G.E. Transportation Project for Pittsadelphia

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Client: General Electric

EDSGN100.014Team 8 - Nainjot Singh, Connor Smith, Matt Wertz,& Matthew Skotnick

Problem Statement

Our objective was to design a cost-effective freight shipping system that will reduce the amount of environmental impact and meets EPA requirements. This system must also improve or maintain its freight capacity into and out of Pittsadelphia. Current Situation, Pittsadelphia: Approx 165,000-tons of freight or minerals (coal, etc) per day travel in or out of the port city of Pittsadelphia via rail. However, the Tier 2 locomotives that are currently being used are approaching age for overhaul. At this point the investments of the Tier 2 will be required to meet EPA requirements of Tier 3 locomotives.

Stakeholders, Customers and Needs

Improving the function and efficiency of our freight shipping system will benefit GE, along with many other groups. Mining companies will be asked to produce more coal because GE will be transporting product at a faster pace. Transportation companies will benefit from the change, as will fossil fuel/natural gas suppliers. Last and most importantly, the general public will be flourished with an improved environment and EPA-met standards. Our needs, as related to accomplishing our goal, are first and foremost to meet our EPA requirements. Also, we need to focus on on-time deliveries of the product, as well as efficient and safe transportation. At the end of the day, we need the operation to be cost-efficient and productive.

Concept Generalization and Calculations

After conducting research, our group decided that Pittsadelphia was, logistically speaking, the best choice of city for our project. After weighing a variety of factors and criteria, such as emissions, fuel efficiency, capital cost, longevity of the solution, delivery speed, and return on investment, our research brought us to three potential design solutions:

The first option is to sell all 50 of our Tier II locomotives and use the money to buy 25 new Tier III locomotives and then buy another 25 Tier III locomotives. This will cost $75M. With the Tier III's being 1.25 times more fuel efficient than the Tier II's, we will save money with each new locomotive and it will take roughly 3.5 years before we will make back the $75M. This is our longer term solution. This gives us brand new locomotives which will last us a long time and depending on maintenance and things of that nature, we will get our money back in reasonable amount of time.

The second option is to convert all of the Tier II locomotives from regular diesel fuel to biodiesel. This will take an investment of roughly $50M. Because biodiesel is basically the same as diesel we won't have to make any changes to the fuel stations saving us the $1B cost.

This will reduce the particulate matter emissions of the locomotives to the required levels, however, it will not keep us below the required range of the NOx emissions. This solution does reduce the majority of pollutants without sacrificing too much power and will also move us to a more renewable fuel source in case of a rise in petroleum prices. This is a mid-term solution. There is no guarantee that they locomotives will last a long time and there is no return on our investment, but it does set us up to not be very dependent on regular diesel.

The third option is to upgrade the current locomotives from Tier II to Tier III. This will cost us $37.5M. This is the cheapest option, however, it is an extremely short term solution. There is no guarantee that these will last a long time, but it will get the job done for right now. There is also no return on the investment that we would have to put in.

Concept Selection

To decide which of our design options we wanted to select we used an Analytic Hierarchy Process matrix, or AHP matrix. With this we gave number values to which design criteria we thought were the most important compared to the others.

AHP		Emission	Fuel Eff.	Capital cost	Longevity	Delivery speed	ROI	SUM	weights
	Emissions	1.000	3.000	2.000	3.000	4.000	2.000	15.000	0.294
	Fuel Eff.	0.500	1.000	1.500	3.000	4.000	1.500	11.500	0.225
	Capital cost	0.500	0.667	1.000	3.000	3.000	1.000	9.167	0.180
	Longevity	0.333	0.333	0.333	1.000	2.000	0.500	4.500	0.088
	Delivery speed	0.250	0.250	0.333	0.500	1.000	0.333	2.667	0.052
	Return on invest	0.500	0.667	1.000	2.000	3.000	1.000	8.167	0.160
							Total	51.000	1.000

Table 1 AHP matrix. Used to calculate weights of the design criteria. Fuel Eff. is fuel efficiency and ROI and return on invest are return on investment

Design Selection Matrix		Weights	D1	Weighted	D2	Weighted	D3	Weighted
	Emissions	0.294	5	1.471	3	0.882	4	1.176
	Fuel Eff.	0.225	4	0.902	2	0.451	3	0.676
	Capital cost	0.180	2	0.359	4	0.719	3	0.539
	Longevity	0.088	4	0.353	2	0.176	3	0.265
	Delivery speed	0.052	3	0.157	3	0.157	3	0.157
	Return on invest	0.160	3	0.480	1	0.160	2	0.320
			SUM->	3.722	SUM->	2.546	SUM->	3.134

Table 2 Design Selection matrix. D1, D2, and D3 are Design 1, Design 2, and Design 3 respectively.

With the weights from the AHP matrix, we then discussed how well each design criterion is fulfilled within each solution. We then applied our calculated weights to each design solution

and compared the solutions' results. As you can see in Table 2, our first solution had the highest score of 3.722, option 3 had the next highest score with 3.134, and design option 2 had the lowest score of 2.546. Seeing the results, it was clear that option 1 was the best solution to the proposed problem.

