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Proposal Title: Impact of Bus Idling at Rutgers University
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Summary of the proposal:

According to the Department of Energy, personal-vehicle idling wastes about 3 billion gallons of fuel and generates around 30 million tons of CO_2 in the United States annually. It is recommended that if a vehicle remains idle for longer than 10 seconds, the engine should be turned off as the fuel consumed is equivalent to starting it up. Rutgers University has the 2nd largest bus system in New Jersey and contributes largely to wasted fuel and carbon emissions due to bus idling. This proposal estimates that Rutgers loses $35,301 from idling and heat losses and produces 128 tons of CO_2 every academic year. It is recommended that Rutgers bus drivers follows three simple rules to limit its impact on the environment: turning off engine if idling for longer than 30 seconds, avoiding usage of HVAC unit when outside temperature is $\pm$ 5°F desired cabin temperature, leaving only driver side door open to limit energy loss during breaks.

I. INTRODUCTION

In 2017, the EPA estimated that the transportation sector produced 29% of all emissions in the United States, making it the largest contributor of pollution[1]. With accessibility and demand for travel on the rise, carbon emissions are expected to grow exponentially unless alternatives or efficient practices are adopted. One efficient practice is turning a vehicle off when sitting idle for longer than 10 seconds to avoid unnecessary consumption of fuel. In the United States, personal-vehicle idling wastes about 3 billion gallons of fuel and generates around 30 million tons of CO_2 annually[4]. In response, federal laws and guidelines have been put in place to limit the amount of time a vehicle can sit idle for in one place. If disregarded, motorists can face fines up to $2,000. Laws like these, though tough, are essential in changing habitual practices of humans in hopes to dramatically reduce carbon emissions, save money and take strain off the environment. This paper will focus on the effects of idling on Rutgers bus system in an attempt to find means of energy savings and carbon reduction.

II. BACKGROUND

Rutgers University's is home to the second largest bus system in New Jersey and is one of the largest of all universities in the United States. With fourteen different routes peaking up to fifty-three buses on any given day, Rutgers' bus system has a large presence in the lives of the students and the environment it operates in. The buses used at Rutgers are built by Eldorado National California Inc who produces a variety of bus models ranging from 33-foot handicap buses to 40-foot passenger buses. Eldorado was contacted where a work order made by Rutgers in 2010 was attained indicating the purchase of 38 Axess forty-foot buses[2]. The dimensions listed in Figure 1 indicated the size and dimensions for a 38 Axess forty-foot bus.

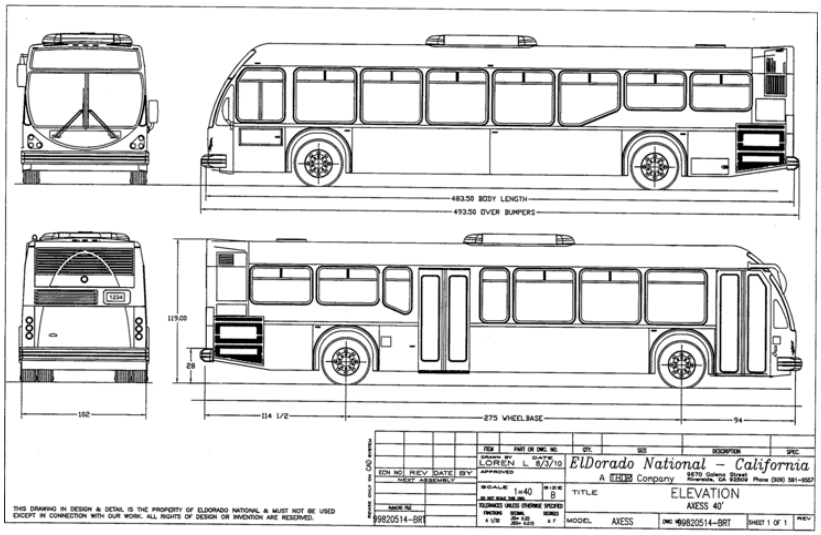

Figure 1. *Dimensions of 40' Eldorado bus*

It is important to note that Rutgers sources their buses from First Transit, a privately-owned company located in New Jersey. The implications of such means potential savings calculated in this paper will not directly go to Rutgers, removing monetary incentives for recommended changes to be implemented. However, the significant decrease in carbon emissions will improve air quality around bus stops and allow Rutgers to brand itself as a sustainable school by initiating projects that decreases energy consumption across its campuses.

III. Methodology and Results

For convenience, calculations regarding CO_2 emissions and heat loss will only reflect bus usage during the academic year: September 4th to December 21st and January 22nd to May 16th. The summer and winter sessions are excluded due to lack of data, therefore, including this time frame would further decrease carbon emissions and increase savings.

