EFFECTS OF BUS IDLING AT RUTGERS UNIVERSITY

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Abstract

An analysis of Rutgers bus system was conducted to understand its environmental and economic impact. Data pertaining to bus specification and operation schedule was obtained from Rutgers Department of Transportation Services (DOTS) and upon evaluation, was estimated that bus idling during drivers' breaks consumes $24,637 in fuel and produces 89.5 tons of CO2. Future direction looks to use the app TransLoc-Rider to more accurately track the length and frequency of idling time along with using its interface to assist with route planning. With proper maintenance and a new protocol, bus idling at Rutgers can be limited at minimal cost.

Background

Rutgers University is home to the second largest bus system in New Jersey, largest of all universities in the U.S. With fourteen routes peaking up to fifty-three buses a day, Rutgers' bus system has a large presence in the environment it operates in. Figure 1 outlines the number of buses used on a daily basis between Monday and Thursday.

	AM						PM												AM		
Route	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3
A	0	3	3	3	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0	0
B	1	4	4	7	7	7	9	9	9	9	9	9	9	5	3	3	1	1	1	1	0
C	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
EE	2	4	4	4	5	5	5	5	5	5	5	5	5	5	3	3	3	2	2	2	2
F	0	5	5	8	8	8	9	9	9	9	9	9	9	8	8	0	0	0	0	0	0
H	2	3	3	4	4	4	4	4	4	4	4	4	4	4	4	3	3	2	2	2	0
LX	2	5	5	6	6	8	8	8	8	8	8	8	8	8	6	4	2	2	2	2	0
Shuttle 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Shuttle 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
REXL	0	3	3	4	4	4	4	5	5	5	5	5	5	4	4	4	4	0	0	0	0
REXB	0	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	0	0	0	0
RBHS	0	1	1	1	1	1	1	1	1	1		1	1	0	0	0	0	0	0	0	0
Total	9	34	34	43	46	48	51	53	53	53	52	53	53	46	40	24	18	8	8	7	2

Figure 1. Hourly Bus Count Between Monday and Thursday

It is common practice for buses to be left idling with both doors open while drivers are on break. As a result, fuel continues to be consumed by the engine and HVAC system and cooled/heated air is able to escape into the environment. Additional idling hours stem from poor communication between bus arrival time resulting in congestion and unproductivity at bus stops The Department of Energy reports that vehicles idling longer than 10 seconds should be turned off as the fuel consumed is equivalent to that used to restart the vehicle. According to DOTS, drivers are allotted one ten minute break per shift, estimated at 3 hours, resulting in 198 idling hours a week.

Methods –Energy Assessment

Figure 2. Line of Rutgers Buses

The fuel distribution of Rutgers buses is 83% B20 and 17% diesel. A work order obtained by Eldorado-California identified the engine model, HVAC system and bus dimensions used in energy calculation. Metrics pertaining to the fuels' heating values and chemistry were found using reference 1. Since the HVAC system is used continuously, its energy consumption is found using idling hours. Weather data was also analyzed to determine when the bus can practically be turned off.

Results

Calculations are based on Rutgers' academic calendar and do not include summer and winter sessions. Important parameters used: HVAC system operates at 3.24 kW, efficiency of engine-alternator system is 21%, and idling consumption is estimated at 0.97 gal/hr [3]. Upon calculations Rutgers pays $24,637 in wasted fuel and produces 89.5 tons of CO_2 - equivalent to 20 cars operating annually.

	Diesel	B20
LHV[1] (Wh/gal)	38,289	38,0556
CO_2 Emissions[2] (tons/gal)	0.0112	0.0101
Cost of Fuel ($/gal)	$2.98	$2.80
Energy Consumed (kWh)	17,573	80,028
Fuel Consumed (gal)	459	2,103
Cost of Fuel Consumed ($)	$1,368	$5,888
CO_2 (tons)	5.14	21.24

Table 1. Excessive Use of HVAC Calculations

	Diesel	B20
Time Idling (hours)	1,139	5,187
Fuel Consumed (gal)	1,105	5,031
Cost ($)	$3,293	$14,088
CO_2 (tons)	12.38	50.81

Table 2. Calculations for Bus Idling

Future Direction

TransLoc-Rider is an application that live tracks the position and timing of buses at registered stops. With Python, this data can be extracted to determine idle times longer than a minute, which can help calculate fuel consumption and CO_2 emissions more accurately.

