles/day – 7 MPG
  - Hybrid system fuel economy improvement **~20%**
- Over-the-road: 350 miles/day – 7 MPG
  - Hybrid system fuel economy improvement **~13%**

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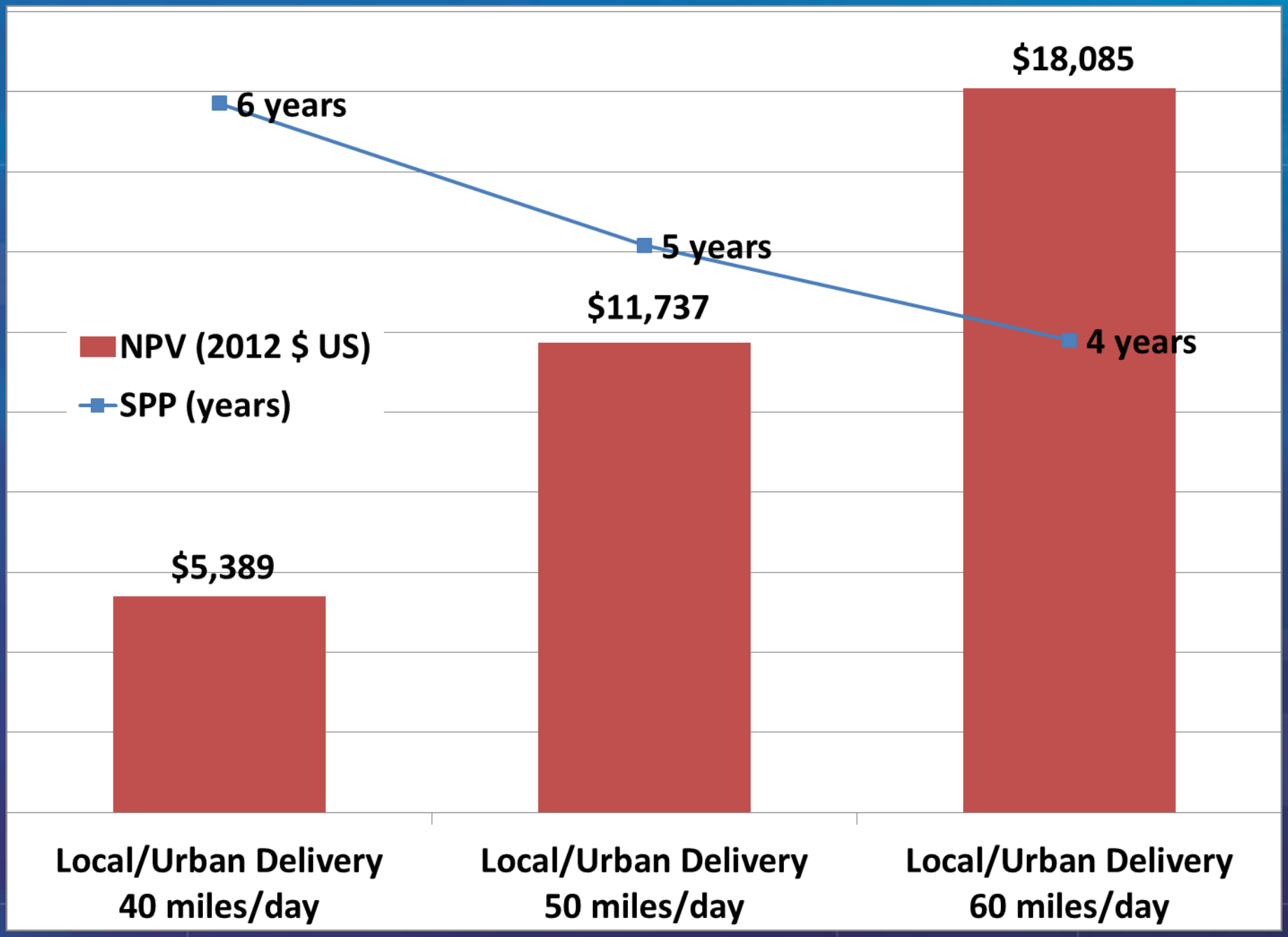

