MOVES
Motor Vehicle Emission Simulator

Updates to Energy & CO_2 Rates for Light-Duty Vehicles with SAFE Rule

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Background

- The Safer Affordable Fuel-Efficient (SAFE) Part I Final Rule released in September 2019 - One National Program
  - EPA withdrew the Clean Air Act preemption waiver for LD vehicles it granted to California
- SAFE Part II FRM released in March 2020
  - Fuel economy and carbon dioxide standard changes for MY2021-2026
- Reduction of CO_2 emission is less stringent
  - Previous EPA program (LD GHG phase 2 MY2017-2025 rule): Fleet Target CO_2 reduction ~ 5%/year
  - SAFE FRM: Fleet Target CO_2 reduction ~ 1.5%/year

What are "Fleet Targets" in LD GHG Phase 2 and SAFE?

Standards include updates in historical years starting in MY2017

CO_2 Emission Rate Fleet Target for Light Duty Passenger Cars

Passenger cars, CO2 g/mile	LD GHG rule phase 2	SAFE FRM
MY 2017	212	219
MY 2018	202	208
MY2019	191	197
MY 2020	182	188
MY2021	172	183
MY2022	164	180
MY2023	157	177
MY2024	150	174
MY2025	143	171
MY2026	143	168
MY2026 +	143	168

Standards become constant starting in MY2025 for GHG rule

Standards become constant starting in MY2026 for SAFE rule

CO_2 Emission Rate Fleet Target for Light Duty Passenger Trucks

Light trucks, CO2 g/mile	LD GHG rule phase 2	SAFE FRM
MY 2017	295	295
MY 2018	285	285
MY2019	277	278
MY 2020	269	270
MY2021	249	264
MY2022	237	259
MY2023	225	255
MY2024	214	251
MY2025	203	247
MY2026	203	243
MY2026 +	203	243

Ref: Federal Register/Vol.77, No. 199/Monday, October 15, 2012/Rules and Regulations (2017-2025 LD GHG FRM)
Federal Register/Vol. 85, No. 84/Thursday, April 30,2020/Rules and Regulations (SAFE FRM)

MOVES uses "Real-World" CO_2 Rates

"Fleet Target" CO_2 rates vs. "Real-World" CO_2 rates

- "Fleet Target" CO_2 rates
  - National Highway Traffic Safety Administration (NHTSA)'s Corporate Average Fuel Economy (CAFE) Test (MPG)
  - 2 Cycle Test: FTP + HFET
- "Real-World" CO_2 rates
  - "These real world estimates, similar to values shown on new vehicle labels, reflect the fact that the way cars and trucks are operated in the real world generally results in higher CO_2 emissions and lower fuel economy than laboratory test results used to determine compliance with the standards."[a]
  - EPA Fuel Economy Label (MPG) 5 Cycle Test[b] :

FTP @ 75F; HFET @ 75F; US06 @ 75F; SC03 @ 95F; UDDS @ 20F

Classic cycles — Aggressive cycle — Extreme Temperatures

[a] *Ref: 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Federal Register, Vol 77, No.199, October, 2012*

[b] *Ref: https://www.epa.gov/vehicle-and-fuel-emissions-testing/dynamometer-drive-schedules#vehicleDDS*

How to Calculate "Real-World" CO_2 Rates based on "Fleet Target"?

- SAFE FRM has "Fleet Target" CO_2 rates, but no "Real-Word" CO_2 rates

"Projected CO_2 compliance target" - Fleet average from the Foot Print Curve standard numbers and sales projections

"The 1.25 factor is an approximation of the ratio of real world CO_2 emissions to 2-cycle test CO_2 emissions for the fleet in the recent past." [a]

"Real-World" Tailpipe CO_2 Rates = (Projected "Fleet Target" CO_2 Rates + Incentives + A/C Refrigerant Credits) *1.25 [a]

Input for MOVES3 default database table

Values in SAFE FRM

- "In the real world, fuel economy is, on average, about 20% lower than as measured under regulatory test procedures." [b]

[a] *Ref: 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Federal Register, Vol 77, No.199, October, 2012*

[b] *Ref: Final Regulatory Impact Analysis, The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021 – 2026 Passenger Cars and Light Trucks*

How do we Incorporate SAFE into MOVES?

