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# Choice Modeling for Alternative Energy Trucks

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Sandia National Laboratories

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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# Educational Background

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- Graduated with a B.S. in Electrical Engineering from UC San Diego.
- Two years of simulation and modeling experience.
- Currently pursuing a M.S. in Electrical Engineering from the University of Southern California.
  - Expected to graduate May, 2017.
- Working with the BioWatch team.

# Outline

- Why the Heavy-Duty Vehicle Market?
- The ParaChoice Simulation
- Expanding the ParaChoice Simulation
- Natural Gas Fuel Incentives
- Vocational Vehicles
- Review
- Internship Takeaways

# Why is the HDV Market Important?

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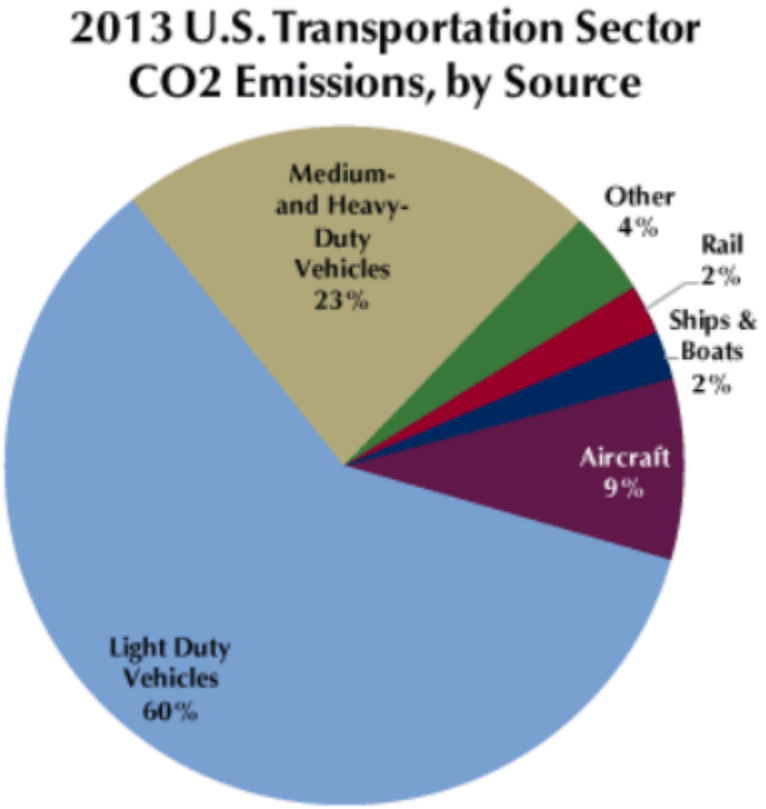
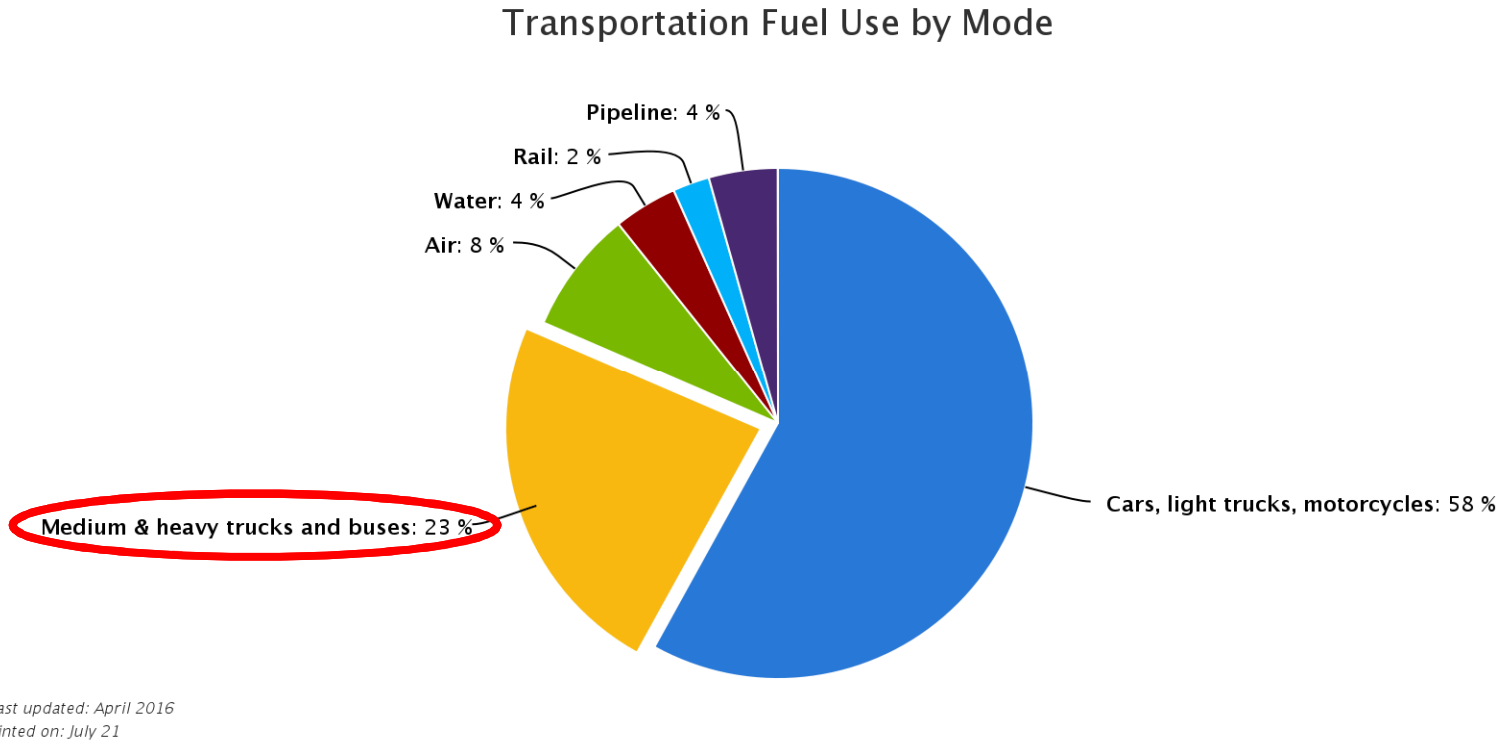
- Government aims to **reduce green house gas emissions** by **40%** by 2025.
- Large effort is used in the Light Duty Vehicle sector.
- Medium- and Heavy-Duty Vehicles are a large contributor.