Backup Concept

Knowing that all plans have the potential to fail, our specialized team of researchers decided to create a backup concept in case our initial plan falls through. Our backup plan was to create a better engine to use in our current tier 2 locomotives. This engine is developed to efficiently use the fuel it consumes, giving us more mile per gallon and longer distance traveled. Or the engine could be relatively similar to a current diesel engine but use a different more affordable fuel.

According to research being done on current diesel engines **Argonne National Laboratory**, they are discovering new ways to process gasoline through a standard diesel engine. Although quite odd and unconventional, the results they have found so far are quite remarkable. Through countless tweaks and the addition of a new engine controller, the team created a diesel engine that runs purely on gasoline. Using this method will create cleaner emissions and achieve better efficiency overall. However, the engine will have to sacrifice about 25% of its power density with the use of gasoline. In the future, we might see more of these engines used for diesel engined cars, but it's a little unlikely to see them in locomotives that transport tons a freight a day. With more research I can see this one day working, but for our case, it would consume vast amounts of our time and money. Considering this was not a full proof, set in stone idea like our primary idea, we decided it would be less risky to to purchase more higher tier locomotives. However, in the future both plans may coincide. When we eventually upgrade to the top tier locomotives, the research for such gasoline/ alternative fuel powered engines may have come to completion. We can then swap out our original engines for more efficient, cleaner, cheaper ones.

Final Description

We chose Solution 1 for various reasons other than just reducing emissions. Due to the effects of inflation in the future, it is actually more profitable to buy now rather than buy later. At first we will be in debt to the lender for some time however, with changing to Tier 3, we save massive amounts of money due to the decrease consumption of fuel and the added amount of miles we can travel with the fuel. This leaves us completing our supply of locomotives by 2019; less than 4 years after selling our tier 2 locomotives. We have also considered the fact that we are going to have brand new locomotives opposed to the old and worn tier 2 locomotives. Eventually, everything has to get upgraded because no locomotive can perform at full capacity forever.

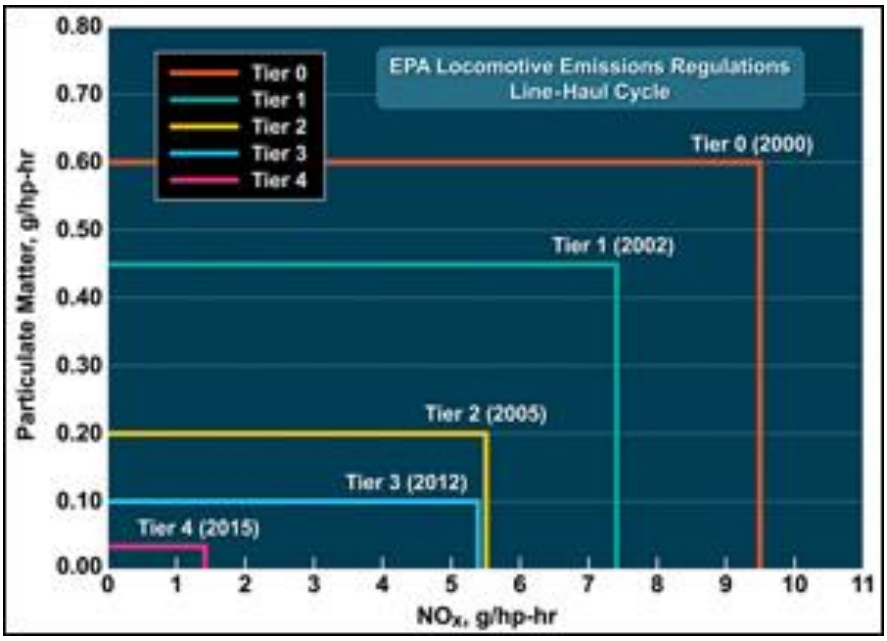

Figure 1: Graph of the different EPA tiers for locomotives

The environmental impact is drastically reduced due to the design of the tier 3 locomotive. It will produce less of the particulate matter that has a negative impact on the environment.

