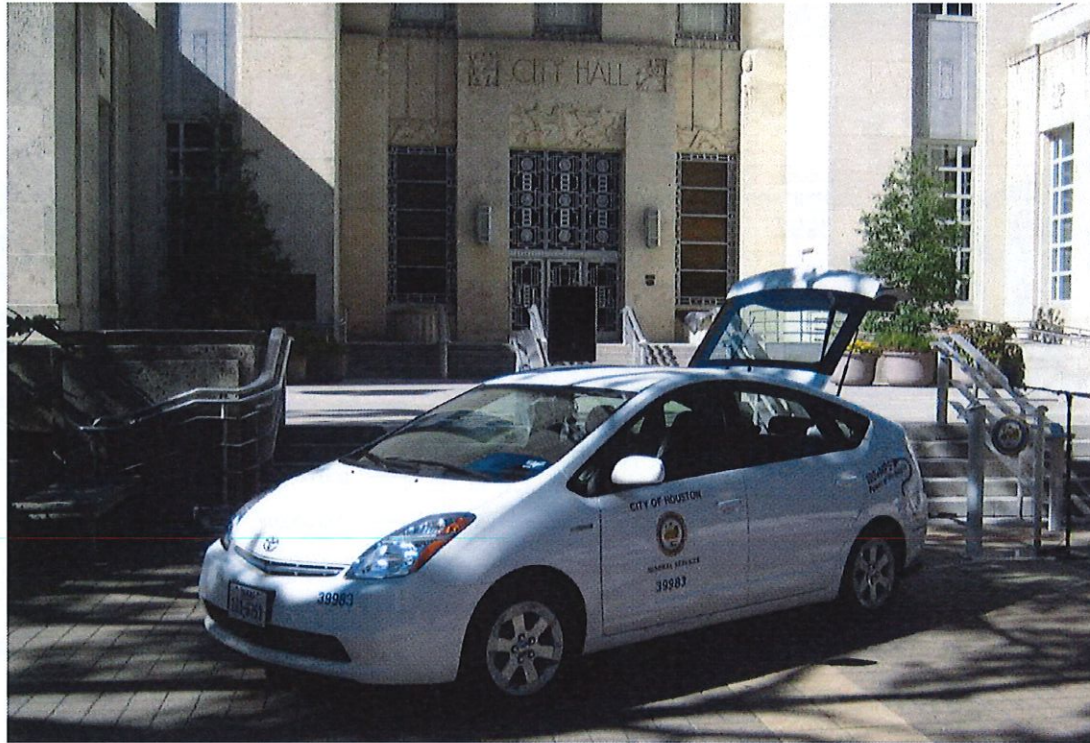


Sustainable Vehicle Fleet Options for the City of Houston



Daniel Cohan, Laura Schaefer, and
Joanna Slusarewicz
Presentation to City of Houston
March 2020



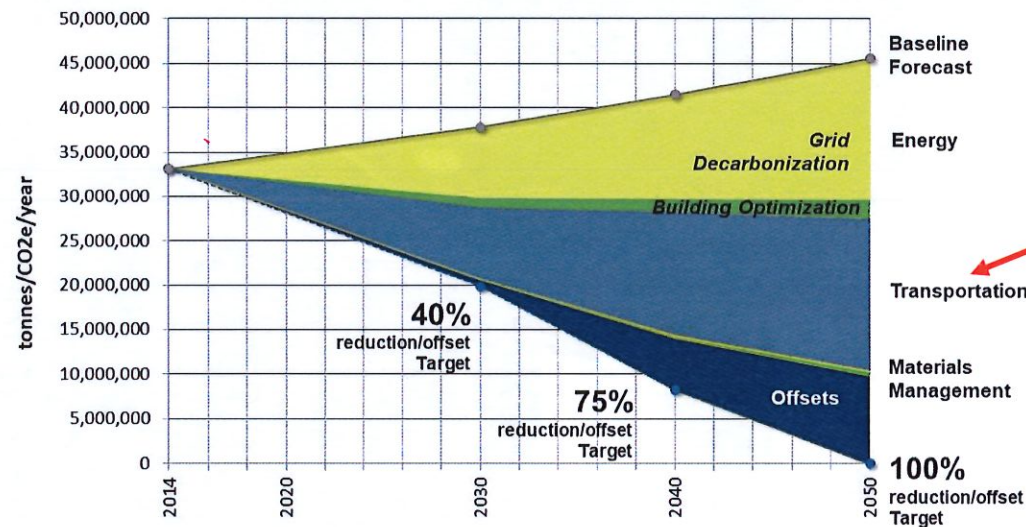
RICE

Context: City of Houston Climate Action Plan (2019 draft)