- SAFE Part I (One National Program) rule
  - Incorporated into MOVES so states can model if desired
- SAFE Part II (CAFE changes)
  - "Real-World" CO_2 rates estimated using Projected "Fleet Target" CO_2 rates, Air Conditioning (A/C) Refrigerant Credits, and Incentives from SAFE FRM
  - Calculate adjustment ratios based on LD GHG Phase 2 rule and SAFE FRM "Real-World" CO_2 rates
  - Applied ratios for:
    - PolProcess 9101 (Total Energy Consumption/Running Exhaust) and 9102 (Total Energy Consumption/Start Exhaust)
    - Source Types 21 (Passenger Car), 31 (Passenger Truck), and 32 (Light Commercial Truck)
    - Regulatory Class 20 (Light Duty Vehicles) and 30 (Light Duty Trucks)
  - Adjustment ratios vary by MY from MY 2017 to MY 2026
    - Applied adjustment ratios to historical MY 2017 to MY2020 to account for updated information used in SAFE rulemaking
  - CO_2 standards for MY2026 applied to MY2027 and later

How do we Incorporate SAFE into MOVES?

Passenger Cars in EmissionRateAdjustment Table in MOVES Default Database

polProcessID	sourceTypeID	regClassID	fuelTypeID	beginModelYearID	endModelYearID	emissionRateAdjustment
9101	21	20	1	2017	2017	1.029891304
9101	21	20	1	2018	2018	1.026315789
9101	21	20	1	2019	2019	1.026470588
9101	21	20	1	2020	2020	1.033811475
9101	21	20	1	2021	2021	1.057692308
9101	21	20	1	2022	2022	1.08632287
9101	21	20	1	2023	2023	1.109302326
9101	21	20	1	2024	2024	1.145121951
9101	21	20	1	2025	2025	1.178571429
9101	21	20	1	2026	2060	1.159438776
9102	21	20	1	2017	2017	1.029891304
9102	21	20	1	2018	2018	1.026315789
9102	21	20	1	2019	2019	1.026470588
9102	21	20	1	2020	2020	1.033811475
9102	21	20	1	2021	2021	1.057692308
9102	21	20	1	2022	2022	1.08632287
9102	21	20	1	2023	2023	1.109302326
9102	21	20	1	2024	2024	1.145121951
9102	21	20	1	2025	2025	1.178571429
9102	21	20	1	2026	2060	1.159438776

Running

Start

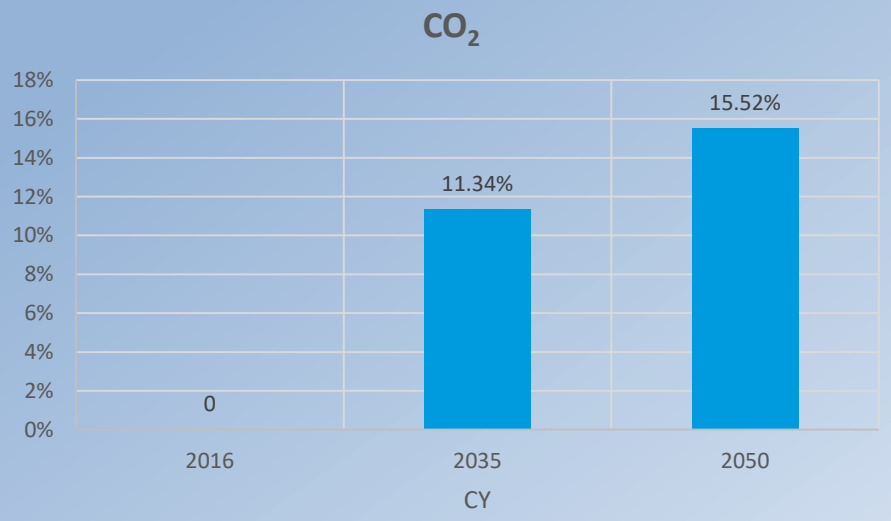
Applied adjustment ratios to historical MY 2017 to MY2020 to account for updated information used in SAFE rulemaking

