Sustainable Vehicle Fleet Options for the City of Houston

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Presentation to City of Houston
March 2020
Context: City of Houston Climate Action Plan (2019 draft)

**Net-zero emissions by 2050**

Projected emissions with and without action

- **Baseline Forecast**
- **Grid Decarbonization**
- **Energy**
- **Building Optimization**
- **Transportation**
- **Materials Management**
- **Offsets**

![Graph showing net-zero emissions by 2050](image)

Transportation is nearly half of emissions

**Electric vehicle fleet by 2030**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Year Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>2025</td>
</tr>
<tr>
<td>Increase public infrastructure for EV and alternative renewable fuels, installing EV charging stations at public-facing City buildings.</td>
<td>2025</td>
</tr>
<tr>
<td>Convert non-emergency, light-duty municipal fleet to 100% EV.</td>
<td>2030</td>
</tr>
</tbody>
</table>
Context: Advantages of Electric Vehicles

- No tailpipe emissions
- Quiet
- Electricity is getting cleaner
  - City buys >90% wind and solar electricity
  - Combusted liquid and gas fuels can only get so clean
- Battery costs are declining
- Lower maintenance costs (fewer moving parts)
Alternative Vehicle Types Considered

<table>
<thead>
<tr>
<th>Type</th>
<th>Fuel</th>
<th>Description</th>
<th>Diagram</th>
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</thead>
<tbody>
<tr>
<td>HEV</td>
<td>Gasoline</td>
<td>Hybrid Electric Vehicle</td>
<td><img src="#" alt="HEV Diagram" /></td>
</tr>
<tr>
<td>PHEV</td>
<td>Gasoline and/or electricity from grid</td>
<td>Plug-in Hybrid Electric Vehicle</td>
<td><img src="#" alt="PHEV Diagram" /></td>
</tr>
<tr>
<td>BEV</td>
<td>100% electricity from grid</td>
<td>Battery Electric Vehicle</td>
<td><img src="#" alt="BEV Diagram" /></td>
</tr>
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</table>

No emissions savings from CNG for City of Houston conditions (our 2017 study)


2015-2021 Life Cycle Average GHG Emissions

- Feedstock
- Fuel
- Vehicle Operation

Fig. 1. Fuel cycle COₐe emissions estimates from GREET (solid bars) with best, 5th percentile, and 95th percentile upstream emissions from the Venkatesh studies (error bars and dot). Dashed bars show emissions under ERCOT grid electricity.

Fuel-cycle analysis of City of Houston vehicle options (Sengupta and Cohan, 2017)
Other uses of natural gas can reduce emissions

Vehicles: No emissions savings; Require new fueling infrastructure

Furnaces: NG is cleaner than fuel oil

Electricity: NG is cleaner than coal

Cohen and Sengupta 2016
Gasoline & Electric Sedan Options

Conventional

2019 Toyota Camry
$23,845
34 MPG

Plug-in Hybrid

2019 Toyota Prius Prime
$27,350
Gasoline: 54 MPG
Electric: 250 Wh/mi

Hybrid

2019 Toyota Camry Hybrid
$28,150
52 MPG

2019 Nissan Leaf
$29,900
300 Wh/mi
Range: 151 miles

Battery Electric

2019 Nissan Leaf e+
$36,550
300 Wh/mi
Range: 256 miles
Gasoline and Electric SUV Options

Conventional Gasoline

- **Ford Explorer**
  - Price: $32,765
  - MPG: 24

- **Toyota Highlander**
  - Price: $31,680
  - MPG: 22

- **Mitsubishi Outlander**
  - Price: $24,695
  - MPG: 27

- **Subaru Crosstrek**
  - Price: $21,895
  - MPG: 25

- **2019 Hyundai Kona**
  - Price: $19,990
  - MPG: 30

Hybrid

- **Ford Explorer HEV**
  - Price: $52,280
  - MPG: 24

- **Toyota Highlander HEV**
  - Price: $37,320
  - MPG: 29

- **Mitsubishi Outlander PHEV**
  - Price: $35,795
  - Electric: 450 Wh/mi
  - Gasoline: 25 MPG

Plug-in Hybrid

- **Subaru Crosstrek PHEV**
  - Price: $34,995
  - Electric: 380 Wh/mi
  - Gasoline: 35 MPG

Electric

- **Hyundai Kona Electric**
  - Price: $36,950
  - 280 Wh/mi
  - 258 mile range
## Diesel Pick-up Truck Options

### 2019 Ram 1500

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Conventional</th>
<th>Hybrid</th>
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<tr>
<td>RAM 1500</td>
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<td>$35,400, 23</td>
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<tr>
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<tr>
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*No Plug-in Hybrid or Electric models available in 2019*
EV Cost and Sales Forecasts

How fast will battery costs fall?

How fast will total costs fall?

How fast will EV sales grow?

EV Outlooks then and now

Million EVs

Source: BloombergNEF, organization websites. Note: BNEF's 2019 outlook includes passenger and commercial EVs. Some values for other outlooks are BNEF estimates based on organization charts, reports and/or data (estimates assume linear growth between known data points). Outlook assumptions and methodologies vary. See organization publications for more.

International Council on Clean Transportation
Key Assumptions

- Gasoline: $2.01/gallon*
- Electricity: 7.3 cents/kWh
- Charging infrastructure: $700/vehicle/year*
- Tax credits for EVs: None*
- Vehicle lifetime: 7 years*
- Lifetime miles driven (based on existing fleet):
  - Sedans: 81,920 miles
  - SUVs: 78,525 miles

*Conservative assumptions that favor gasoline vehicles over electric vehicles
Lifetime Cost Comparison: Sedans

Similar lifetime costs, apart from infrastructure costs

- EV: Nissan Leaf e+
- PHEV: Toyota Prius Prime
- EV: Nissan Leaf
- HEV: Toyota Camry
- ICEV: Toyota Camry

Legend:
- MSRP
- Fuel
- Maintenance
- Charging Infrastructure
Emissions Comparisons: Sedans

Lifetime Greenhouse Gas Emissions

Emissions Savings

Lifetime NOx Emissions

Emissions Savings

<table>
<thead>
<tr>
<th>Type</th>
<th>Toyota Camry</th>
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<th>Toyota Prius Prime</th>
<th>Nissan Leaf e+</th>
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Legend:
- Tailpipe
- Fuel Production
- Vehicle Parts
- Vehicle ADR

Legend:
- Tailpipe
- Fuel Production
Lifetime Cost Comparisons: SUVs

In each pair of SUVs, plug-in hybrid or electric option is more expensive
Emissions Comparisons: SUVs

Life-cycle GHG Emissions

- Toyota Highlander
- Ford Explorer
- Subaru Crosstrek
- Mitsubishi Outlander
- Hyundai Kona

- Vehicle Parts
- Vehicle ADR
- Fuel Production
- Tailpipe

Emissions Savings
Conclusions

- Electric vehicles are rapidly becoming more affordable, with new models arriving soon
- Sedans: Electric vehicles and plug-in hybrids are already cost-competitive
- SUVs and pick-up trucks: Await affordable options
- Substantial emissions savings
  - 25 tonnes CO$_2$, 18 kg NO$_x$ per sedan
- Charging infrastructure is key to viability of electric fleet
Acknowledgments

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