Path to Electrifying Rice's Shuttle Fleet

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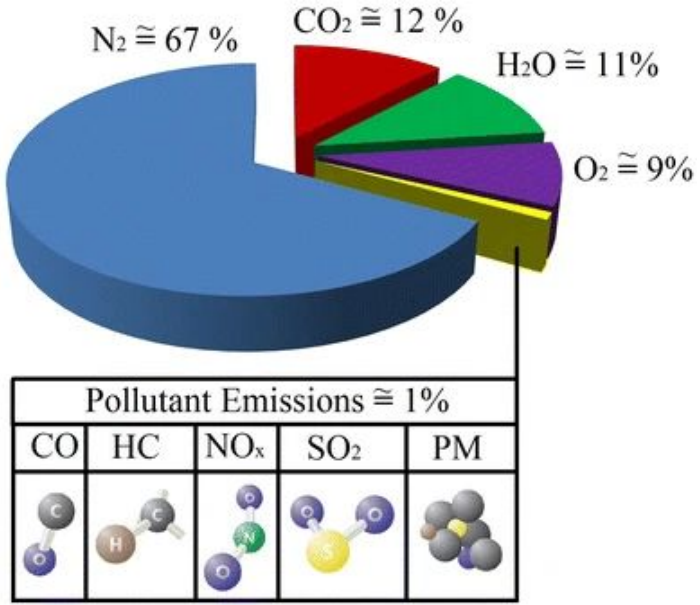
Rice sets plan to be climate-neutral by 2038

- Building-level energy-efficiency retrofits.
- Adherence to stricter standards for energy efficiency for new construction.
- Utility plant-level efficiency investments and operational adjustments.
- On-campus renewable energy investments.
- Greener power procurement.
- Continued decarbonization of electricity in Texas.
- Use of carbon sequestration value of the Rice Management Company's Rice Land Lumber Company property in Louisiana.
- Continued monitoring of potential electricity procurement opportunities that allow Rice to obtain greener electricity at no increase in cost.

What about decarbonizing campus-based transportation?

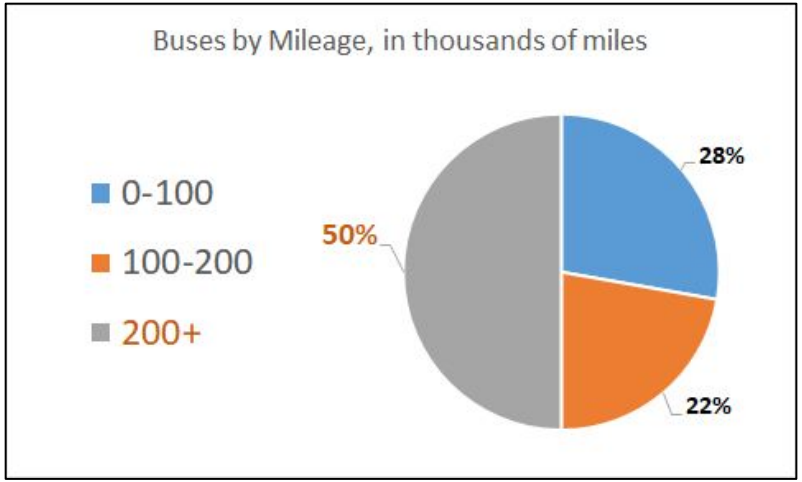
https://news.rice.edu/2014/10/20/rice-sets-plan-to-be-climate-neutral-by-2038/

Air Pollution

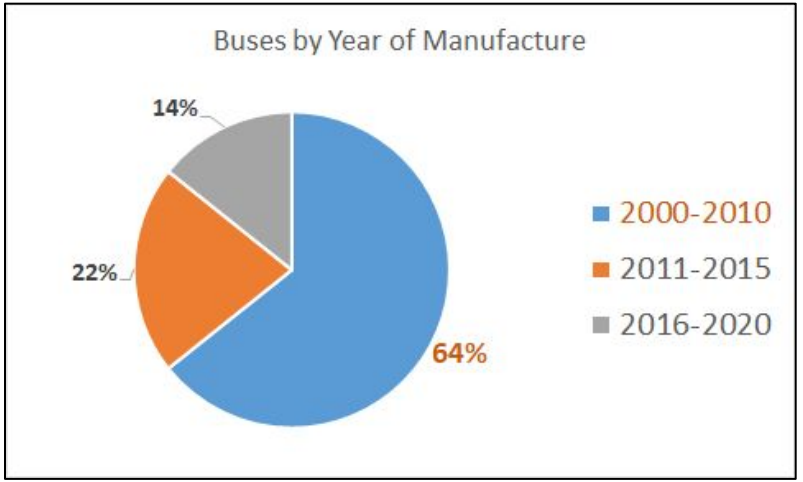


- Diesel engines
- Pollutants largely NO_x and Particulate Matter
- Largely depends on engine quality and driving conditions