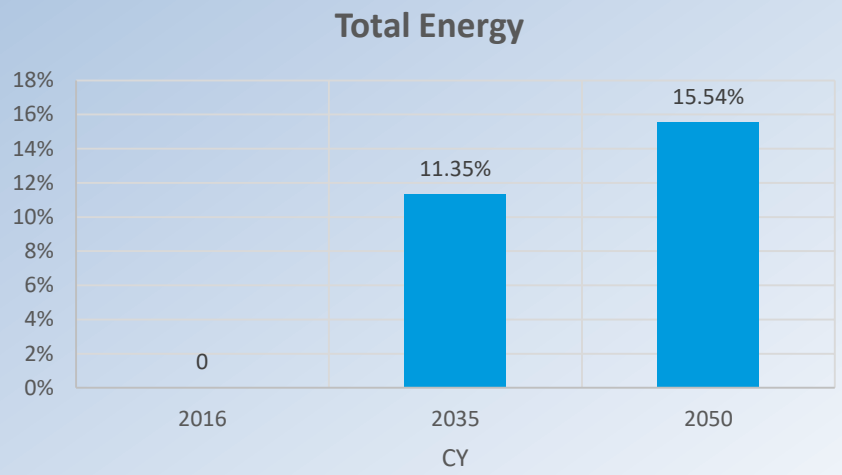
CO_2 standards for MY2026 continue for future model years

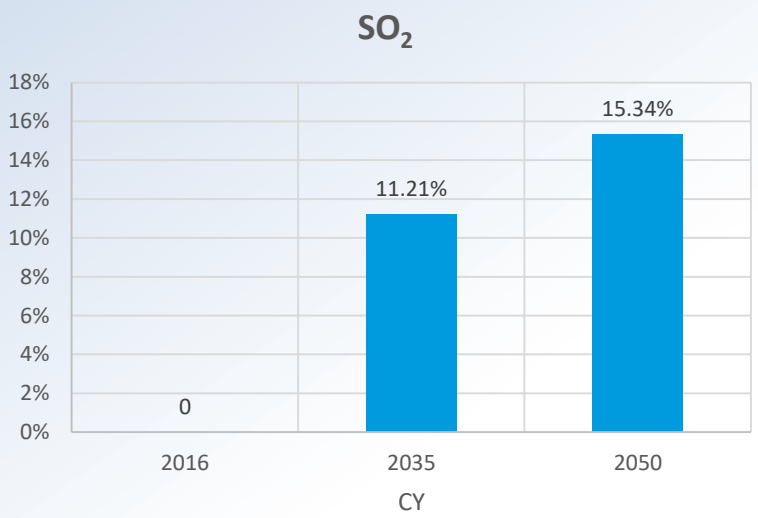
Applied the same adjustment ratios to start as for running