TransLoc-Rider can also allow drivers to see the location of other buses along their route. This can help improve communication amongst drivers, limit congestion at stops, and space buses more evenly. A phone-dashboard setup can be incorporated to allow this feature to be used responsibly by drivers.

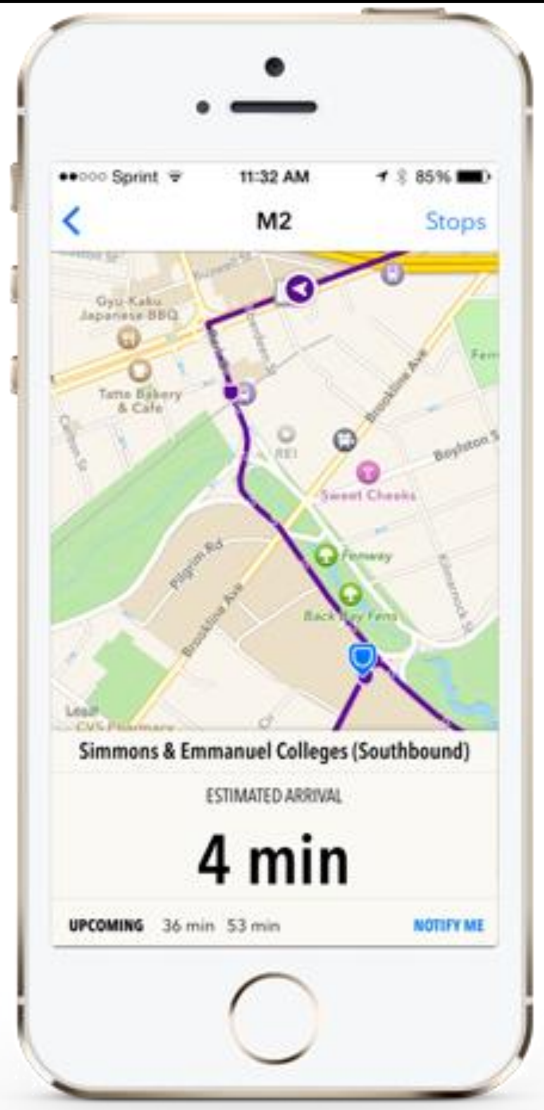

Figure 3. TransLoc-Rider Interface

Discussion

Implementation of this recommendation requires buses being turned off while drivers are on breaks. Interior and exterior lighting will still be operational, however the HVAC system will not. To limit the change in the cabin temperature, only the front door of the bus should be left open. When assuming a 25% loss of air to the environment, the HVAC system should be turn on when the outside temperature is ±20ºF the desired cabin temperature to prevent a variation greater than 5ºF.

As the buses run on diesel, they use compression ignition, resulting in little wear and tear from more frequent startups. They are also outsourced, meaning fuel savings do not directly benefit Rutgers, however a reduction in emission around campus is an incentive since no capital cost come from implementation.

Calculations also assumed a ten minute break per shift based on information provided by DOTS, however the frequency is predicted to be higher and can be verified using coding with the TransLoc-Rider app. Integration of TransLoc-Rider shows great potential in increasing overall efficiency of the bus system.

References

1. *Tesfa, B. et al. "LHV predication models and LHV effect on the performance of CI engine running with biodiesel blends." (2013).*
2. U.S. Energy Information Administration *"How much carbon dioxide is produced by burning gasoline"* 2014. PDF file
3. "Fact #861 February 23, 2015 Idle Fuel Consumption for Selected Gasoline and Diesel Vehicles." *Energy.gov*,.