Rice Needs New Buses



½ have over 200,000 miles



⅔ are over a decade old

Possible Solutions

- Long Term Solutions:
  - Electrifying Rice's Shuttle Fleet
    - Buying new electric buses
    - Repowering current shuttles
    - Investing in charging infrastructure
- Short Term Supplemental Solutions:
  - Smarter bus routes
  - Switching to biodiesel

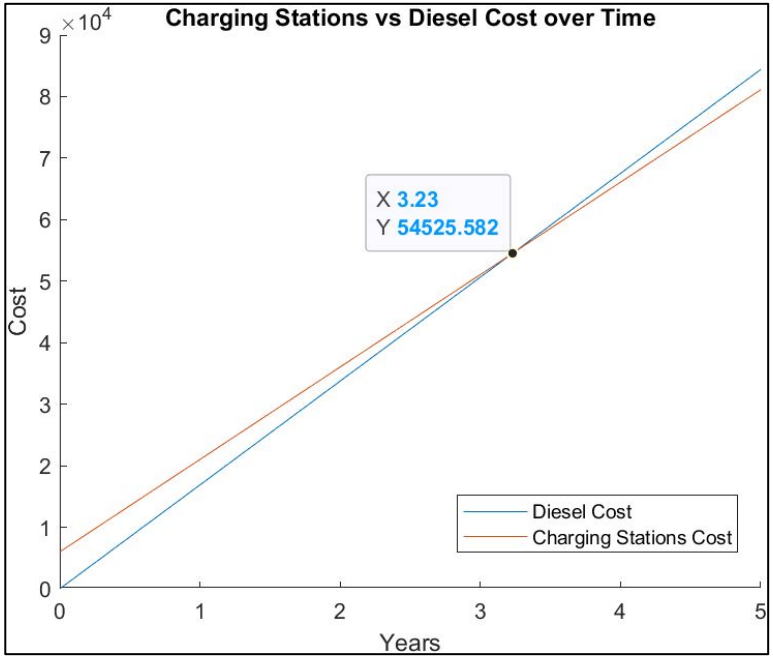
Most Promising Option:

Optimal-EV S1LF Shuttle Bus

Seats	23
Length	26' 6"
Range	>125 miles
Charging time	8 hours standard charging, 2 fast charging using Proterra charger
Tentative time of availability	Q3 2021
Tentative cost	$235,000 per bus

Charging Stations

- 75kW station can be bought with new bus for extra $2000
- Would cover about 4 buses' charging needs each night
- For entire fleet covered, cost would be ~$6000 on top of replacement cost



Monetary Benefits

New diesel buses of comparable size are between $60,000 to $75,000, but:

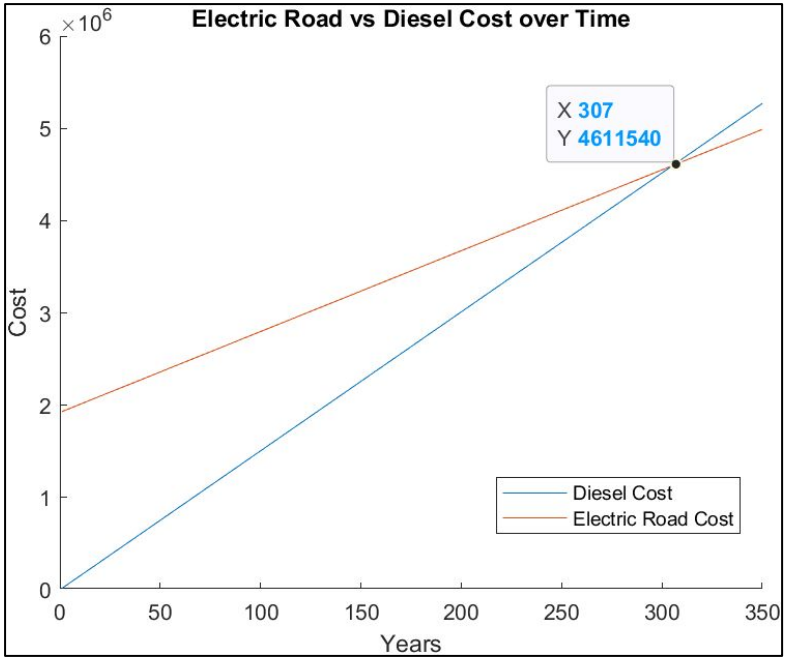
- Optimal-EV: S1 "can save >$7000/year compared to gasoline shuttle bus"
- Other universities have benefitted: Duke, UGA
- Charging infrastructure is one time cost
- Grants available
- More than just financial benefit

Students Repowering

- Could act as both senior project for students and marketing for Rice
- Way to familiarize current mechanic with electric vehicles
- Deemed infeasible by Dr. Woods (ELEC professor) from a liability and technical standpoint

Electric Roads

- Cost of installation is approx. $1.2mil/km
- For entire inner loop track: ~$3mil
- For just straightaways: ~$2mil
- Would not meet charging demands for buses



Demand-Based Technology

Benefits:

- Greater reliability
- Reduced fuel use
- Extended vehicle life

Reducing Emission by Switching to Biodiesel

- B100 results in 71% lower emissions than petroleum diesel
  - 43.2% less carbon monoxide
  - 55.4% less particulate matter
  - Increase in nitrogen oxides by 5.4%
- Most common biodiesel blend, B20, reduces emissions but not as significantly
  - 12.6% less carbon monoxide
  - 18% less particulate matter
  - Increase in nitrogen oxides by 1.2%

Biodiesel Options

On Campus Biodiesel Production

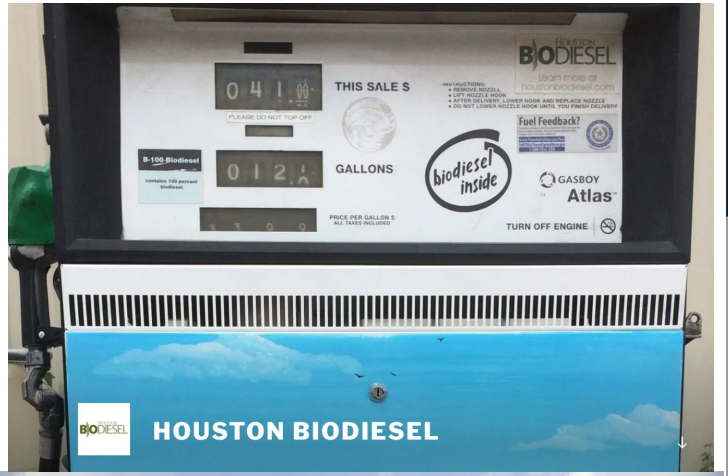
- 2005 Rice University Biodiesel Initiative (RUBI)
  - Converting fry oil from the serveries into biodiesel for riding lawn mowers
  - Functioned off and on for about 10 years
  - Unable to meet needs of shuttle fleet

RUBI founders picture above: Matt Yarison, Christine Robichaud, Christina Eddleman, Lizzi Clark, Guyton Durnin

Biodiesel Options

Purchasing options

- Off campus biodiesel fueling station
  - 7.1 miles from Rice (approx. 19 minute drive)
  - No updates on its functionality since 2019
- Suncoast Resources fueling service
  - Based on market price from 11/3/20 $1.94 per gallon
  - $90 charge per delivery
  - Total of about $575 per delivery



Should we pursue biodiesel as an intermediate step?

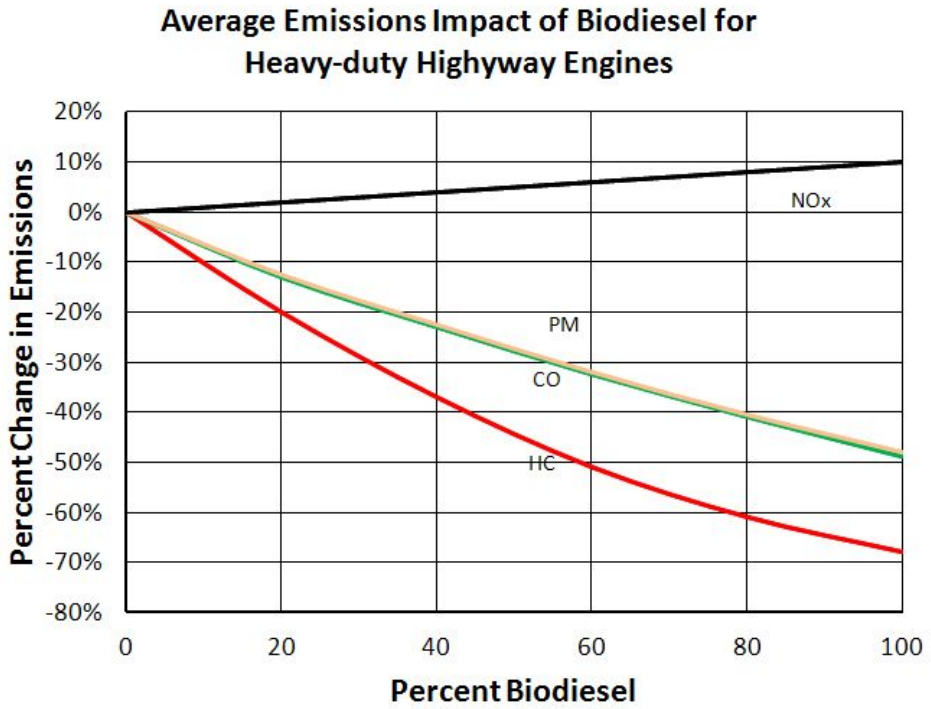
Weekly Petroleum Diesel Price:

$2372

Estimate of Weekly Biodiesel Price:

$2300

Should we pursue biodiesel as an intermediate step?



https://afdc.energy.gov/vehicles/diesels_emissions.html

Final Recommendation

- Transition to electric fleet
  - Pilot with Optimal-EV S1LF Shuttle Bus
  - Allow students to repower oldest van in the fleet
- Invest in a new charging station
- Pursue and expand on demand technologies

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