Net-zero emissions by 2050

Projected emissions with and without action



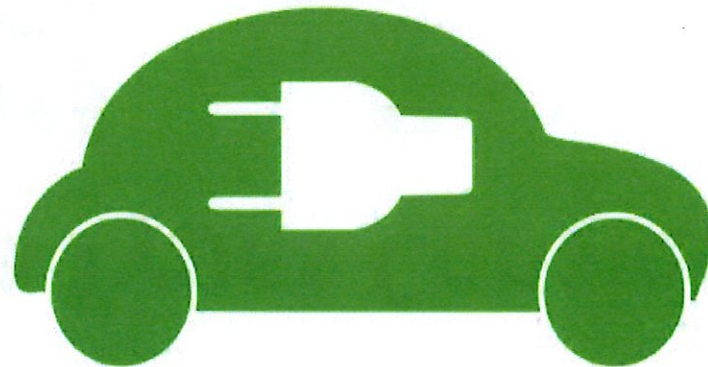
Transportation is nearly half of emissions

**Electric vehicle
fleet by 2030**

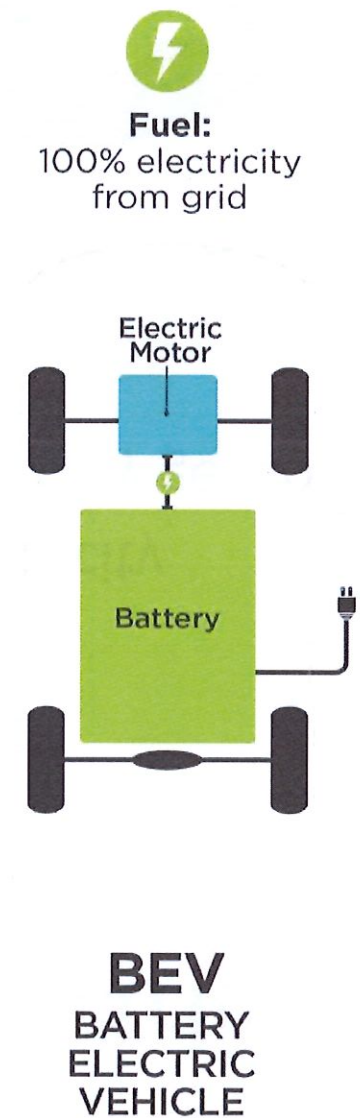
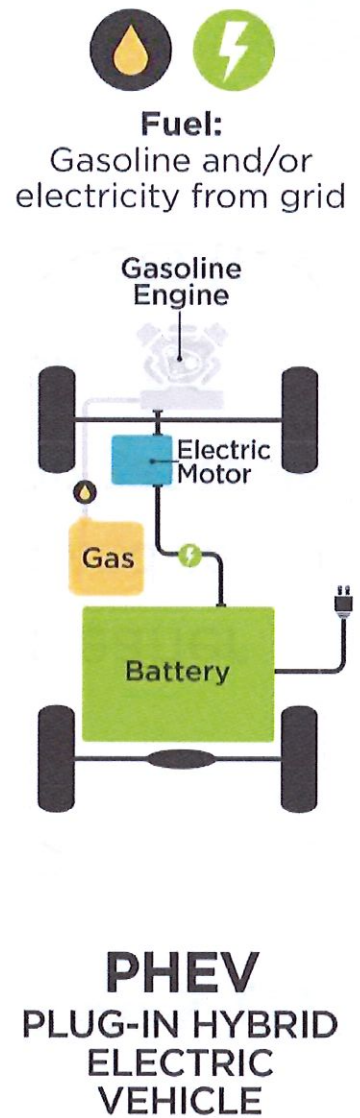
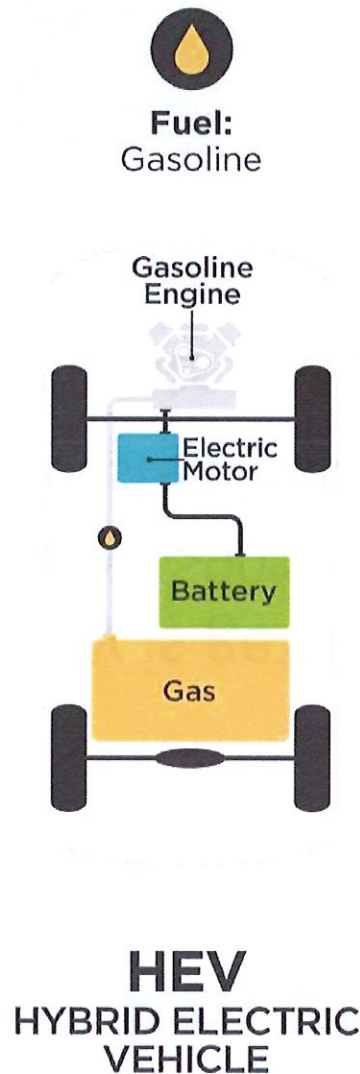
Activity	Year Completed
Transportation	
Increase public infrastructure for EV and alternative renewable fuels, installing EV charging stations at public-facing City buildings.	2025
Convert non-emergency, light-duty municipal fleet to 100% EV.	2030