Applied the same adjustment ratios to diesel as for gasoline

Emission Impacts: Light-duty Fleet



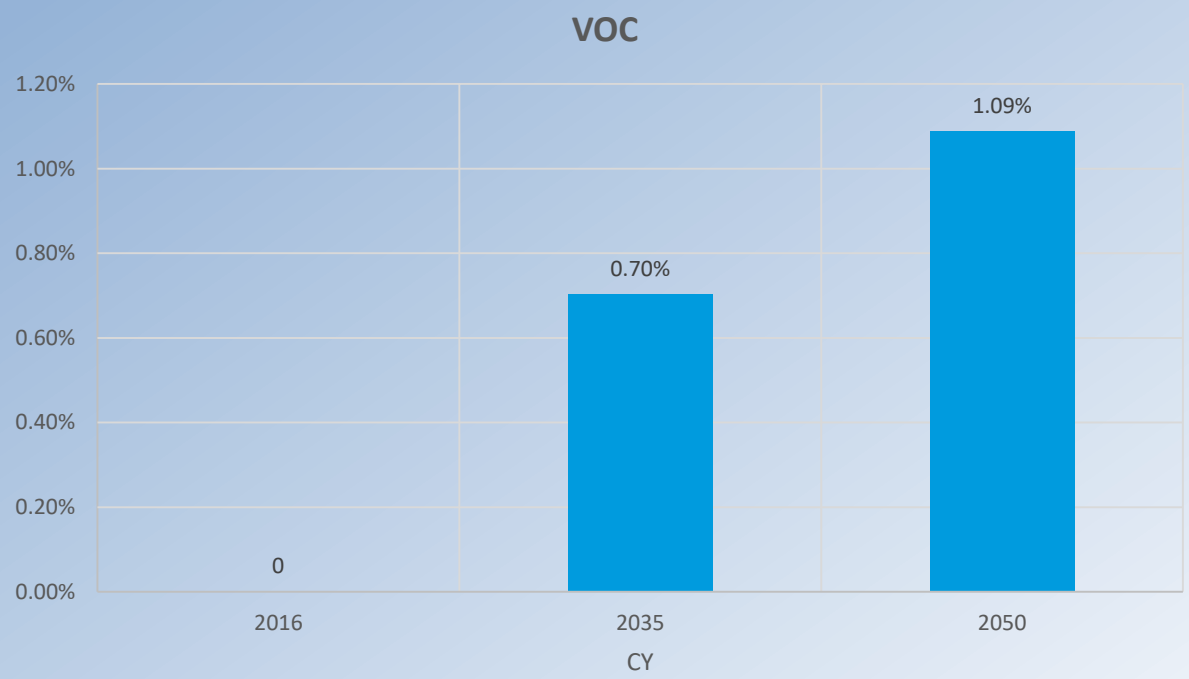




- National, all fuel types, by Calendar Years (CY)
- All light duty vehicles (passenger cars, passenger trucks, and light commercial trucks)
- MOVES estimates SO_2 as proportional to fuel consumption