# HDV Market's Fuel Perspective

- Heavy-Duty Vehicles (HDVs) consume **12.4 % of the total petroleum** used in the US.
- HDVs transports **70% of freight tonnage**.



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# THE PARACHOICE SIMULATION

# What is ParaChoice?

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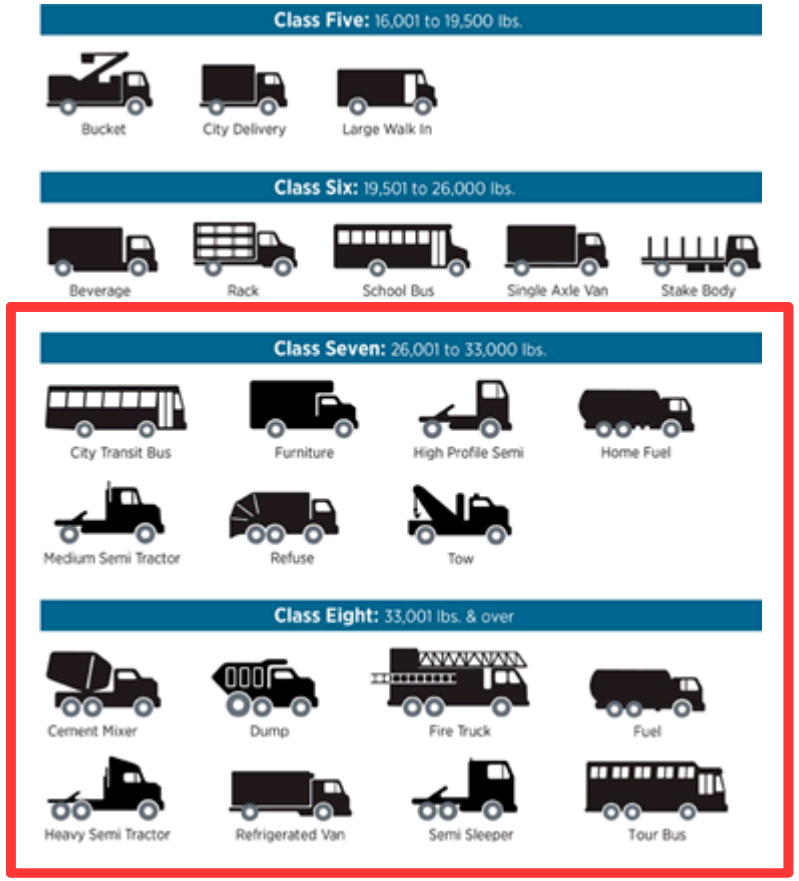
- The ParaChoice Heavy-Duty Vehicle (HDV) Simulation **determines trends for the trucking industry** up to year 2050.