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



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

S. Sengupta, D.S. Cohan/Transportation Research Part D 54 (2017) 160–171

165

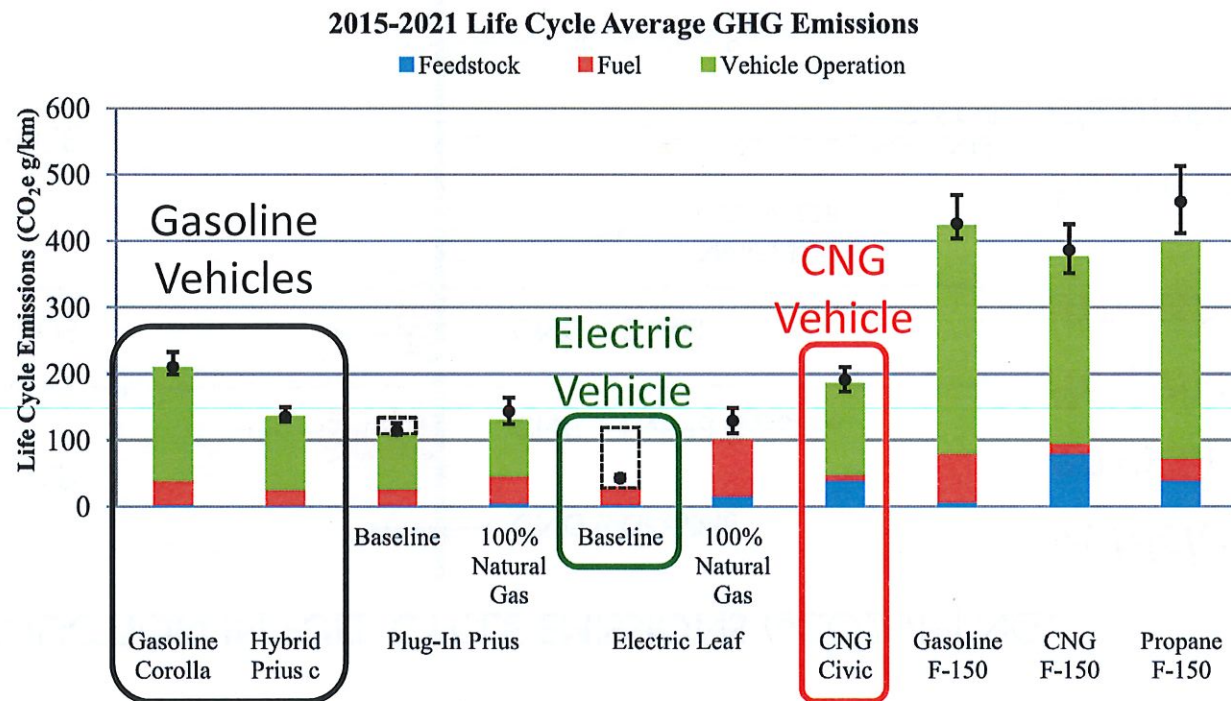
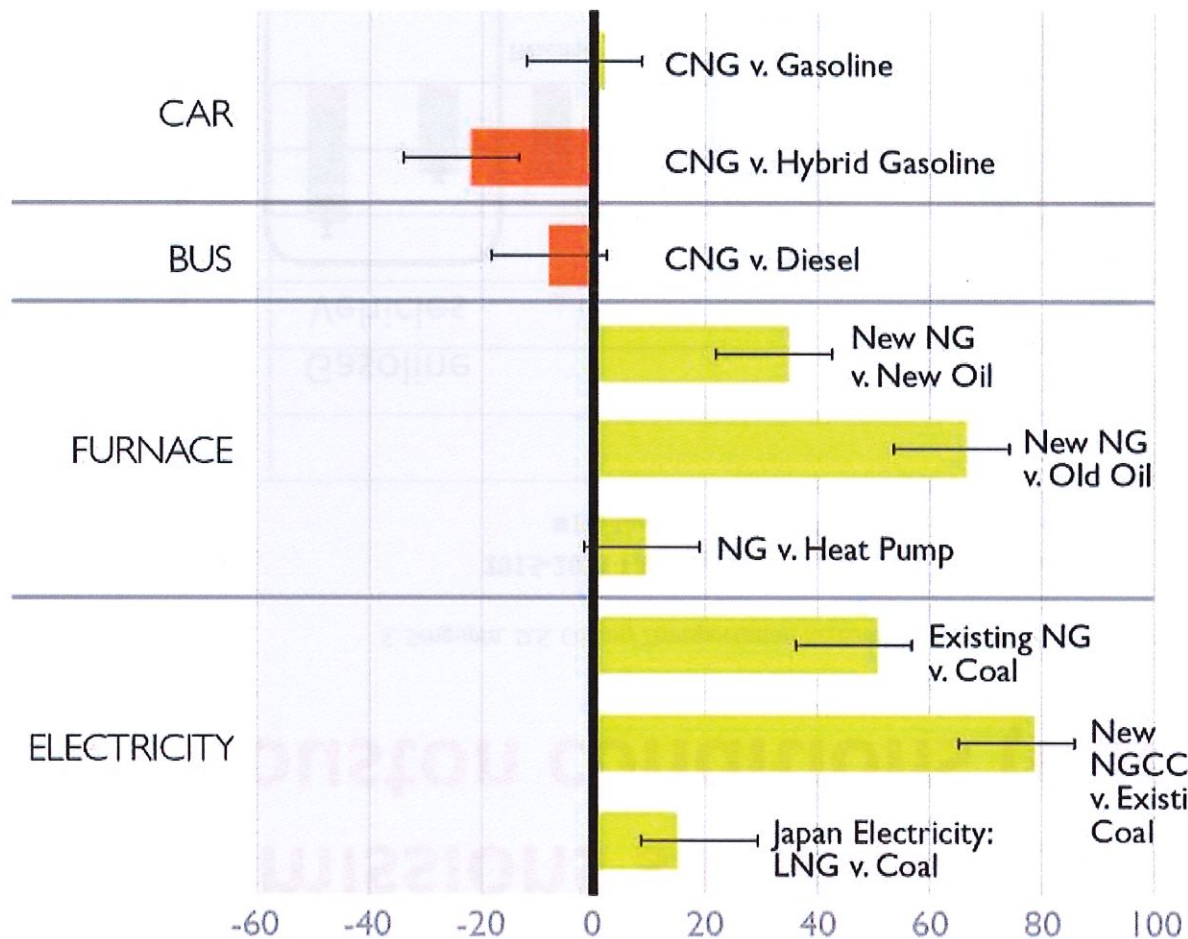


