

GO ELECTRIC: Analysis of an All-Electric Transportation Fleet at Rutgers University

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Project Summary:

Using a systematic approach to modeling the current bus transportation system, a streamlined and more efficient bus transportation network is proposed to decrease the size of the Rutgers transportation fleet from ~50 biodiesel buses to ~40 electric buses. The environmental and financial impact of the transition from biodiesel buses to electric buses is also analyzed and presented in this proposal. Over a 12-year period, switching from the current biodiesel fleet to an all-electric bus fleet can prevent 23,640 metric tons of CO₂ gas emissions and save \$12.4 million.

Part 1: Reducing the Rutgers Transportation Network

Objective: Streamline campus routes to focus solely on intercampus traveling. The following 6 routes for intercampus travel are proposed. These routes can deliver more students between campus centers at a faster rate while reducing the transportation fleet size by 10~12 buses.

Six Proposed Bus Routes

 Main	<ul style="list-style-type: none">LSC (5min →)BCC (7min →)Sem Pl (8min →)
 Back	<ul style="list-style-type: none">LSC (8.5min →)Sem Pl (9min →)BCC (5min →)
 F	<ul style="list-style-type: none">Sem Pl (7min →)DCC (3min →)CCC (3min →)DCC (6min →)
 REXB	<ul style="list-style-type: none">BCC (9min →)DCC (10min →)
 REXL	<ul style="list-style-type: none">LSC (12min →)DCC (10min →)
 EE	<ul style="list-style-type: none">RSC (1.5min →)Scott (1min →)Train St (2min →)Paterson (2min →)Rockoff (3min →)Pub. Safe (2min →)DCC (3min →)CCC (3min →)Pub. Safe (1min →)Liberty (1min →)Train St (3min →)SAC (2min →)

Distribution of Buses in Current and Proposed			
Bus Route	Total Time	# of Buses	Min/Bus
A	29.5	4	7.4
B	24.5	6	4.1
EE	35.0	5	7.0
F	28.0	6	4.7
H	30.5	5	6.1
LX	27.0	9	3.0
REXB	32.0	4	8.0
REXL	32.0	5	6.4
Total Buses Used:		44	
Main	20.0	8	2.5
Back	22.5	8	2.8
F	19.0	4	4.8
REXB	19.0	4	4.8
REXL	22.0	4	5.5
EE	26.5	4	6.6
Total Buses Used:		32	

Travel Times between Campus Centers						
Campus Centers	Current (mins)	Proposed (mins)				
BCC ↔ LSC	10.6	22.1	7.8	7.5	26.2%	66.0%
BCC ↔ RSC	14.4	19.6	9.5	11.8	33.9%	39.7%
BCC ↔ DCC	25.0	20.0	13.8	14.8	45.0%	26.3%
RSC ↔ LSC	19.0	14.0	10.5	11.3	44.7%	19.2%
RSC ↔ DCC	15.2	12.7	11.8	10.8	22.5%	15.1%
LSC ↔ DCC	26.4	18.4	17.5	15.5	33.7%	15.8%
Max. Students Transported in 30 Mins						
Between Campuses		Current	Proposed			
Busch	Livi	1102	1700			54.3%
Busch	CAC	1348	1700			26.1%
Busch	C/D	563	947			68.4%
CAC	Livi	1500	1700			13.3%
CAC	C/D	1607	1627			1.2%
Livi	C/D	703	818			16.4%
All Campuses		6823	8492			24.5%

Part 2: Electric Fleet Emission and Financial Analysis

Objective: Transform bus fleet size from ~50 biodiesel New Flyer buses to ~40 electric Proterra buses. This change leads to decreases in greenhouse gas emissions and annual maintenance and fuel costs. The savings over time eventually outmatch initial investment for electric buses.

Greenhouse Gas Emissions

New Flyer Biodiesel Buses

$$\frac{1.723 \text{ kg CO}_2}{1 \text{ mile}} * \frac{38,600 \text{ mi}}{1 \text{ bus/year}} * \frac{1 \text{ mT}}{1000 \text{ kg}} * 85.2\%(\text{B20}) = \frac{56.7 \text{ mT CO}_2}{1 \text{ bus/year}}$$

Proterra Electric Buses

$$\frac{2.15 \text{ kWh}}{1 \text{ mi}} * \frac{38,600 \text{ mi}}{1 \text{ bus/year}} * \frac{573 \text{ lbs CO}_2}{1000 \text{ kWh}} * \frac{1 \text{ mT}}{2204 \text{ lbs}} = \frac{21.6 \text{ mT CO}_2}{1 \text{ bus/year}}$$

Financial Costs

Summary of Costs of Diesel vs. Electric Buses			
Costs	Diesel	Electric	Difference
Annual Fuel (\$)	16,151	10,789	5,362
Annual Maintenance (\$)	22,388	6,562	15,826
Combined Annual Costs (\$)	38,539	17,351	21,188
Vehicle Costs (\$)	621,000	836,000	-215,000

Pay-back Time for Initial Investment with Differing Vehicle Negotiated Prices						
Pay-back time (years)	8	9	10	11	12	13
Savings (\$/year)	-21,188	-21,188	-21,188	-21,188	-21,188	-21,188
Interest Rate	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Vehicle cost difference	\$151,921	\$168,887	\$185,439	\$201,587	\$217,342	\$232,712

CONCLUSION: GO ELECTRIC

Current vs. Proposed Rutgers Bus Fleets			
	Current	Proposed	Difference
Number of Buses	50 Biodiesel	40 Electric	10
CO ₂ Emissions (metric tons/year)	2,833	863	1,970
Annual Fuel Costs (\$/year)	807,550	431,560	375,990
Annual Maintenance Costs (\$/year)	1,119,400	262,480	856,920
Combined Annual Costs (\$/year)	1,926,950	694,040	1,232,910
Individual Vehicle Cost (\$/bus)	621,000	836,000	-215,000
Total 12-Year Emissions (metric tons)	33,996	10,356	23,640
Total 12-Year Costs (\$)	23,123,400	8,328,480	14,794,920
Total Vehicle Costs (\$)	31,050,000	33,440,000	-2,390,000
Total Costs (\$)	54,173,400	41,768,480	12,404,920