- These trends include total amount of vehicles of different:
  - Powertrains
  - Fuel types
  - Incentives
  - Efficiency improvements
  - Infrastructure accessibility
  - Green House Gas Emissions

- **The simulation aids the user in determining what decisions have large impacts on the market.**

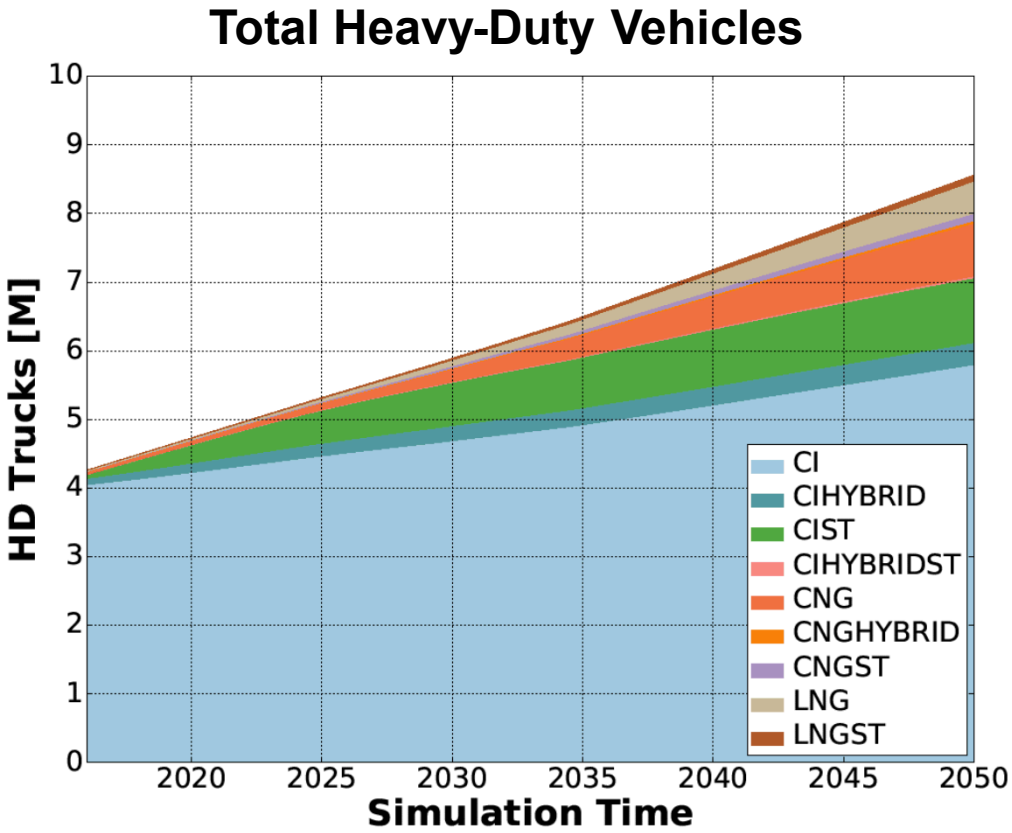
# Vehicles in HDV Model

- Class 7 and 8 HDVs
- Powertrain
  - CI (CI, CI Hybrid, CIST, CI Hybrid ST)
  - CNG (CNG, CNG Hybrid, CNGST)
  - LNG (LNG, LNGST)
- Body
  - Straight Truck
  - Tractor Truck



# Accounted for in the Simulation

- Purchase Price
- Fuel Price
- Age Distribution
- Fleet Size
- Infrastructure
- Efficiencies
- Vehicle Emissions



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# EXPANDING THE PARACHOICE SIMULATION

# Where to Expand the Simulation?

- Vocational Vehicles
- Incentives
- Maintenance Costs
- Efficiencies
- Infrastructure
- Drive Cycles
- HDV with GVW 2-6
- Data Sources and Documentation

# Documentation and Data Sources

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- **Updated installation instructions** for Windows to include solutions to typical installation issues.
- **Created reference document** containing summaries of the code modules.
- Documented and **amalgamated constants, coefficients, and assumptions** found in the model for convenient use.
- **Integrated and updated** the Polk Vehicle Registration Data.

