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Freight, Fuel, & Emissions

GE Transportation

EDSGN 100

Section 002

Design Team 1
The *Bleeding* Frogs
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Section 1 Executive Summary

The following report is a formal suggestion to General Electric regarding the issue of freight transportation in Pittsburgh. With the new tier 4 EPA regulations, locomotive companies are forced to meet very low emission rates. The statement of work addresses the benefits of upgrading to newer tier 4 locomotives. We found that the health benefits and fuel efficiency from upgrading will make up for the roughly MILLIONS ESTIMATE in the long run. This freight solution also uses 2 barges to assist in large volumes of freight that aren't time sensitive. This solution of both barges as well as tier 4 locomotives allows for relatively fast and reliable transport while considering future EPA regulations. With newer tier 4 locomotives, these trains will be able to function for a longer period of time with the option of after treatment in the future. The resolving statement should address the concerns of the community, the emissions, the EPA standards, and the economic benefit and cost predictions.

Section 2 INTRODUCTION

2.1 Project Objectives.

Pittsburgh is looking for a solution to the age old problem of pollution and environmental control. The objective is to design a cost-effective solution that reduces the smog of Pittsburgh's freight fleet and also meets the requirements designated by the EPA. With consideration to this important port city, the solution must maintain or increase the freight capacity into and out of the city.

2.2 Project Background.

An astounding 165,000 tons of freight and mineral cargo travel in and out of Pittsburgh by rail each day. One of the biggest problems associated with such a high rate of travel via trains is the locomotive emissions that results in smog throughout the city. Smog is a fog or haze that is combined with smoke and other particulate matter that are emitted by engines. The residents share the distasteful look of smog on their city as well as related health problems. First, the solution must tackle the problem of smog. At this point, Tier 2 locomotives are approaching overhaul and will be required to meet the tier 3 requirement. There have been suggestions made to address these emissions. The first is to upgrade the fleet to meet the recent emission guidelines set by the EPA and the second option is to alternate the shipping methods. In order to upgrade the fleet, it is possible to sell the existing fleet and buy all new locomotives, upgrade the fleet with exhaust after-treatment hardware, or utilize the alternate fuels which produce less NOx, like Biodiesel, CNG, LNG, and more. Alternate shipping methods via sea, air, or ground could also be used because of Pittsburgh's infrastructure.

2.3 Project Sponsor Background.

GE Transportation is a unit of NYSE: GE that words to solve transportation challenges nationwide. GE Transportation provides efficient modes of transportation for the most commonly used means of transportation in the United States. It builds fuel-efficient and lower-emissions freight and passenger locomotives; high-efficiency diesel engines that are up to EPA codes for railways; marine and stationary power applications associated with barge travel; and systems mining trucks. In addition, GE Transportation produces signaling and software solutions that service customers and help with company growth. GE

Transportation's headquarters is located in Chicago, IL, and employs nearly 13,000 employees across the world. It was established over 100 years ago and has over 65 sites worldwide. Being one of the leading transportation companies in the world, GE Transportation yielded 5.72 Billion US dollars in 2014.

2.4 Project Description. Each design team will research and evaluate the suggestions made for the fleet upgrade or alternate shipping methods. It should be taken into consideration that there are physical restraints of new hardware as well as storage requirements. A recommendation will clearly be stated and comments regarding emissions requirements, costs, freight capacity, public opinion, and on time delivery. A concise description of the solution will be provided.

2.5 Project Freight Requirements. With a transportation requirement of minerals and commodities alike, it is important to consider both in the requirements. The majority of the freight trains transport commodities. This is essential because the transport distance is 1,000 miles round-trip. With a decrease in need for mineral transport and a shorter transport distance of 500 miles round-trip, less freight trains are needed for mineral transport. As a result, the solution must take into consideration the 165,000 tons of either mineral or commodities going in and out of Pittsburgh on any given day. There must be adequate storage for both minerals and commodities and they must be kept separate due to different needs and transportation destinations. If an alternate solution is used, it must be noted of the differences in transportation types and distances.