Fig. 1. Fuel cycle CO₂e emissions estimates from GREET (solid bars) with best, 5th percentile, and 95th percentile upstream emissions from the Venkatesh studies (error bars and dot). Dashed bars show emissions under ERCOT grid electricity.

***Fuel-cycle analysis of City of Houston vehicle options
(Sengupta and Cohan, 2017)***

Other uses of natural gas can reduce emissions

NET REDUCTION IN FUEL CYCLE EMISSIONS (gCO₂e/MJ NG)



Vehicles: No emissions savings; Require new fueling infrastructure

Furnaces: NG is cleaner than fuel oil

Electricity: NG is cleaner than coal

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/mile

Hybrid



2019 Toyota Camry Hybrid

\$28,150

52 MPG

Battery Electric



2019 Nissan Leaf

\$29,900

300 Wh/mi

Range: 151 miles



2019 Nissan Leaf e+

\$36,550

300 Wh/mi

Range: 256 miles

Gasoline and Electric SUV Options

Conventional Gasoline



Ford Explorer
\$32,765
24 MPG



Toyota Highlander
\$31,680
22 MPG



Mitsubishi Outlander
\$24,695
27 MPG



Subaru Crosstrek
\$21,895
25 MPG



2019 Hyundai Kona
\$19,990
30 MPG

Hybrid



**Ford Explorer
HEV**
\$52,280
24 MPG



**Toyota Highlander
HEV**
\$37,320
29 MPG



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



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



**Hyundai Kona
Electric**
\$36,950
280 Wh/mi
258 mile range

Diesel Pick-up Truck Options

2019 Ram 1500



2019 Ford F-150



Model	Type	Conventional		Hybrid	
		MSRP	MPG	MSRP	MPG
RAM 1500	4x2	\$34,100	22	\$35,400	23
Ford F-150	4x2	\$29,000	22	\$30,745	22
RAM 1500	4x4	\$37,600	21	\$38,900	22
Ford F-150	4x4	\$34,400	20	\$35,400	21

No Plug-in Hybrid or Electric models available in 2019

EV Cost and Sales Forecasts

How fast will battery costs fall?