# Integrating Polk Data

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- Data containing US vehicle registration
  - Business
  - Registered Vocation
  - State
  - Fuel
  - Body
  - GVW
  - Model Year
  - Total

- How is it used?
  - **Determines the quantity of vehicles within each fleet.**
  - **Creates initial vehicle set to be used by the model.**

- Reconciling differences in original and updated data sets

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# NATURAL GAS FUEL INCENTIVES

# Natural Gas Fuel Incentives

- **Objective**: determine how natural gas fuel incentives affect the market.
  - Guides the user on where to focus their efforts to increase the natural gas vehicle market.
  - Introduction to understanding how the ParaChoice simulation is organized.
  - Lays the ground work to place all types of incentives into the HDV model.

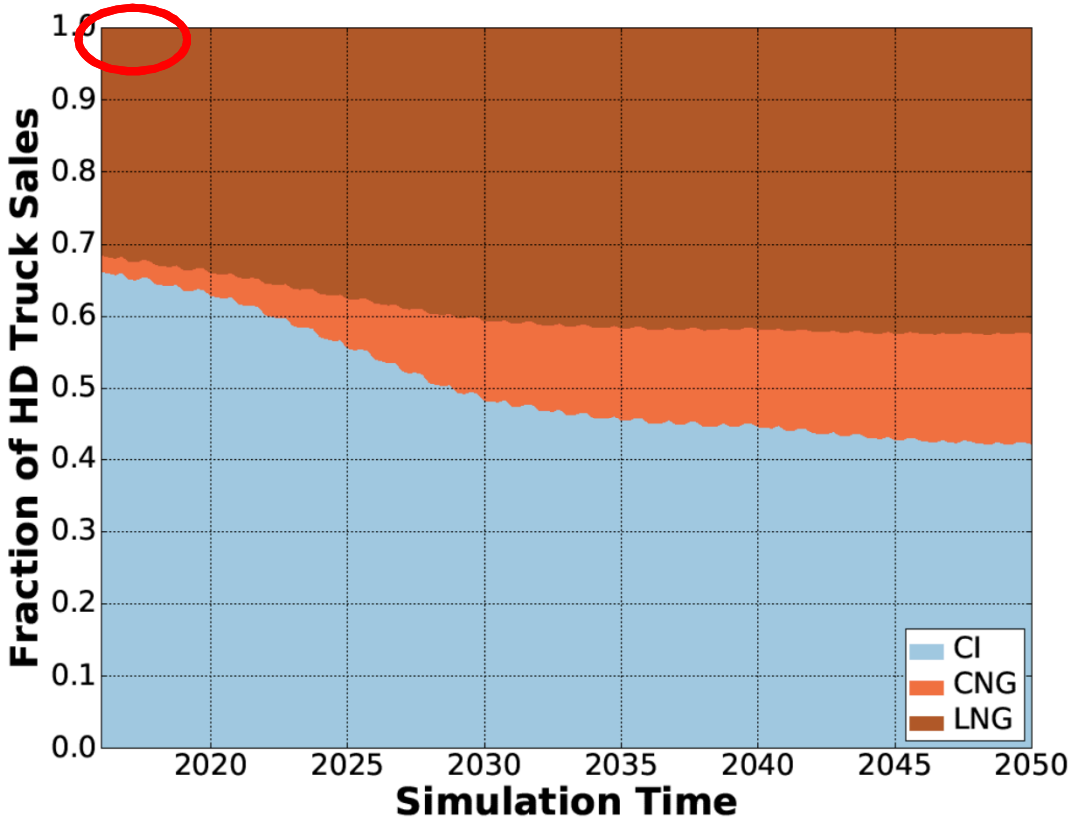
# Federal Fuel Incentive

- Alternative Fuel Excise Tax Credit
  - CNG, LNG and several other fuels offer a **$0.50 per gallon tax credit** until the end of 2016.
  - Originally effective October 2006 but has been extended several times.
  - Available to entities liable for reporting/paying federal excise tax on sale or use of fuel in a motor vehicle.
  - Incentive taken as credit against alternative fuel tax liability
  - Excess is claimed as direct payment from the IRS.