2.6 Transportation Mode Comparisons.

a. Trucks. A truck runs on diesel fuel that is designed to transport cargo. They vary in size, power, and configuration. Large semi-trucks are able to hold up to 26 tons. Compared to the other modes of transportation, trucks have low capacity. To compensate for this, hundreds of trucks are needed to transport the project objective. One barge is equal to 58 large semi-trucks and capable of collectively holding 1,500 Tons. Trucks are lowest in cost per truck and are also faster than trains and barges, making it a viable alternative. However, the low capacity of the trucks and need for a large number of them gives them a disadvantage against trains and barges. see figure 2

b. Barges. Barges are large boats that are used to transport cargo overseas and through the waterways of the United States. Barges are cost efficient, however the time needed to transport cargo is extensive and the lack of transportation changes classify it as an American pastime. Transportation routes are essentially fixed because we cannot realistically add waterways. Travel across the sea is time consuming and dispersal through a land body is tedious and often loads cannot be delivered to all destinations by boat. In the United States, the Inland Waterway System carries cargo to many places, but does not permit travel outside of the central United State making it inefficient. The ASCE ranked the Inland Waterways as a D+ which also is a disadvantage because they need to be improved if barges were to be the best alternative option. The barges are advantageous in capacity and environmental factors. One barge can carry as many tons as 58 large semi-trucks which makes transportation efficient in terms of capacity. With few environmental drawbacks because of low emissions and the vast sea and waterways as its dwelling. see figure 3

c. Railroad. Trains are a form of rail transport that usually include multiple cars with the objective of moving cargo from one place to another. Early trains used to be powered from a separate locomotive car that consists of a coal engine. With the transition into the late 20th century, power sources began to move towards a cleaner diesel and electric

engines. Train tracks have variations including electric conducting tracks, which however, are usually used for human transportation. Transporting cargo through train is advantageous is economically efficient as well as more efficient than transporting cargo by road. Although both economic and efficient, rail freight is disadvantageous in the sense that it has lost most of its business to road competition due its lack of flexibility. The major public complaint of freight cars are its emissions, which is why upgrading to a more environmentally efficient solution is suggested. Freight cars typical capacity is 100 tons. There are multiple types of freight cars including hoppers, refrigerator cars, box cars, intermodal cars, tank cars, and flat cars. These all have similar objectives of transporting goods and commodities, but different uses such as hard goods or oil. <Describe features, pertinent details, discuss advantages vs. disadvantages, etc., of using freight rail transportation.

See figures T.1, T.2, T.3, T.4, T.5, T.6.

SECTION 3 TRANSPORTATION INFRASTRUCTURE CONDITION AND CAPACITY

3.1 Introduction. Overall, Pennsylvania's infrastructure is one of the worst in the nation. Bridges, inland waterways, and roads are all classified as D grade structures by the ASCE, but freight rails are rated in the B range. The report card shows that Pennsylvania is currently not equipt to deal with any disasters, and the infrastructure must be reconsidered and reconstructed to improve. Having two major cities on each side of the state, Pennsylvania is heavily traversed, but at its current standings, none of the travel means will be able to handle the projected growth of population, leading to catastrophic failure and possible danger to citizens. In order to address this issue, budgetary adjustments have been made but no further actions have occurred.

3.2 Pennsylvania Roads and Bridges. Pennsylvania's roadway system has a total of 41,000 miles of state highways and 79,000 local roads. Of these roads, 44% have been rated fair to poor, and if this trend continues, over half of the roads in Pennsylvania will be rated fair to poor by the end of the year 2015. Overall, the PA roadway system received a D- on the infrastructure report conducted by the American Society of Civil Engineers. These poor ratings are a product of underfunding and insufficient planning or the future, resulting in an inadequate roadway system that cannot support the growing population of Pennsylvania. Pennsylvania has the third highest number bridges in the country and the highest number of structurally deficient bridges, standing at 23% of the almost 23,000 bridges. A new bill was passed in 2013 in order to fund the reconstruction of the out of date bridges and no longer have Pennsylvania have the highest number of obsolete bridges in the nation.