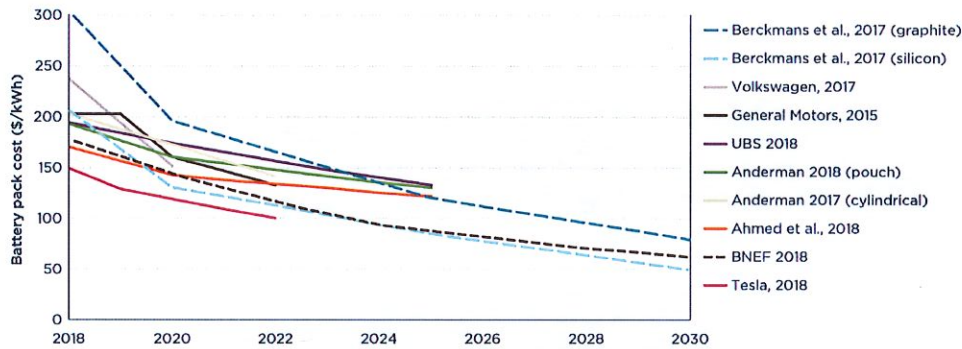
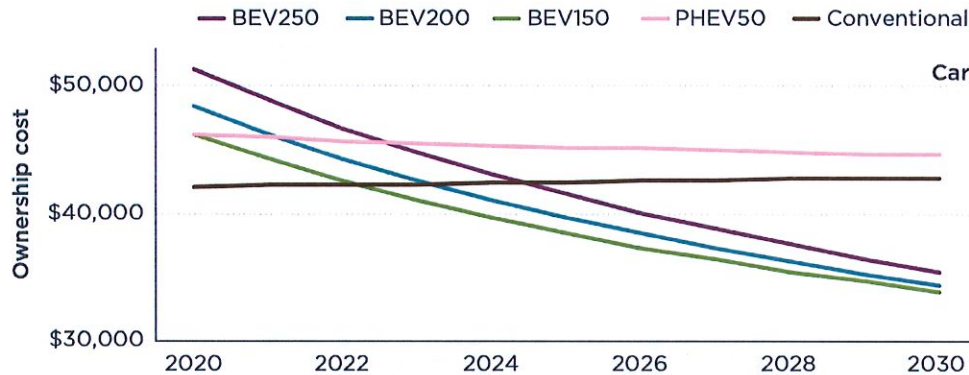


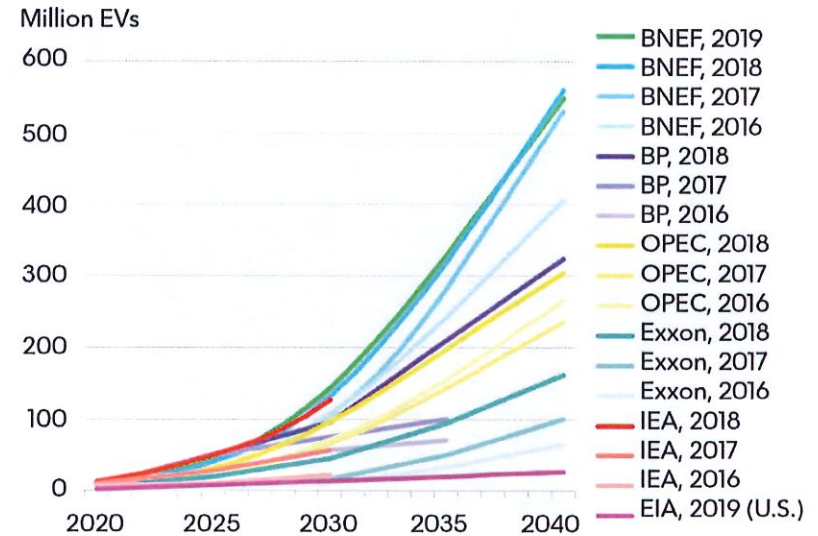
Figure 2. Electric vehicle battery pack costs from technical studies and automaker statements.

How fast will total costs fall?



How fast will EV sales grow?

EV Outlooks then and now



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.