- Roughly costs the IRS **$1B a year** to remain in affect.
  - This would cost over $34B if the incentive is extended to 2050.

# Natural Gas Fuel Incentive Results

- No Alternative Fuel Incentive
- $0.50 Alternative Fuel Incentive through 2016
- $0.50 Alternative Fuel Incentive through 2050
- $3.00 Alternative Fuel Incentive through 2050




- **Implementing an incentive for NGV increases the fraction of NGVs sold.**
- **Are there any companies currently using this sort of strategy to improve their sales?**

# NG Fuel Incentive Conclusions

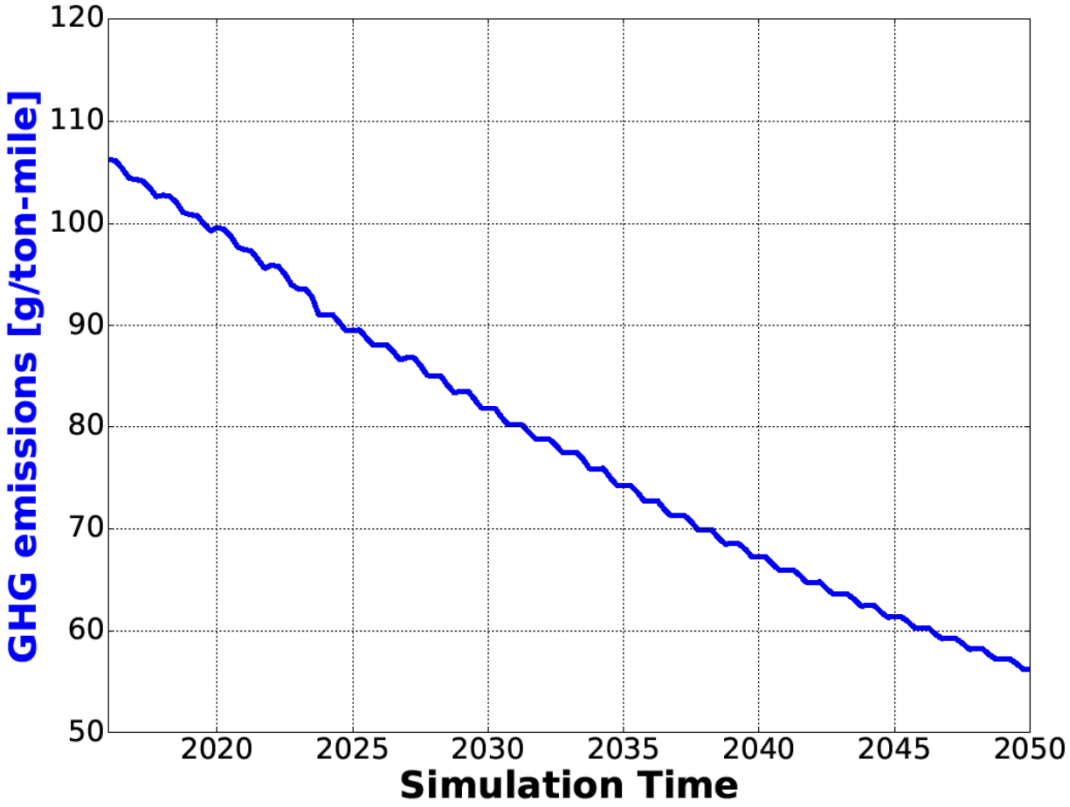
- In order to influence the market using a fuel credit the government could credit the vehicle owner more to drive a natural gas vehicle.

- From an economic perspective the current credit costs **roughly $1B per year**.

- Increased investment would be needed to expand NGVs impact in the market.

# Changes in GHG Emissions

- No Alternative Fuel Incentive
- $0.50 Alternative Fuel Incentive through 2016
- $0.50 Alternative Fuel Incentive through 2050
- $3.00 Alternative Fuel Incentive through 2050




- **GHG emissions increase when natural gas fuel incentives are implemented.**
- Aren't natural gas vehicles suppose to decrease green house gas emissions?

# Strange GHG Emissions Behavior

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- Why is this strange?
  - Vehicles using LNG emit **about 76%** of the GHGs as vehicles using diesel fuels.

