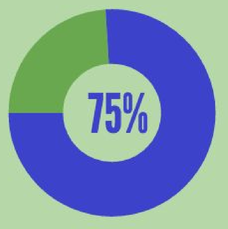
Zero Emissions Bus Potential Amongst Massachusetts Universities

By: Sam Beard, Olivia Griot, and Jaclyn McBain

Introduction

Conventional fossil fuel powered buses are costly to maintain and contribute significantly to greenhouse gas emissions. In comparison, electric buses represent an alternative method of transportation that is both more cost effective and environmentally friendly in the long run. Stanford University and the University of Montana are examples of universities who have found success in the implementation of zero-emission bus systems through a reduction in both emissions and fuel and maintenance costs. Using these universities as models, the University of Massachusetts at Amherst, Tufts University, and Boston University would experience immense long term benefits despite large upfront costs. In this study, we compare the costs and benefits of making a shift from using conventional fuels to electricity to determine the overall feasibility of zero-emission bus implementation on these three Massachusetts campuses. Campuses were chosen from criteria that included history of sustainability and climate action, student population, length of bus routes, and the frequency at which buses travel those routes.



75% of Tufts' current bus emissions could be abated by switching to ZEBs

Methods

Choosing Schools:

- The top fifteen schools largest schools chosen based on population.
- Three schools chosen based on type of campus, diversity in bus system size, their history of sustainable initiative, and funding available for environmental projects
- UMass Amherst, Boston University, and Tufts University were chosen

Cost Metrics:

- Initial Costs
  - Average cost of diesel bus: $300,000 (MacKechnie, 2015)
  - Cost of Proterra Catalyst: $500,000 (Casey, 2015)
  - Average cost of charger for electric bus: $600,000 (Redden, 2014)
- Energy Costs (United States Department of Energy, 2016)
  - Diesel: $2.23 per gallon
  - Electric: $0.13 per kW hour (Equivalent $1.29 per gallon)
- Maintenance Costs (Sierra Club "Zero-Emission", 2015)
  - Diesel bus: $1 per mile and $9,075 yearly
  - Electric bus: $0.20 per mile and $1,170 yearly
- Externalities costs
  - Social Cost of Carbon(EPA Office of Transportation and Air Quality, 2005)
    - Diesel: 22 pounds of Carbon per gallon
    - Electric: 1.18 pounds of Carbon per kW hour
  - Health (National Research Council, 2010)
    - Diesel: $0.08 per mile
    - Electric: $0.0149 per mile

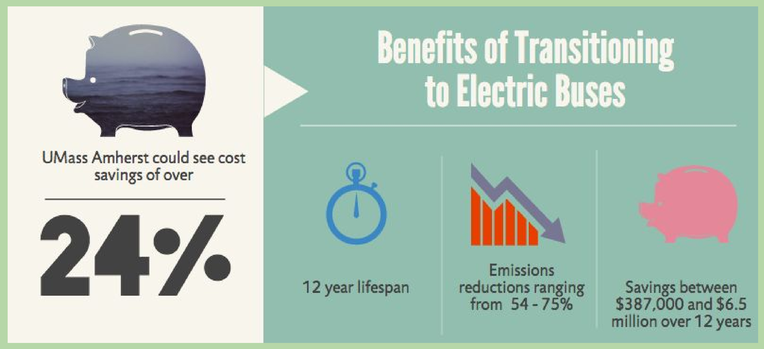
Formula Used:

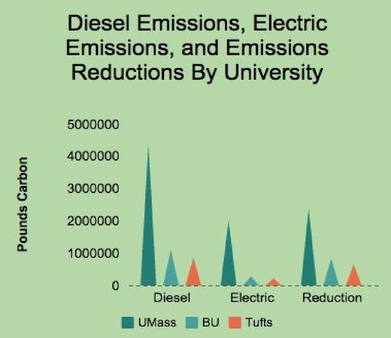
$$NPV = PV_D - PV_E \text{, where } PV_D = \frac{C_{D_1}+M_D+E_D+B_D}{(1+r_d)^1} + \frac{C_{D_2}+M_D+E_D}{(1+r_d)^2} + \ldots + \frac{C_{D_{12}}+M_D+E_D}{(1+r_d)^{12}} \text{ and}$$