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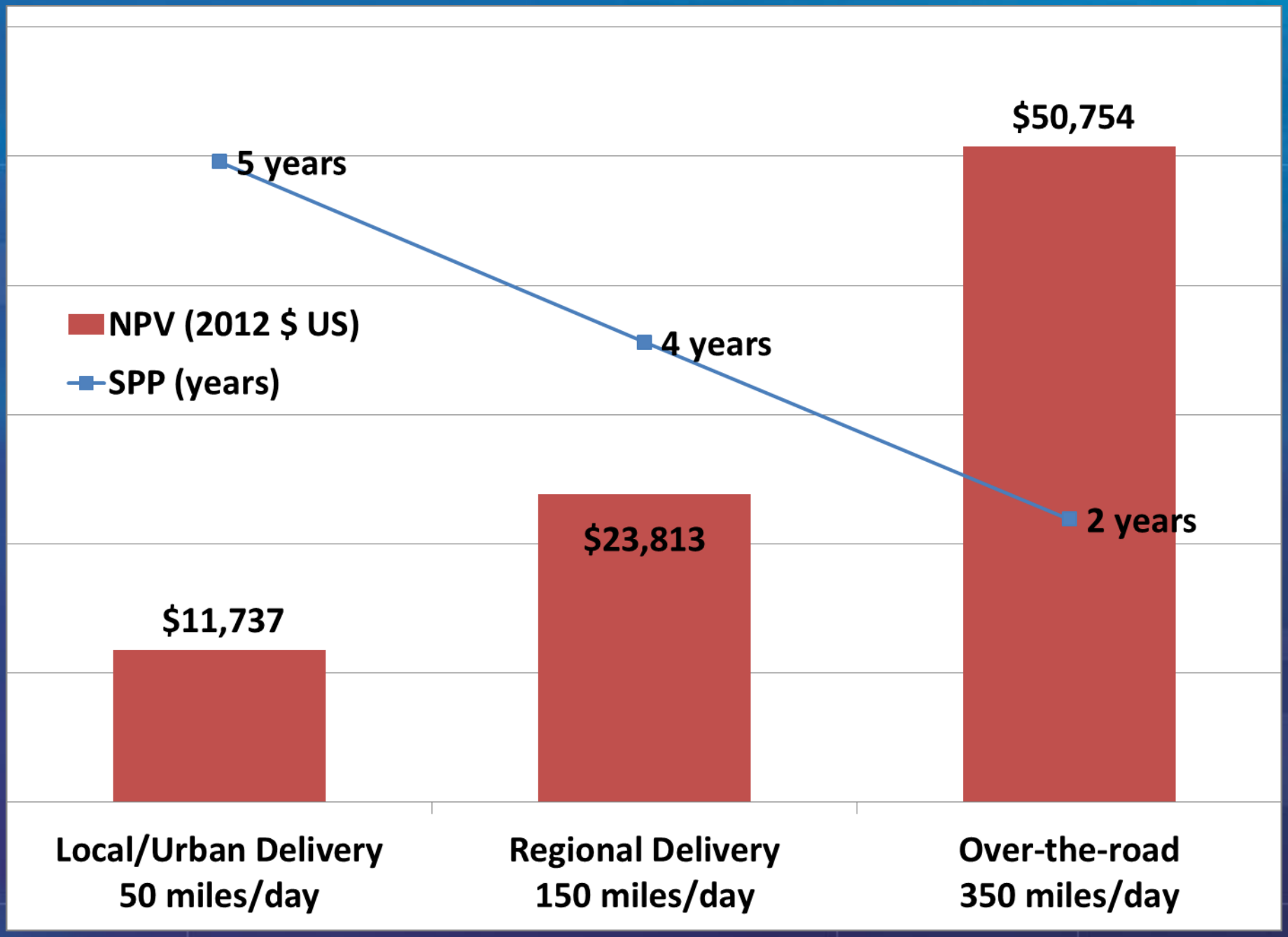

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Conclusions

- Drive cycle heavily affects hybrid fuel economy
  - Know your drive cycle; take some data
  - Make sure your drive cycle will result in adequate savings
  - Consult with truck manufacturers/hybrid system suppliers
- Consider the savings over the life of the vehicle, not just simple payback
- Take advantage of regional, state, and federal incentives to help reduce first cost

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