- Further research needs to be completed to understand what the possible answers are to this question.

- **The incentive increases the amount of LNG vehicles enough to increase GHG emissions.**

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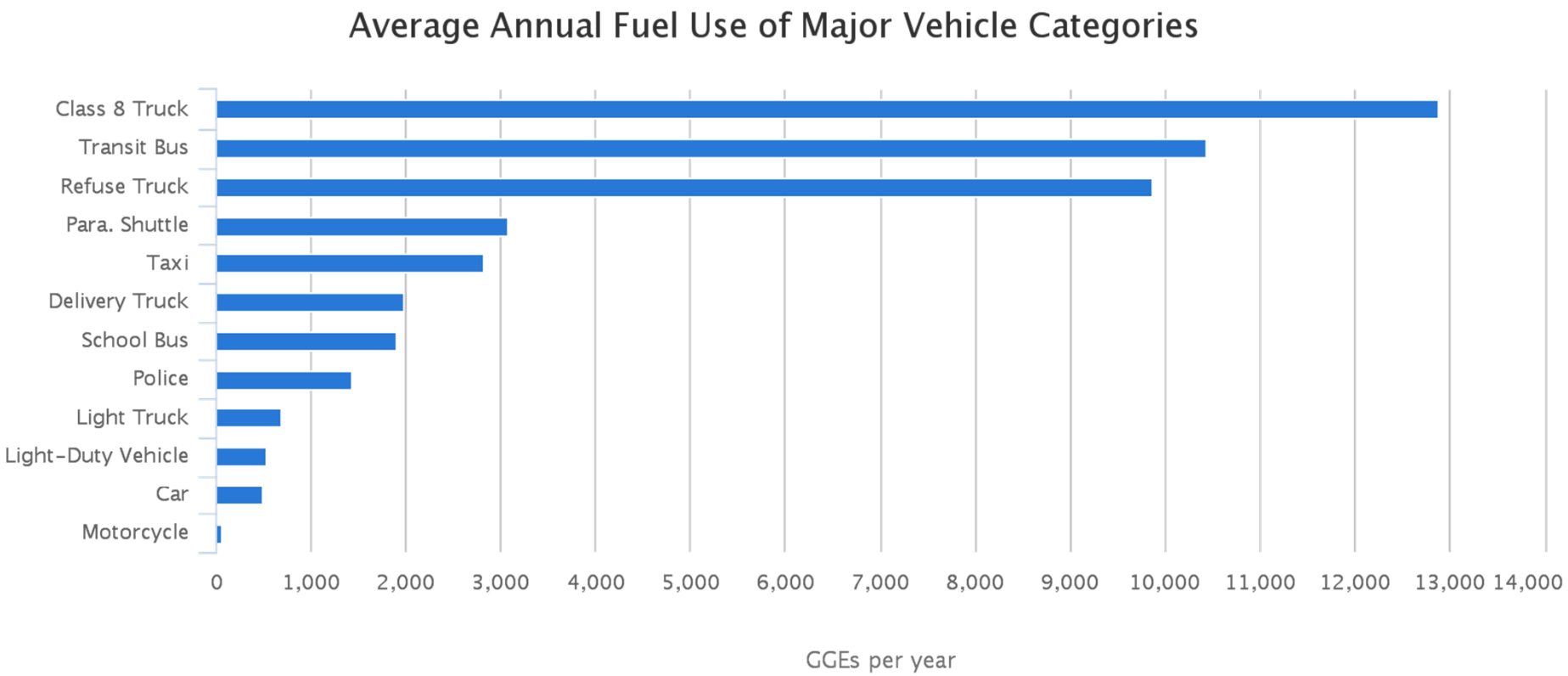
# VOCATIONAL VEHICLES

# Vocational Vehicles

- Per vehicle Transit Buses and Refuse Trucks use the **second and third most fuel annually**.