3.3 Pennsylvania Inland Waterways. Due to severe lack of funding and repair, Pennsylvania's dams are in dire need of reconstruction, and received an overall grade of D+ when evaluated by the American Society of Civil Engineers. Only 18% of the bridges in PA received a "satisfactory" rating. The western side of Pennsylvania has approximately 200 miles of waterways and in 2012 Pittsburgh was the busiest ports in the nation. Fixing the

infrastructure of these dams and locks is extremely important for the high-paced import and export business

3.4 Pennsylvania Freight Rail System. Pennsylvania has an extensive railroad system with 5 freight railroads which account for 5127 miles throughout the state. This puts Pennsylvania at the fourth biggest railroad network based on raw milage in the United States. By 2035, it is estimated that over 246 million tons of freight cargo will pass through Pennsylvania's train infrastructure system. Improvements in the rail infrastructure system could see improvements that could cost more than $280 million while state-of-good-repair and bridge spending is estimated to be $560 million. Most railroads in Pennsylvania are privately owned and improvements are usually able to be financed by the owners. Regional and shortline railroads play a supporting role in the overall transportation network in Pennsylvania. Pennsylvania's main routes include some of the highest volume rates in the United States. On the contrary, some of Pennsylvania's roads are in danger of abandonment because of low use. Revenue in these areas is not sufficient enough to maintain and keep railroads up to date and open. Of the 124 lines, 96 of them are agreed upon by the officials to be at severe risk of abandonment. Rail volume and freight are expected to grow annually by 1.2 and 1.5 percent, respectively. An estimated 60% of the shortline and regional railroad infrastructure. including bridges, is in need of rehabilitation. Some notable areas of rehabilitation are the Erie Corridor, I-95 Corridor, Harrisburg-Binghamton Corridor, and the Crescent Corridor. The renovation and improvement of these railroad and bridge locations will have high expenditures from the Pennsylvania government. However, this will create jobs for the construction. .

SECTION 4 STANDARD CAPACITY FOR ALTERNATE TRANSPORTATION MODES

4.1 Cargo Capacity. The typical cargo ship capacity ranges from 1,500 tons for a single barge and 2,250 tons for a 15 barge tow. An average transport truck may hold up to 26 tons, and the capacity of trains ranges from 100 tons for a single car to 10,500 tons for a 100 car unit. Overall, the train system has the greatest capacity when considering all factors.

See figure 4.1

4.2 Equivalent Units. A single, small barge is equivalent to 15 railroad cars, and 58 large semi trucks. A 15 barge tow, however, is equivalent to 2.25 100 car trains and 870 large semi trucks. Because trains have a set path that they must follow, they will have no delays in transportation and save money and time. Barges must use waterways for transportation, which can very efficient considering there are waterways all across the world, but may encounter waterway traffic and issues with weather. Semi trucks can encounter traffic and issues with transportation, making it a non-ideal option.

4.3 Equivalent Lengths. A single 15 barge tow is ¼ or a mile long, 2.225 100 car trains is 2.75 miles long, and 870 semi trucks is equivalent to 11.5 miles in length. It must be considered that a single 15 barge tow is the largest of the three which may cause transportation issues, depending on the size of waterways. Trains can be split into separate cars and therefore take up less space and can carry different amounts of cargo, while a

single truck can only carry a limited amount of cargo and more trucks are needed to carry the same amount as the other transportation methods.

See Figure 4.1

SECTION 5 TRANSPORTATION COSTS AND CONCEPT OF OPERATIONS (ConOps)

5.1 Trucks. Given that trucking is an extremely competitive industry and has potential to be extremely lucrative, the cost to run the average semi truck varies in order to keep up with the changing market. The average semi truck is run anywhere between 30,000 to 120,000 miles a year. The cost for diesel fuel for these trucks was most expensive in 2008 at nearly $5 a gallon, while it currently stands at a little above $3. Each average semi truck has a lifespan of around 10 years. There are a total of 35,000 trucks, 80,000 trailers, and over 3.5 billion miles traveled a year. Costs and negative effects of emissions are vastly increasing. In 2013, it cost about 1.68 cents per mile to run these trucks, while the average truck driver earned about 44 cents per mile.