The impact of eliminating bus idling will now be considered. A common practice of Rutgers' bus drivers is to leave their buses running when taking breaks, resulting in internal equipment to continue to consume energy. The Department of Energy estimates that idling consumes 0.6 – 1.5 gallons of fuel for every hour the engine is left running[3]. It is recommended

that if a car is left idling for more than 10 seconds, it should be turned off as it will consume the same amount of fuel as it would to start a vehicle back up. To properly calculate the hours of bus idling, Domenick Rizzo, Assistant Manager of Transit Services at Rutgers, was contacted to determine the times of operations on an hourly basis. Below is a sample of the bus schedule for Monday through Thursday:

SCHEDULE FOR MONDAY - THURSDAY																					
AM/PM	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	1	0	0	0	0	0	0	0	0
Total	9	34	34	43	46	48	51	53	53	53	53	53	53	46	40	24	18	8	8	7	2
*Note: Weekend 1 & 2 buses run from 4-6 AM																					

Figure 2: Number of buses operating between Monday and Friday

Mr. Rizzo informed that drivers are formally allotted a ten-minute break during each shift, so a conservative estimate of a ten-minute break every three hours will be used. Shorter breaks for when drivers make a phone call or attend to personal matters will be excluded. When factored in with the schedule in figure 2, the number of idling hours each week is 198 and for the academic year is 6,326. When combined with the DOE's estimate of about 1.05 gallons of fuel consumed for each hour of idling, 6,642 gallons of fuel are consumed during the academic year at Rutgers due to idling.

To find the CO_2 produced from idling, the fuel type for the buses needed to be determined. It was found that 18% of the buses run on traditional diesel while the remaining 82% run on biodiesel. It is assumed that the specific biodiesel used is B20 which is a blend of 20% biofuel and the remaining diesel. B20 is a good substitute for diesel as it produces 10% less carbon emission.

Biodiesel can go up to 100% biofuel (B100), which further decreases emission, however B100 is not compatible with most engines. After distributing buses by fuel type, the total amount of CO_2 produced from idling was 68 tons while the cost of wasted fuel added up to $18,813.

The next portion of this paper will focus on heat loss during breaks. Currently, the set temperature for the heating and cooling is dependent on the driver's preference making it difficult to accurately calculate the current energy consumption of HVAC units. Instead, heat loss will be calculated during breaks. Important assumptions made are 1) zero pressure difference between the ambient and bus environment 2) uniform mass and temperature distribution 3) air acting as an ideal gas. From the work order, the HVAC unit used is a Thermal King Roof System, more specifically the Athenia AM II 960. This unit specifies its cooling and heating capacity as 92,000 Btu/hr and 115,000 Btu/hr respectively. Based on observations, these units are continuously running during breaks, therefore energy loss can be calculated by multiplying the cumulative hours of idling by the cooling and heating capacity, however it is necessary to determine the number of days that require heating and cooling. Standard practice places the optimal temperature for human comfort is 65°F. Comparing this value to historical weather data from The Weather Channel, there are a total of 105 days that required cooling and 109 days that required heating. Factoring in an efficiency of 90%, a total of 757 MMBtu is wasted. To translate this loss into carbon emissions and money loss from burnt fuel, values from table 1 are used. The total cost of running the HVAC units during breaks is $16,488 while the CO_2 produced is 60 tons.

	Diesel	B20
HV (Btu/Gal)	130,630	129,836
CO2 emissions (kg/gal)	10.15	9.17
Btu Produced	136,202,252	620,476,925
Cost of Fuel	$2.98	$2.80

Table 1. Values for Diesel and B20.

It is important to acknowledge that turning off the engine renders the HVAC system useless causing the cabin temperature to change. Currently, drivers leave both doors open when on break causing most of the heated or cooled air to escape the cabin rendering the work useless. It is recommended that drivers leave one door open – the one closes to the driver's side as this location impedes the flow of air from circulating quickly throughout the bus. It is estimated that 30% of air will exit the bus during the average ten-minute break. Using conservation mass, a good rule of thumb to follow is if temperature is $\pm$ 25% of the optimal set temperature to keep the units running. This suggestion will never let the inside cabin exceed $\pm$ 5^{o}F the set temperature.

IV. IMPLEMENTATION

Due to the simplicity of this recommendation, its implementation is almost instantaneous. It is assumed that First Transit has bi-annual trainings for its staff where good practices could be passed on to the drivers. The following practices should be mentioned:

1) Turning off engine if idling for longer than 30 seconds

2) Avoid using HVAC unit when temperature outside is $\pm$ 5^{o}F desired cabin temperature

3) During breaks, leave only driver side door open to limit energy loss

Values used in calculation were largely based on estimates obtained from research. To get more accurate results, data can be manually collected in several categories: idling time, levels of CO_2 emissions, and usage of HVAC unit. Sensors can be used to track HVAC usage and the emissions produced from a bus while a coding script in conjunction with the TransLoc Rider App (a popular mobile app that accurately tracks bus location along a route) can record the total time the buses remain idle. Data can also be collected to account for bus usage during the summer and winter sessions to get the cumulative energy wastage from idling annually.

A benefit of this proposal is it costs no money to implement. Although bus drivers will be starting their engines 4 times as often, the buses are diesel based meaning they use compression ignition to start, not spark ignition. There is no need to replace a spark plug since they are not used. Another concern that can be disregarded is the higher concentration of pollutants that generally occur during an initial start-up. Since the engines are only off for a short duration, the catalytic converter will still be warm enough to operate at a high efficiency. The last concern is that both internal and external light can still be used even if buses are off. Students will not be left without lighting when waiting for a driver to return from a break and the exterior light that indicates the bus letter will still be visible.

V. CONCLUSION

Bus idling has a significant impact on both Rutgers' environment and economics. Every academic year, Rutgers loses $35,301 from bus idling and heat loss and produces 128 tons of CO_2 which is equivalent to 21 cars operating on a yearly basis. These calculations were based solely on the academic year and are expected to be about 10% greater when including the winter and summer sessions. It is apparent that making small changes in our daily habits can have a significant impact on our environment. It is highly encouraged that Rutgers implements the recommendations mentioned as the savings are evident.

VI. REFERENCES

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