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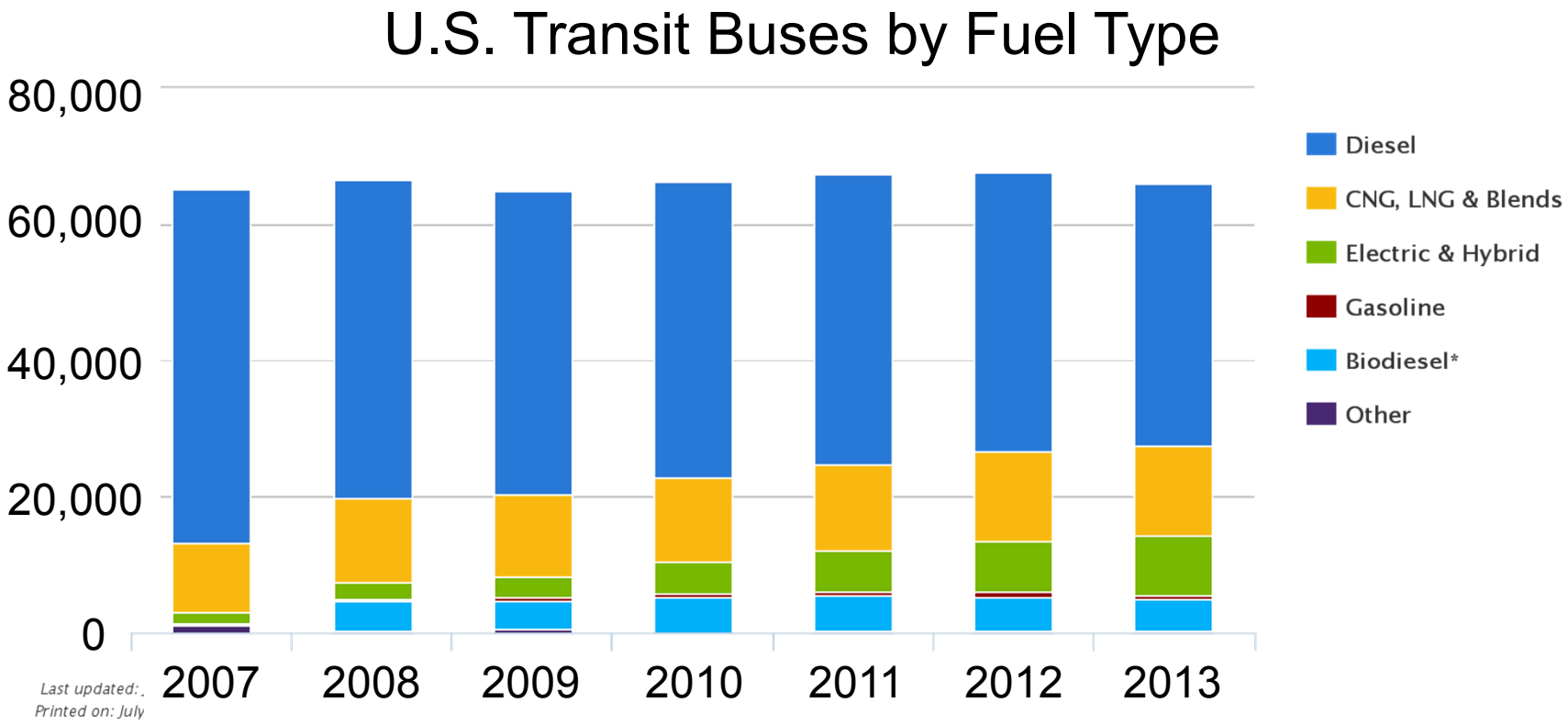
*Printed on: July 18*