5.2 Barges. While carrying 1 ton of cargo, a barge can travel 514 mpg and costs $2,700 a day. The fuel cost is 0.97 cents per ton mile, which is the least cost in comparison to the other transportation systems. Barges, however, are at risk for sinking and causing major environmental issues that can greatly increases the overall cost of barges because of cleanup costs.

5.3 Railroad. Typical transportation costs of rail freight were about 4.0 cents measured by revenue ton per mile. This rate fell 43 percent from 1981 where it was 7.0 cents a revenue ton per mile. This means that today's goods could ship twice the amount of what could be shipped in 1981 at half the price. Cost efficiency has improved significantly. Railroads are also very efficient

https://www.aar.org/BackgroundPapers/Cost%20Effectiveness%20of%20Freight%20Railroads.pdf

5.4 Most Economical Transportation Solution. The solution that seems to be the most economically efficient is the purchase of all new Tier IV trains as well as two barges that will slightly increase the cargo capacity of Pittsburgh's ports. It was determined that the trains emit a high level of emissions that contribute to the continuing growth of smog in Pittsburgh. In order to satisfy that community complaint, we found it in the best interest of everyone to replace the trains with Tier IV locomotives, which drastically decreases the emissions in the city. As well as decreasing the emissions, the replacing the trains ensures that the trains will meet standards for a longer time.

Although more expensive, our team had strong rationale as to why the trains should be upgraded to Tier IV locomotives. It costs just under one million dollars to upgrade a Tier II train to Tier III. While this eliminates some emissions and allows the trains to meet

standards, it does not quite do enough. If we are going to put money into upgrading our railroad system now, we should make sure that the solution will last a long time. Within the next couple of years, it's possible that these tier II trains could no longer be capable of running at its normal rate and will need replaced. At this point, the money put into after treatment would have gone to waste. This leaves two possible solutions, replace the trains to Tier III locomotives (which meets the current standards for three million dollars) or replace the trains to Tier IV locomotives for four million dollars. It was reasoned that the trains should be replaced to Tier IV locomotives. Why settle for here and now when we could take care of the future as well. By replacing the trains, and getting all new Tier IV trains, the trains will be in good condition to run well for many years to come and will meet the standards in the future with aftertreatment. For just an additional one million dollars, it is worth it to know that the money put into the train system will last for years to come. In this way, it can be sure that the railroad system will be in good condition for the future and that is vital. In addition to cost, the added decrease in emissions that creates smog is a major reason for choosing Tier IV. With the number one priority being the environmental effects of the emissions that is such a large concern for the community, choosing a train that releases such a low level of emissions, although costly, will immediately start reducing the smog and making Pittsburgh a cleaner and safer place to be. Figure 5 shows an emissions chart that shows how environmentally friendly the Tier IV trains are.. In addition to trains, we decided that the addition of two barges to the cargo fleet could be revolutionary in cargo transportation. The rivers surrounding Pittsburgh provide an opportunity to be taken advantage of. With a capacity of about 1,500 tons, barges are good for replacing large and less time sensitive cargo. Examples of this could be coal or commodities. The combination of locomotive and barge transportation would satisfy both cargo capacity as well as time efficiency.