BNEF Electric Vehicle Outlook 2019

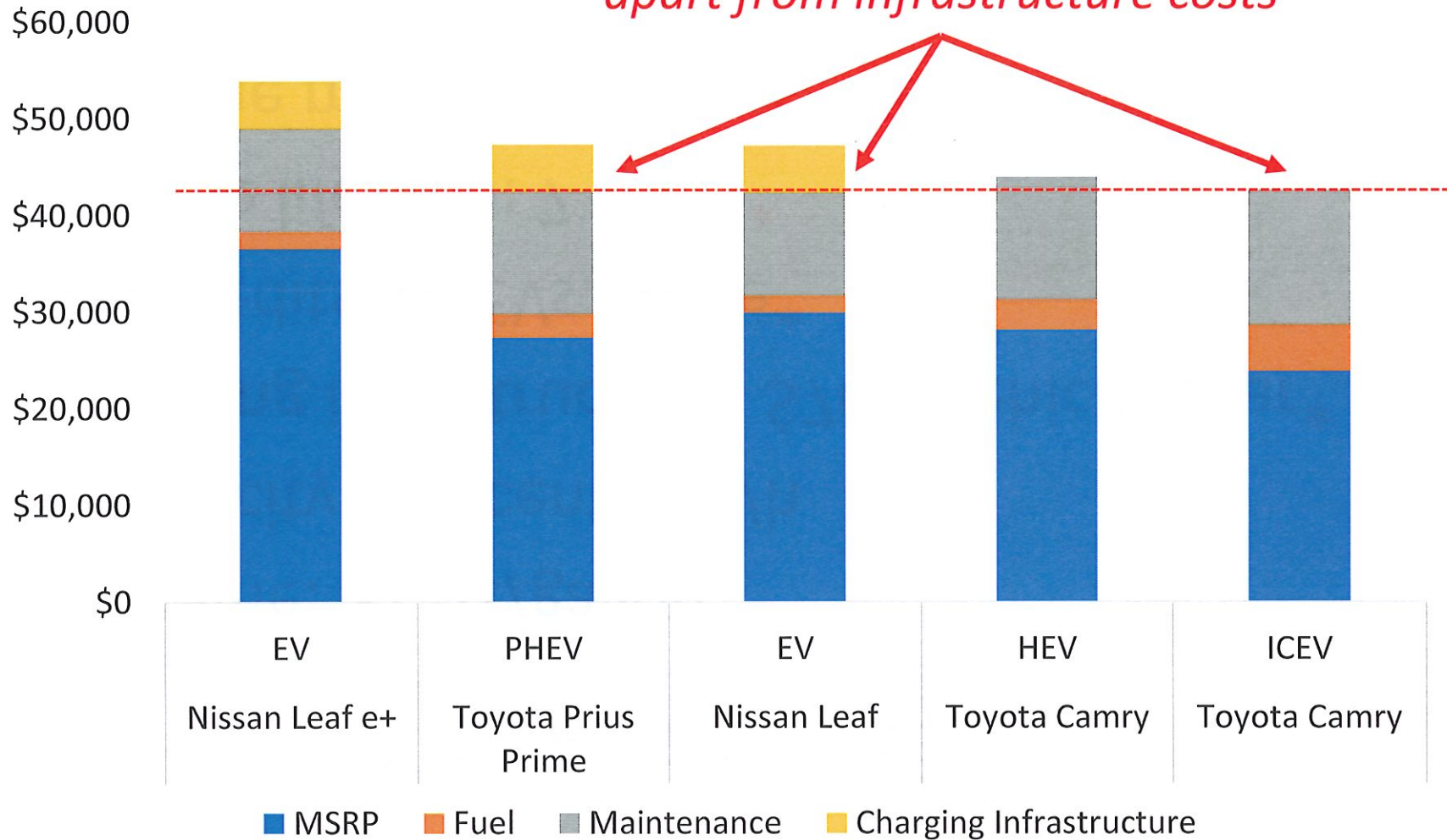
Key Assumptions

- 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***

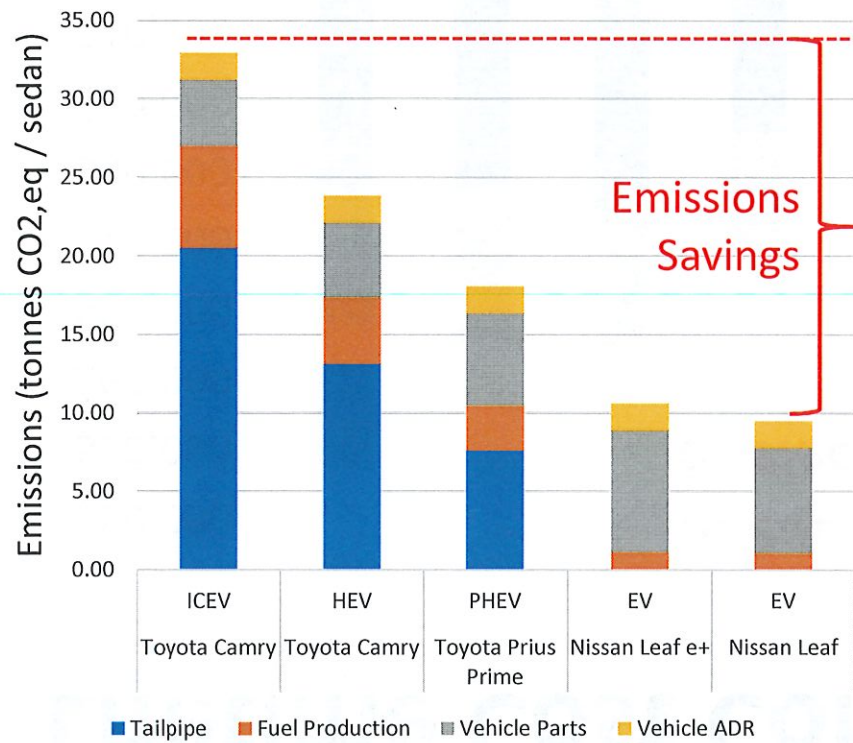
Lifetime Cost Comparison: Sedans

*Similar lifetime costs,
apart from infrastructure costs*

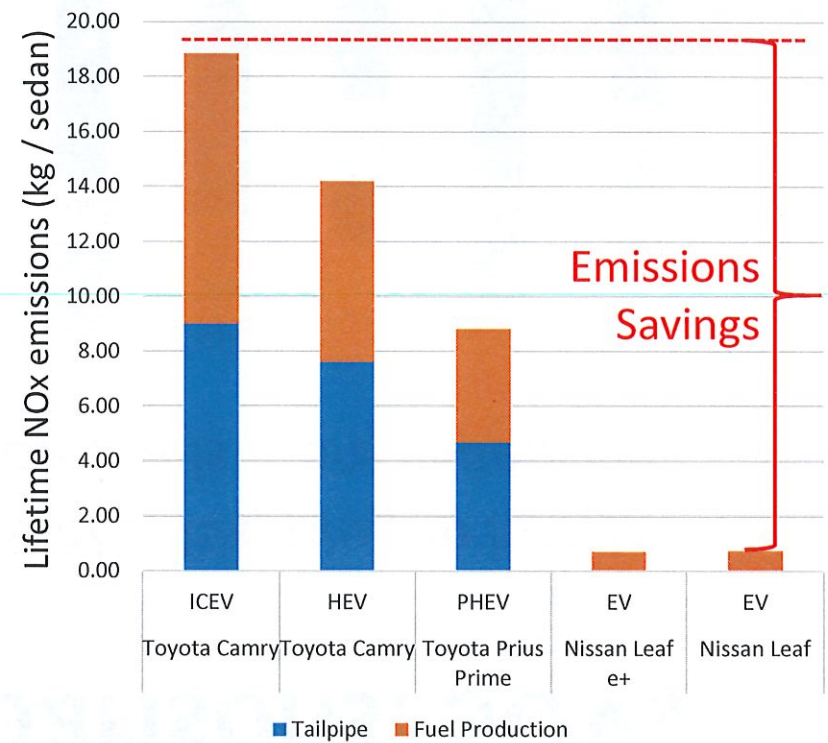