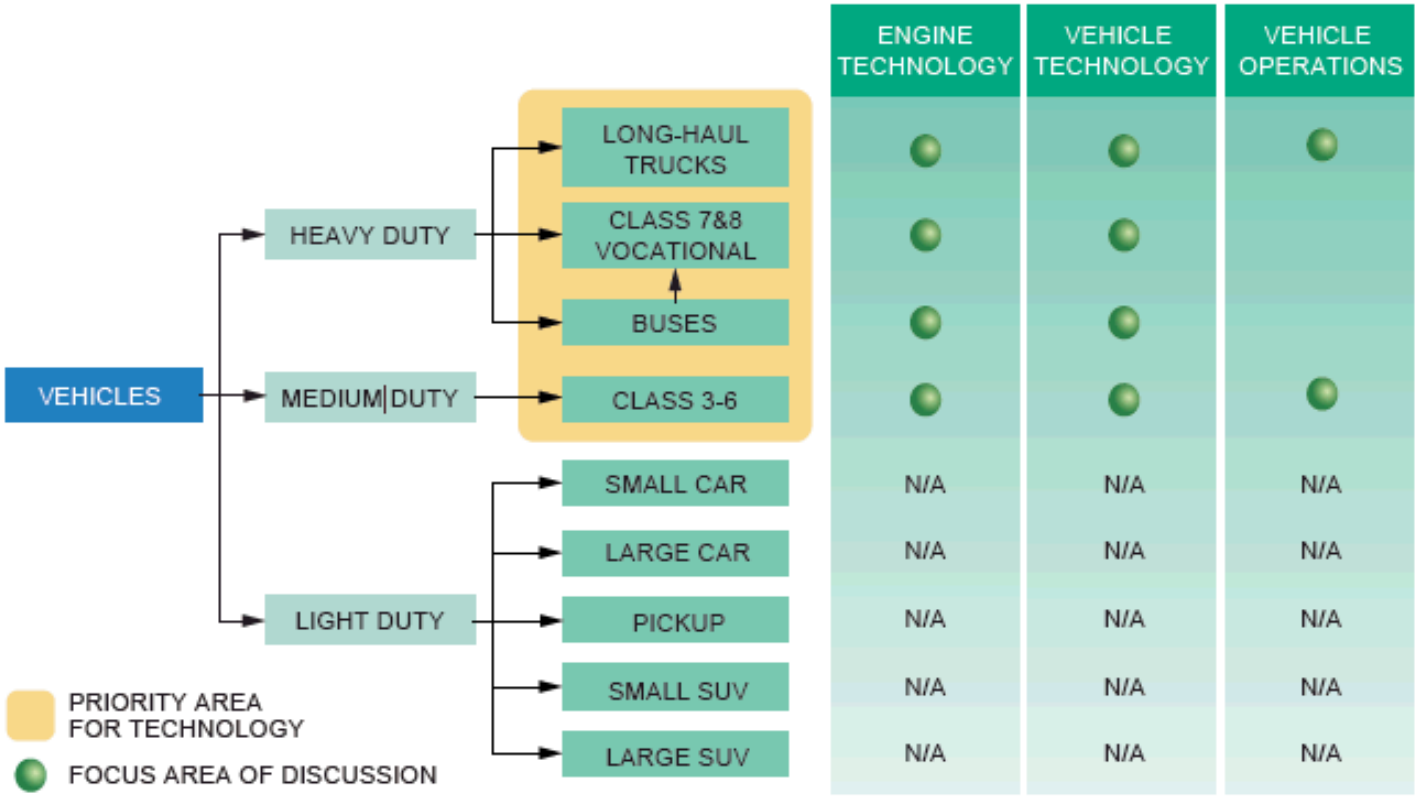
# Vocational Vehicles

- The use of alternative fuels has steadily **increased in vocational vehicles**.



# Why Include Buses?

- Buses are a large section of the HDV market.
- The government may use buses as a **lever to meet reduction standards**.



# Address Concerns

- How much of an impact do NG buses have on the GHG emissions?
- How will the increase in bus electrification change the market?
- Is infrastructure a large factor for buses?

# Including Buses

- Currently the model excludes all types of buses from the Polk Data Set.
  - This causes them to be removed from the simulation completely.

- To include buses into the simulation many of the modules had to be modified.
  - **Added a new body type:** Bus
  - **Added vocational vehicles:** General Freight, Food, Bus Transportation.
  - **Focus:** Class 7 and 8's Non School Buses.
    - Vast majority of School Buses are class 6 vehicles.
    - School buses would have different efficiencies than non school buses.

# Expected Results

- Expected to add over 26,000 vehicles to the model.
  - Majority of these vehicles use diesel type fuel.
- Help determine the value of improving natural gas vehicles in the bus market.
- Help determine the impact of electric HDVs.

# Review

- Focused on HDV Market due to its **consumption of fuel** and **contribution to green house gases**.

- The ParaChoice simulation provides trends in the trucking industry to **guide decisions**.

- **Expanded the ParaChoice simulation**:
  - Natural Gas Fuel Incentives
  - Non School Buses

# Internship Takeaways

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- Importance of understanding assumptions and where information is coming from.
- Inserting test cases throughout code.
  - Verify things are working correctly and running as planned.
- The simulation and modeling of any system is complex.
  - Understand the basic concepts of creating a new model.
  - Reliable data and assumptions that would be used.
- Validation of simulation.
- Documentation is helpful to increase turn over efficiency of existing projects.