Based on preliminary MOVES results

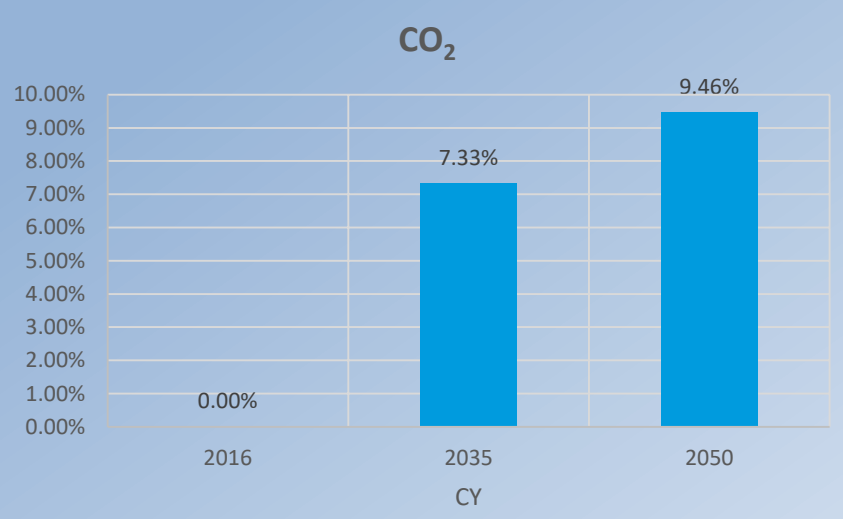
Emission Impacts: Light-duty Fleet

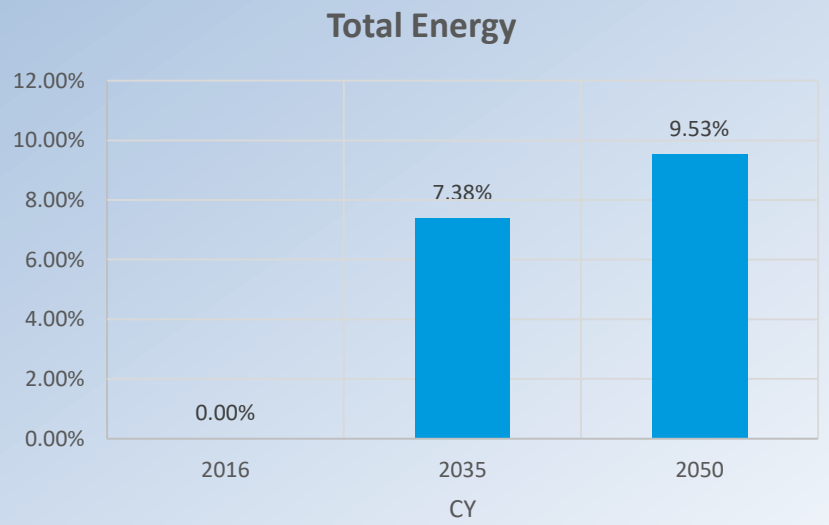


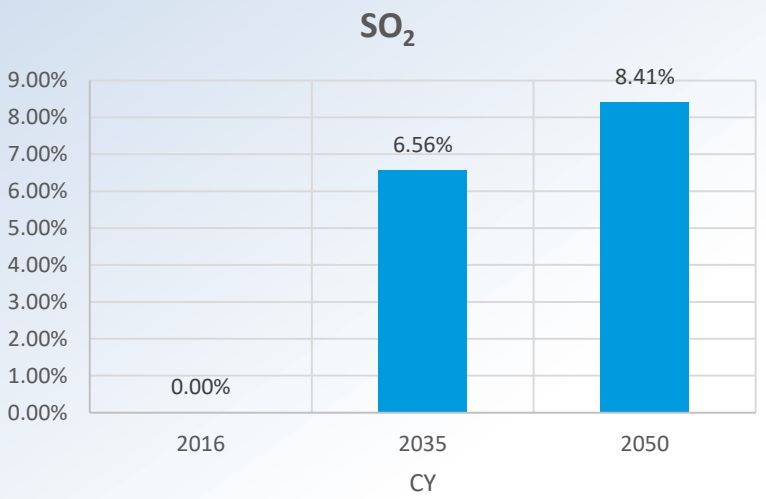
- National, all fuel types, by Calendar Years (CY)
- All light duty vehicles (passenger cars, passenger trucks, and light commercial trucks)
- The increases in VOC are due to more refueling/lower fuel economy
- No impact on NOx and PM

Based on preliminary MOVES results

Emission Impacts: Onroad Fleet



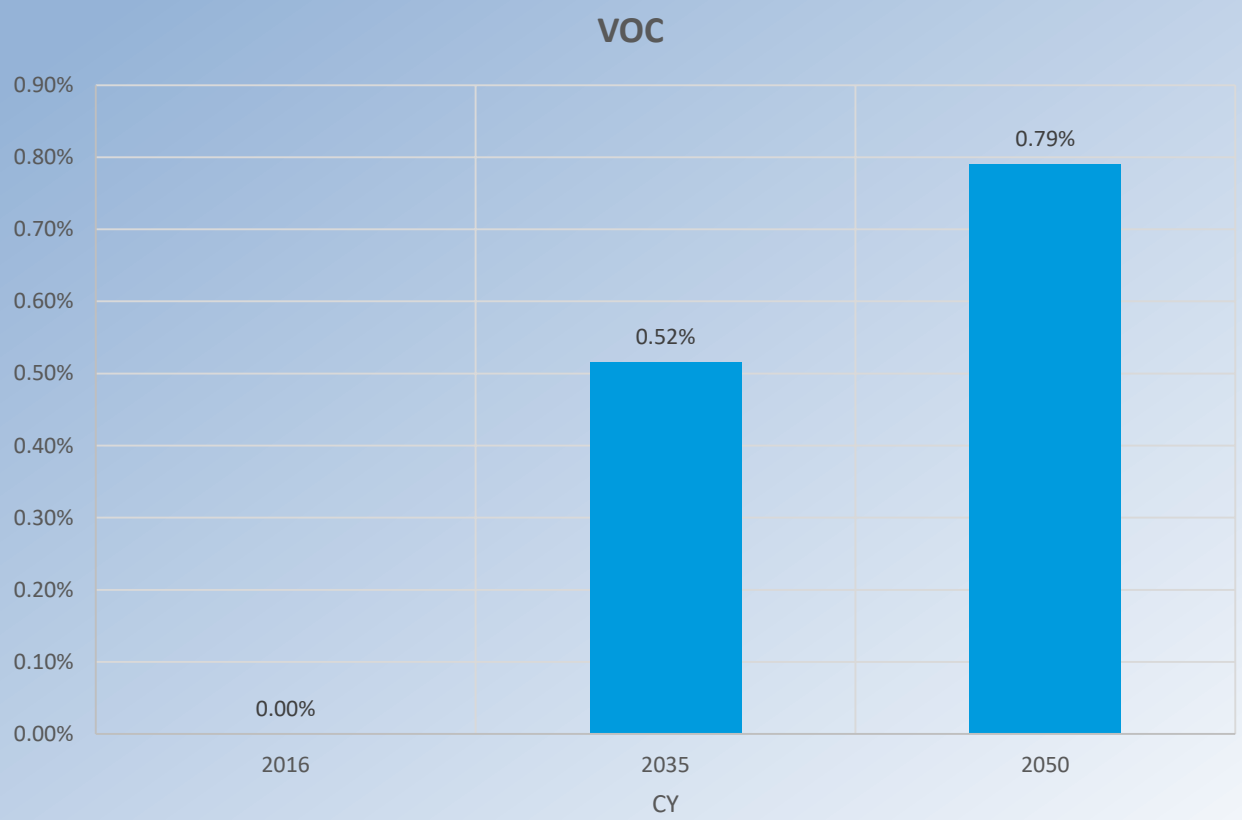




- National, all source types, all fuel types, by Calender Years (CY)
- Emissions change is less than the emissions change for just light-duty fleet
- Percent change in emissions increase in future years due to fleet turnover