Emissions Comparisons: Sedans

Lifetime Greenhouse Gas Emissions

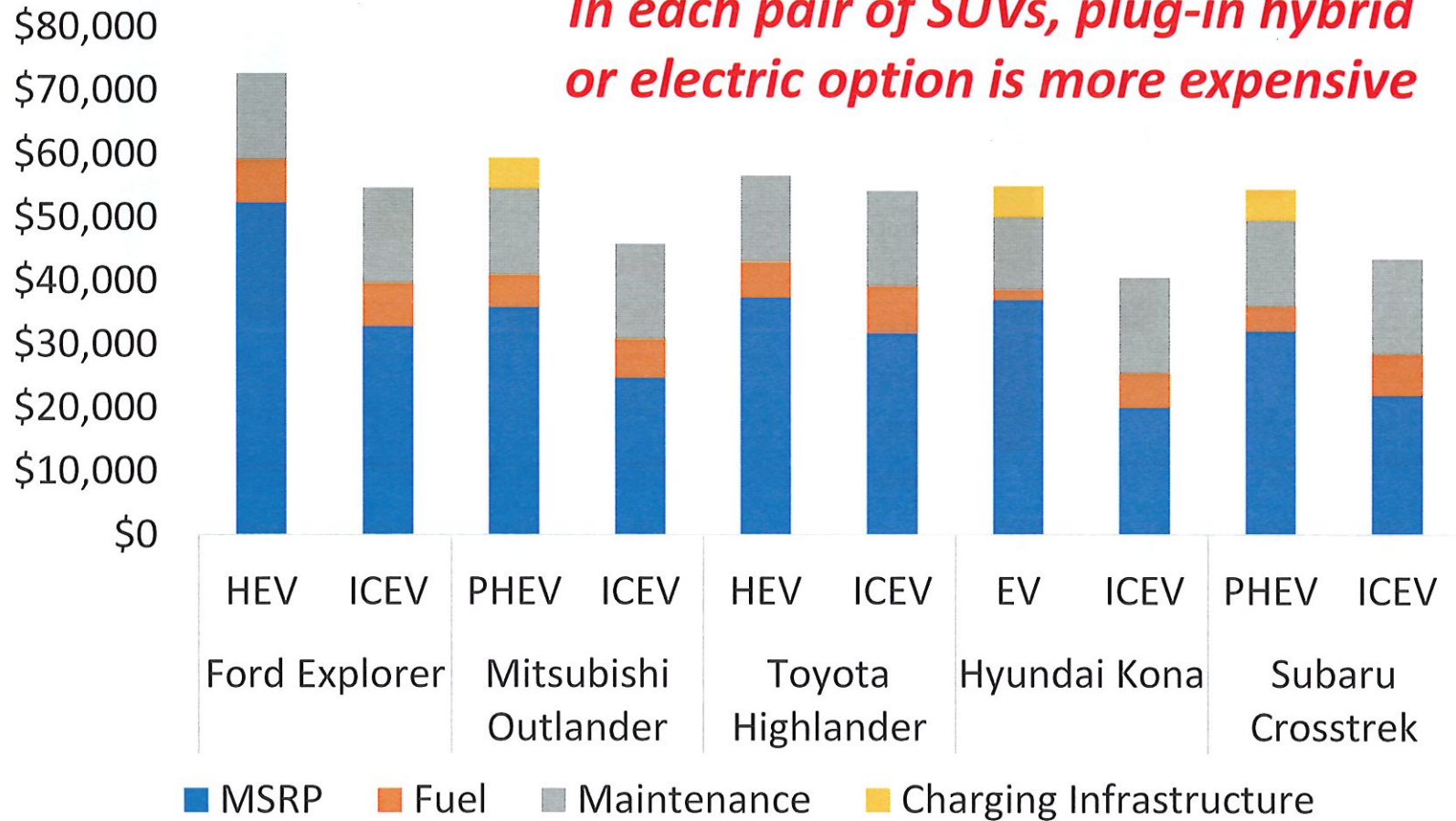


Lifetime NOx Emissions

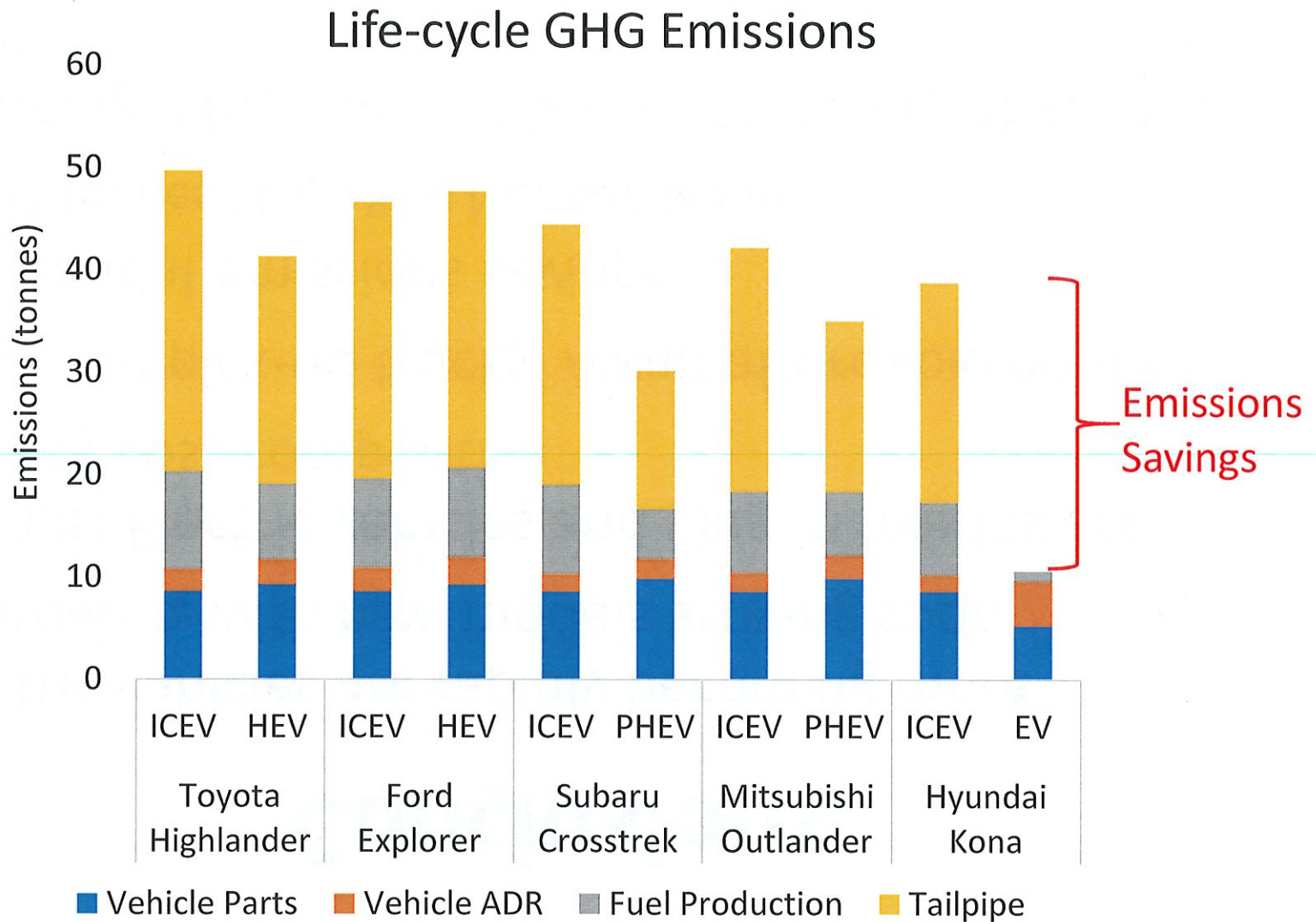


Lifetime Cost Comparisons: SUVs

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



Emissions Comparisons: SUVs



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 CO₂, 18 kg NO_x per sedan
- Charging infrastructure is key to viability of electric fleet

Acknowledgments

- Funding: Houston Solutions Lab
- Rice Kinder Institute for Urban Research: Kyle Shelton
- City of Houston: Lara Cottingham, Marchelle Cain, Vic Ayres, and others



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