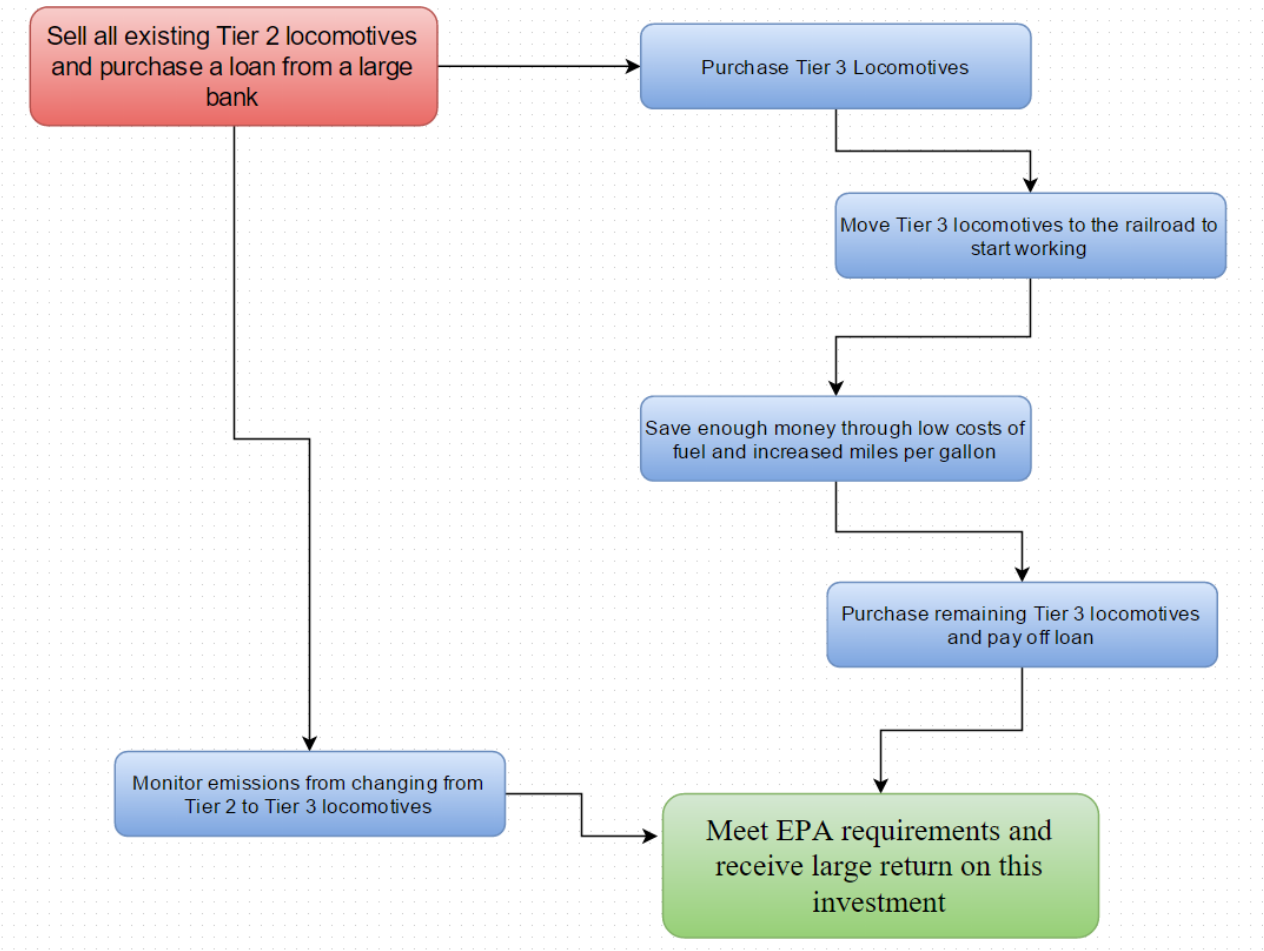

Figure 2. Systems diagram of our solution.

We not going to stop there because EPA requirements will continue to get stricter (based off of previous requirements) and we need a plan for the future. So, we plan, after we have purchased all of our tier 3 locomotives, we will start saving towards tier 4 locomotives. This way we continue to consistently improve our locomotives and our company and companies that we ship for.

Despite having a high capital cost, will be the most sound economically in the long run. The savings from the more fuel efficient locomotives will pay for the investment that needs to be made in order to buy the second half of the new fleet of locomotives. After 3.5 years, the investment will be made back through fuel savings, which is a very reasonable length of time to get the return on the investment. Also, this solution will immediately gain support from the public because the instant reduction in the emissions given off from the locomotives.

In our opinion, this option is feasible. The only potentially big problem could be getting a loan or finding the money for the high capital cost. A small railway company may not be able to pay for the locomotives out of pocket or get a bank to loan them the money. However, if the

company can get the money, the only other issue would be training the employees on how to run the locomotives, which isn't really a problem. So, the feasibility of this solution is very good. The stakeholders don't have much to lose with this solution either. The city and the people will have the emissions reduced, the railway companies will be up to date on the EPA regulations, and will also have a good chance to get a quick return on their investment.

According to an article published by the NY times, the public opinion on smog are very negative. Most people living in big cities where smog is very prominent hate the fact that smog is everywhere. Almost half of people in Beijing prefer to wear a mask when traveling outside. Researchers have conducted various tests on the effects of smog and the air we breathe. It turns out that breathing in the smog leaves a residue that can be very detrimental to one's health and cost thousands in medical bills. Therefore, we believe that public opinion will be on our side because we are reducing the amount of smog being produced.

Conclusion

After completing this project, we learned how to solve a large scale problem with a realistic and feasible solution. This project could be expanded on in the fashion that we described earlier in the report. A company can start to switch over to Tier IV's from Tier III's and continue to improve their emission rates.

References

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