5.5 Concept of Operations (ConOps).

a. General Description. The proposed transportation system is a replacement of all current locomotives with Tier IV locomotives which meet EPA requirements and promote cleaner air, as well as two barges that serve as an alternative method that utilizes Pittsburgh's waterways. This requires an entirely new locomotive fleet. however the old fleet can be sold for parts. The barges will cover a lot of nearby ports that are along the prominent waterways. The system will operate mostly by day because it can travel more quickly and deliver goods within the work day. The barges will travel by night and be ready for delivery at the beginning of the work day. This will give both operations a break and relieve some of the pressure of excess transportation. The cargo delivery is such an important industry in Pittsburgh that the more transportation methods that there are to utilize and the usage of multiple means will provide Pittsburgh with an advantage in this vital industry.

b. Operational Policies and Constraints. The hours of operations for the locomotives will run 24 hours a day until all deliveries are made. There will be multiple staff crews in order to attain this. The hours of operations of the barges will also run through the night and day in order to make all deliveries on time. The trains and barges will have staff that are qualified to work on these modes of transportation. With the additional transportation space will allow for more cargo and equipment space. The staff will be limited, but enough to meet requirements in order to save money.

c. Performance characteristics. The speed of the locomotives will be the speed that matches the security regulations for the Pittsburgh area. The capacity for each train and barge will be filled to 100 tons less than the full capacity. This ensures adequate room for all the cargo as well as necessary equipment. The new trains will be more reliable and safe because they are updated and brand new. The brand new Tier IV locomotive will provide all the necessary updates in safety and will also be eliminating much of the emissions. The performance will be drastically increased in these new models.

d. Operational Impacts In general, Pittsburgh is experiencing a massive amount of emissions that will damage the environment and ecosystem for years to come. Pittsburgh is a major hub for barges because of two main rivers running through it, the Allegheny and the Monongahela rivers. This puts the rivers at risk for pollutants originating from the barge Because of Pittsburgh's' former reputation of being "Steel City," there are many railroad yards that often are uncared for and littered with trash. With the combination of barges and trains, emissions should be relatively low when compared to trucking. The public would be breathing less diesel pollutants.

e. Continuity of Operations. During extreme weather the locomotives will be stopped, however the barges will be able to travel in most conditions. Barges can travel with minimal issues and will not have to be caught in traffic. This way, some transportation of cargo can still take place. In cases of drought, barges may not be able to travel because of low water levels..In the case of an emergency, both transportation methods can be evacuated if necessary.

SECTION 6 EPA DIESEL EMISSION STANDARDS

6.1 Background. Since the establishment of the EPA in 1970, the US government has influenced emissions between both the commercial and private sectors. By regulating emissions, the EPA is able to lower emissions of the NOx and other diesel byproducts. Regulation of the Locomotive industry was first proposed in 1998, standardizing emissions. The EPA established standards of different tiers of emission that a locomotive could be placed in based on the year of manufacturing.. For example, a tier 0 locomotive could be manufactured no later than 1992.

6.2 Tier 0-2 Standards. This level of emission standards were the beginning of locomotive regulation. In these tiers, locomotives manufactured 1973-2011 are restricted to certain amounts of emissions based on NOx, Particulate Matter, Carbon Dioxide and Hydrocarbons. For specific values, see Figure 4.

6.3 Tier 3-4 Standards. This level of emission standards are the toughest for manufacturers to meet. In this tier, locomotives manufactured between 2012-2015 are restricted to very low levels of emissions. Compared to Tier 2 locomotives, Tier 4 standards would reduce NOx emissions by nearly 76%. This is a huge overhaul which causes rail owners to upgrade their locomotives. See Figure 5.

SECTION 7 DIESEL ENGINE EXHAUST EMISSIONS (DEEE)

7.1 Diesel Emission Chemistry.

a. NOx. NOx is a byproduct of a diesel engine found in locomotives. NOx is formed when oxygen from the air is combined with nitrogen with the help of intense heat. With more heat the the engine creates, the greater amount of NOx is produced. As a result, tier 4 locomotives are designed to be cooled efficiently, resulting in the heat to be minimized.

b. Particulate Matter (PM). Particulate Matter refers to any substance that is tested on a filter. Examples of PM are soot, dust, smoke, and fumes. Particulates originate from the mechanical motions of burning diesel fuel as well as the results of the chemical reaction. An example of this is soot from the combustion explosions within the engine. Particulate Matter is also caused by organics such as fuel and lube. This PM comes from running the engine, causing wear. To reach minimum amounts of PM from fuel and lube, an engine must maintain an optimal ratio of oil and compression.