Based on preliminary MOVES results

Emission Impacts: Onroad Fleet



- National, all source types, all fuel types, by Calender Years (CY)
- Small change on VOC due to refueling
- No impact on NOx and PM

Based on preliminary MOVES results

Conclusion

- SAFE Part I (One National Program) rule was incorporated
- SAFE Part II (CAFE changes):
  - Moderate (~15%) increases in future year LD energy consumption and CO_2;
    - About a 10% increase in total onroad CO_2 (LD+HD)
  - Small (~1%) increases in VOC and toxic emissions due to refueling
- Overall, the percent change in light-duty CO_2 emissions is what is expected from the change in the standard

APPENDIX

Derivation of "Real-World" CO_2 Calculation

- The real world tailpipe CO_2 emissions projections are calculated starting with the projected 2-cycle CO2 emissions values, subtracting the air conditioner efficiency and off-cycle credits, and then multiplying by a factor of 1.25. [a]

TABLE III–1—EPA PROJECTIONS FOR FLEETWIDE TAILPIPE EMISSIONS COMPLIANCE WITH CO_2 STANDARDS—PASSENGER CARS [401]

[Grams per mile]

Model year	Projected CO_2 compliance target	Incentives [402]		Projected achieved CO_2	Credits			Projected 2-cycle CO_2
		Advanced technology multiplier	Intermediate volume provisions		Off cycle credit	A/C refrigerant	A/C efficiency	
2016 (base)	225 [403]	0	0	225	0.4	5.4	4.8	235
2017	212	0.6	0.1	213	0.5	7.8	5.0	226
2018	202	1.1	0.3	203	0.6	9.3	5.0	218
2019	191	1.6	0.1	193	0.7	10.8	5.0	210
2020	182	1.5	0.1	183	0.8	12.3	5.0	201
2021	172	1.2	0.0	173	0.8	13.8	5.0	193
2022	164	0.0	0.0	164	0.9	13.8	5.0	184
2023	157	0.0	0.0	157	1.0	13.8	5.0	177
2024	150	0.0	0.0	150	1.1	13.8	5.0	170
2025	143	0.0	0.0	143	1.4	13.8	5.0	163

[a] *Ref: 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Federal Register, Vol 77, No.199, October, 2012*

Credits and Incentives in SAFE

- Air Conditioning (A/C) credits
  - A/C refrigerant credits (aka leakage credits), and A/C efficiency credits
  - All vary by model year and for cars or trucks
  - SAFE A/C leakage credits stays the same as in GHG rule
  - SAFE adds one technology (advanced A/C compressor) to the A/C efficiency credits menu
- Incentives
  - Electric Vehicle(EV) incentives
    - Vary by MY, EV types, and for cars and trucks
    - SAFE eliminates EV incentives for trucks starting MY2022
    - 0 g/miles – upstream incentive (Not appliable for MOVES – only tailpipe emission)
  - CNG incentives (Not appliable for MOVES since there are no CNG LD vehicle)

Energy and CO_2 Calculations in MOVES

- Energy rate is calculated based on lab tested CO_2, CO, HC emission rate, H:C ratio, and Heating value for different type of fuel
- MOVES output based on energy rate:
  - Fuel consumption $$Fuel\ (gallons) = Energy\ (KJ) \times \left(\frac{1}{energyContent}\right)\left(\frac{g}{KJ}\right) \times \left(\frac{1}{fuelDensity}\right)\left(\frac{gallons}{g}\right)$$
    - Energy Content (KJ/g) for each fuel subtype - Lower Heating Values (LHVs)
  - CO_2 emission $$CO_2 = Total\ Energy\ Consumed \times Carbon\ Content \times Oxidation\ Fraction \times \left(\frac{44}{12}\right)$$
    - Carbon content (g/KJ): values were developed for each fuelTypeID for MOVES2004 derived from the life-cycle model GREET. Currently assume oxidation fraction is 1 for all the hydrocarbon-based fuels
  - SO_2 emission $$SO_2(g) = FC(g) \times [S]\ (ppm) \times \frac{MW\_SO_2}{MW\_S} \times fSO_2 \times \left(\frac{10^{-6}}{ppm}\right)$$
    - [S]: relative fuel-sulfur concentration, fSO_2: fraction of fuel sulfur that is converted to gaseous SO_2 emissions