Reducing Emissions from the GA State Vehicle Fleet

Formulation and Application of a Vehicle Replacement Model

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Master's of Sustainable Energy & Environmental Management Capstone Project

Introduction

- Research question: How much would it cost to reduce CO_2 emissions from public vehicles?
- 28% of GHG emissions came from transportation sector in 2018 (EPA)
- State fleet data acquired via Open Records Request
- Calculated life-cycle emissions for Georgia's publicly owned and operated light-duty cars, SUVS, and PUTs
- Designed a vehicle replacement model to make fleet management decisions and quantify emissions abatement costs for different market scenarios, demonstrating which policy mechanisms are most important for low-emissions vehicles

The Georgia State Fleet

- Purchased, leased, rented
- 20,264 vehicles
- 16,929 light duty (< 10,000 lbs)
- 957 medium duty (< 26,000 lbs)
- 2,378 heavy duty (> 26,001 lbs)

- Only 94 hybrids, PHEVs, & EVs

15 million gallons

211 million miles

11,000

4,000

2,000

Cleaning the Dataset

- Focus on light-duty vehicles to refine analysis
- Vehicles lacking fuel consumption or VMT data omitted
- Lack of telematics
- Fire, medical, emergency, law enforcement, and off-road vehicles omitted
- 9,031 vehicles analyzed

3,325 cars **1,139 SUVs** **4,567 PUTs**

Baseline Methodology & Emissions

- Missing CO_2 was calculated via model-specific per-mile emissions rates (FuelEconomy.gov)
  - Operation conducted for 1,026 vehicles
- Upstream fuel pathway emissions calculated using GREET lifecycle model
  - Gasoline (E10), CNG, LNG, flex fuel (E85)
- Upstream vehicle pathways emissions also via GREET
  - Engine types: ICE, EV, PHEV, natural gas

Tailpipe	**Fuel**	**Vehicle**	**Total**
39,217 t	14,998 t	3,119 t	*57,336 t*

Vehicle Replacement Model

- Spreadsheet model selects most economic new replacement vehicles to purchase each year
    - Assumed 15 year operational lifetime, modelled lifecycle of vehicles until MY2030
    - Tesla Model 3, Nissan Leaf, Toyota Prius, Kia Forte, Hyundai Kona (EV), Toyota RAV4, Mazda CX-5, Honda CRV, Chevy Silverado, Ford F-150, Ford F-150 Diesel, Toyota Tacoma, Rivian R1T (MY2021+)
- Increased demand modelled with increased VMT, not increased vehicle count (1% per year)
- MSRP +2% ICE, -8% EVs until 2025 (price parity)
- MPG +1.5%; grams CO_2 per mile -0.017%
- Assumed VMT replaced directly by new vehicles
- 3% discount rate

VRM - Formulation of Scenarios

- 8 unique policy/market scenarios
- Filled boxes indicate high values used
- Each scenario modelled for purchased to 2030, lifetime impacts to 2044
- 88 executions

S0	Baseline		
S1	High Fuel		
S2		EV Credit	
S3			GHG Cost
S4	High Fuel	EV Credit	
S5	High Fuel		GHG Cost
S6		EV Credit	GHG Cost
S7	High Fuel	EV Credit	GHG Cost

	Base Case	Extreme Case
Gasoline Price ($/gallon)	$2.49	$4.14
Diesel Price ($/gallon)	$2.44	$4.07
Electricity Price ($/kWh)	$0.08	$0.15
EV Tax Credit	$0	$7,500
GHG Cost ($/ton CO2)	$0	$60

VRM - Optimization Function & Constraints

Minimize:
Total Capital Costs + Maintenance Costs + Fuel Costs + Emissions Charges - Salvage Values

Constraints:

1. The quantity of each vehicle model purchased must be greater than or equal to 0
2. The quantity of each vehicle model purchased must be an integer value
3. The quantity of new cars purchased must equal the quantity of cars retired
4. The quantity of new SUVs purchased must equal the quantity of SUVs retired
5. The quantity of new PUTs purchased must equal the quantity of PUTs retired
6. There must be a negative change in total emissions