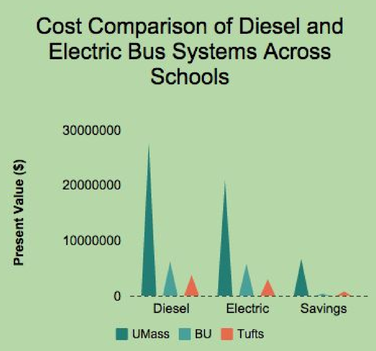
$$PV_E = \frac{C_{E_1}+M_E+E_E+B_E}{(1+r_d)^1} + \frac{C_{E_2}+M_E+E_E}{(1+r_d)^2} + \ldots + \frac{C_{E_{12}}+M_E+E_E}{(1+r_d)^{12}}.$$

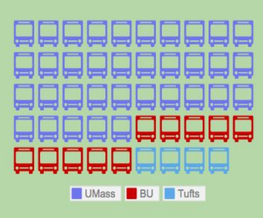
CD = Cost of diesel
CE = Cost of electricity
MD = Maintenance diesel
ME = Maintenance electric
ED = External cost diesel
EE= External cost electric
BD = Upfront cost diesel
BE = Upfront cost electric

This model finds the present value of the costs of the diesel bus system and the present value of the costs of the electric bus system. Present valuation is used to try to account for the time value of money, rather than just summing up the costs incurred each year. It sums up the discounted costs each year to determine the value of these future costs in the present. If the present value of the costs of the diesel bus system is higher than the present value of the electric bus system, then the electric bus system is a good investment.

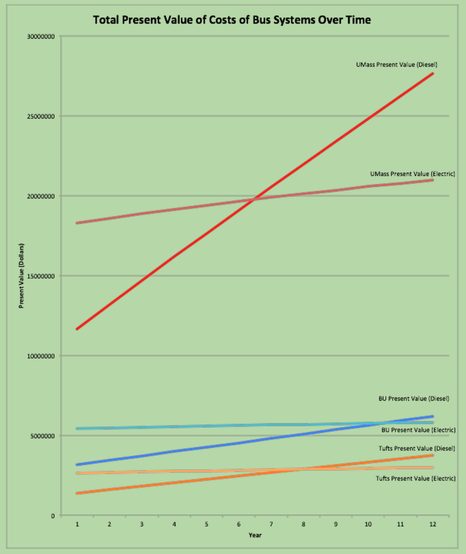








UMass: 35 buses
BU: 10 buses
Tufts: 4 Buses



Results

For each school, the present value of the electric bus system's lifetime costs was lower than the present value of the diesel bus system's lifetime cost, making electric bus systems a good and feasible investment.

UMass would see cost savings over 12 years with the present value of $6,650,050.08 in total or $190,001.43 per bus. During year six, UMass will see the present value of the diesel bus system become more expensive than the present value of the electric system, and by year 12, the present values show that the electric bus system is significantly cheaper overall.

BU would see cost savings over 12 years with the present value of $387,367.74 in total or $38,736.77 per bus. During year ten, BU will see the present value of the diesel bus system become more expensive than the present value of the electric system, and by year 12, the present values show that the electric bus system is cheaper overall.

Tufts would see cost savings over 12 years with the present value of $776,760.69 in total or $194,190.17 per bus. During year seven, Tufts will see the present value of the diesel bus system become more expensive than the present value of the electric system, and by year 12, the present values show that the electric bus system is cheaper overall.

Even with a model that does not include externalities, electric bus systems are more cost-effective overall than diesel bus systems.

UMass could see emissions reductions of 2,394,000 pounds of carbon per year, which is a 54.4% reduction.

BU could see emissions reductions of 826,353.82 pounds of carbon per year, which is a massive reduction of 74.93%.

Tufts could see emissions reductions of 645,817.54 pounds of carbon per year, which is a reduction of 74.93%.

Recommendation

1. The University of Massachusetts, Tufts University, and Boston University should begin the transition away from diesel buses as soon as possible. To mitigate costs, universities should either utilize alternative methods such as hybrids or gradually replace fossil fuel powered buses with electric buses as current buses retire if complete replacement of the entire system is not feasible.
2. When determining schools which would benefit the most from transitioning to electric buses, it is best to look at schools with more extensive bus systems and schools that use bus systems where each bus in the fleet travels a large number of miles. These schools should be the target of government funding for the purposes of promoting cleaner air quality.

Conclusion

As the University of Massachusetts, Tufts University, and Boston University adopt the initiative to shift from their current bus fleets that are fueled by conventional methods to a zero-emission bus system, they will begin to see a rapid decrease of costs and emissions just like Stanford University and the University of Montana witnessed. Because the University of Massachusetts possesses a more extensive system of routes and buses, it will be the most likely to experience a more immediate difference in costs than the other two universities. However, each university will certainly note a reduction in costs and emissions in the long term. As a result, other surrounding universities will note the benefits these universities have experienced despite the initial costs they incurred, and ultimately, many universities will follow the lead of these three models.

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