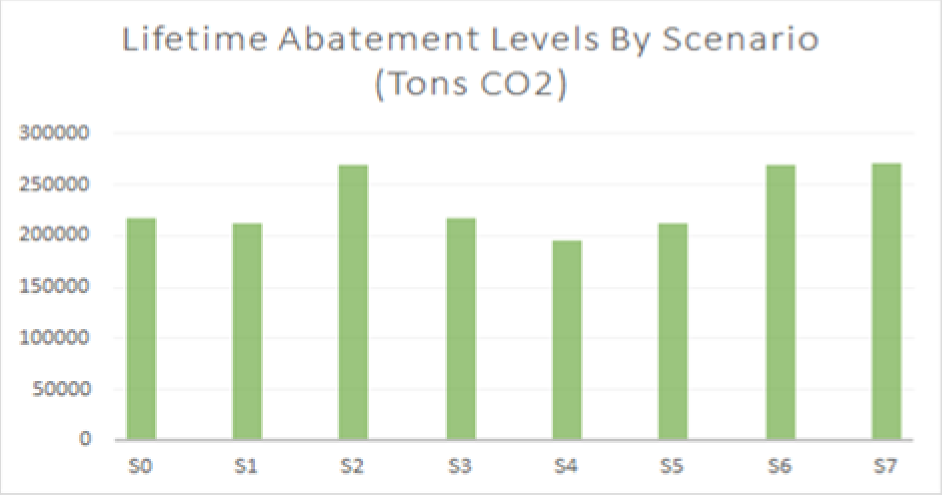
VRM - Example

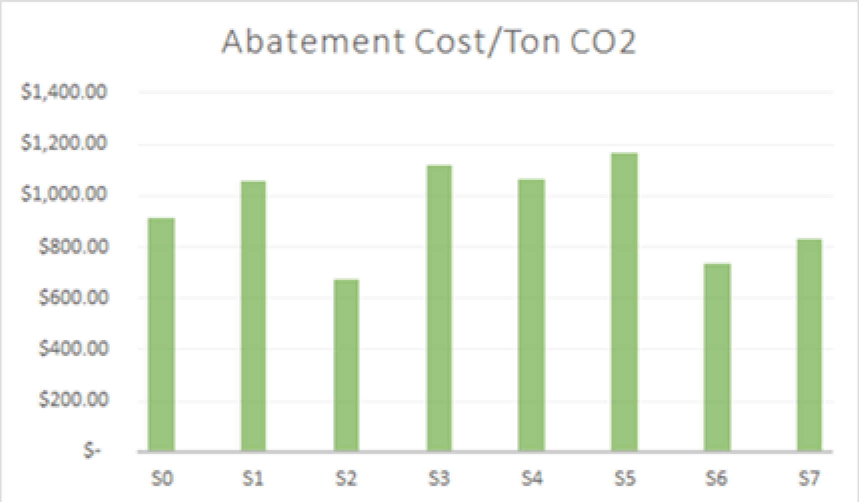
Example model run for S0 - 2030

Quantity	Vehicle M&M	Capital Costs	Mntnce Costs	Fuel Cost	Fuel Consumption			VMT	Tailpipe	Vehicle	Fuel		Salvage		
0	Tesla Model 3	$0.00	$0.00	$0.00	-	kwh	Cars	5,641,146.94	-	-	-	Cars	$265,600		
0	Nissan Leaf	$0.00	$0.00	$0.00	-	kwh	SUVs	1,540,477.25	-	-	-	SUVs	$106,000		
0	Toyota Prius	$0.00	$0.00	$0.00	-	gal	PUTs	3,483,800.07	-	-	-	PUTs	$222,000		
332	Kia Forte	$7,098,228.41	$166,000.00	$60,881.29	24,469.97	gal			1,300.47	82	49.18				
106	Hyundai Kona EV	$2,868,613.51	$10,600.00	$28,858.73	360,734.07	kwh		Total	-	32	165.94				
0	Toyota RAV4	$0.00	$0.00	$0.00	-	gal	Cars	332	-	-	-			Total Reduced Emissions	
0	Mazda CX-5	$0.00	$0.00	$0.00	-	gal	SUVs	106	-	-	-			3028.96	
0	Honda CRV	$0.00	$0.00	$0.00	-	gal	PUTs	185	-	-	-				
0	Chevy Silverado	$0.00	$0.00	$0.00	-	gal			-	-	-				
0	Rivian RT1	$0.00	$0.00	$0.00	-	kwh			-	-	-				
0	Ford F150	$0.00	$0.00	$0.00	-	gal			-	-	-				
0	Ford F150 Diesel	$0.00	$0.00	$0.00	-	gal			-	-	-				
185	Toyota Tacoma	$5,759,449.86	$92,500.00	$358,003.40	143,892.04	gal			1,161.07	67	289.22			Total Cost 2020	Total Emissions 2
		$15,726,291.78	$269,100.00	$447,743.42	529,096.08				2,461.55	181	504.35			$16,443,135.20	3,146.67
														$15,849,535.20	

Findings & Discussion

- Lowest cost under Scenario 2 (\$671/ton CO_2 abated)
- Highest cost under Scenario 5 (\$1166/ton CO_2 abated)

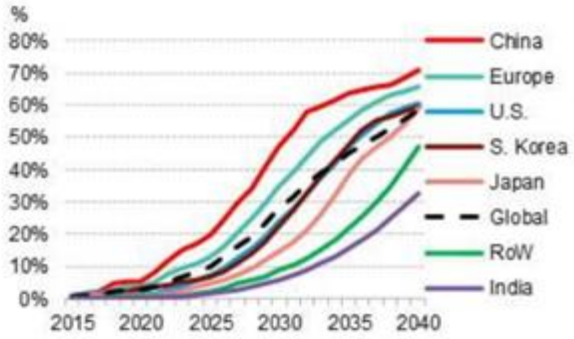




Findings & Discussion

- Tax credits remain crucial for EVs under modelled market scenarios
  - With tax credits, EVs become cheaper than ICEVs by 2023 (Leafs & Konas)
  - S2 - 2,265 EVs by 2030; S7 - 2,737
- No competitive low-emitting PUT, but on the way
- Abatement costs way too high to justify for reducing CO_2 alone
  - Public procurement for pilot & demonstration
  - Economies of scale
- CO_2 is not the whole story!
  - CH_4, CO, SO_x, NO_x, PM, VOCs

Figure 2: Global long-term EV share of new passenger vehicle sales by region



Source: BNEF. Note: Europe includes EU, U.K. and EFTA.

Next Steps...

- Telematics device deployment for more dynamic modelling of emissions from on-road activity
  - Could help identify specific vehicle activities that should be targeted for electrification, diesel, hybrid
- Re-visit and update as electric trucks come on the market
  - Ford F-150 EV in MY2022
- Attempt to quantify benefits of public procurements on EV technology costs
- Potentially expand to include M/HD vehicles as alternative technologies become available in that space

Thanks for a great year!