c. CO_2. Carbon Dioxide is formed when fuel is ignited with oxygen. The byproducts of this reaction is Carbon Dioxide as well as water. Because Carbon dioxide is directly proportional to the amount of fuel used in powering an engine, modern rails must be fuel efficient.

d. Hydrocarbons (HC). Another byproduct of combustion are Hydrocarbons. HC's are made completely out of hydrogen and carbon atoms. Despite their relatively simple makeup, HC's are a big contributor to smog in cities. Smog is viewed negatively by the public and is harmful for human health. Fuel efficient engines are used to minimize HC's.

7.2 Diesel Emission Reduction Strategies. One of the big emission reduction strategies is to upgrade from tier 2 locomotives to tier 4. By doing this, we are able to cut down on emissions of NOx by nearly 75%. This is the most dramatic improvement because newer tier 4 locomotives are so efficient when compared to older tiers. In dealing with the PM, we have decided to continue using PM filters. By keeping with current filters and hopefully upgrading whenever better technology available, we are able to meet tier 4 EPA standards.

7.3 Alternate Fuels. Alternative fuels have always been considered with the growing concerns of pollution. Fuels that are commonly used in engines are diesel, biodiesel, compressed natural gas, and liquefied natural gas. Diesel is currently the main source of fuel that powers modern locomotives. Biodiesel, or commonly referred to as B100, is a biodegradable fuel that originates from organics such as vegetable oils. B100 reduces carbon dioxide emissions by more than 75% when compared to diesel. Natural gas is predominantly made of methane. Natural gas has benefits of being low priced and commercially available. Both Compressed and liquefied natural gas require certain conditions in order to function correctly. Compressed natural gas must be stored at incredibly high PSI. Liquefied natural gas needs to be cooled and maintained at very low temperatures. Because of this, LNG is quite expensive because of the need to constantly keep the fuel cold. Natural gas vehicles deliver less power and acceleration compared to their diesel counterparts. But, Natural gas is fuel efficient as well as having low emission levels.

7.4 Human Health Issues. Diesel, the main source of fuel for locomotives, has been researched to have negative impacts on human health. When diesel is burned in large amounts, pollutants such as NOx and PM can enter the atmosphere. In a study by the EPA, diesel was shown to have both short term and long term side effects. In short amounts of exposure, diesel was seen to irritate respiratory airways. Unfortunately, long term exposure has more severe side effects ranging from inflammation to predisposed lung

cancer. The study also stated that newer diesel engines may help produce less pollutants. This chance of having healthier air helps rationalize the cost of acquiring tier 4 locomotives.

SECTION 8 LOCOMOTIVE FLEET UPGRADE

8.1 Alternatives.

After treatment is a physical addition to the locomotive that allows tier 2 locomotives to reach tier 3 EPA emission standards. Because this upgrade is physical, there are some concerns that adding an after treatment would cause the profile of the locomotive to be too large. To avoid this we chose to sell our existing fleet of tier 2 locomotives and buy tier 4 models. We feel that the after treatment is simply delaying the inevitable move towards tier 4 emission standards. By avoiding the after treatment, we are dodging the 100 thousand cost and preparing our fleet for the future.

Between Diesel, biodiesel, Compressed natural gas, and liquefied natural gas, we believed that Diesel is the most efficient cost to benefit fuel. This is because with the new tier 4 locomotives, which are the most fuel efficient, emissions of Carbon dioxide and hydrocarbons would be relatively low. Diesel also has a relatively low cost when compared to other fuels while still maintaining the existing diesel infrastructure. Other types of fuel simply do not offer enough benefits in cost or emissions to justify a 1 Billion infrastructure overhaul. As a result, electric- diesel engines will continue to be used until more affordable and available energy source comes along.(Figure 5.)

8.2 Existing Fleet Make-Up.

No. of Existing Locomotives	Locomotive Group Designation	Assumed Existing Locomotive Mileage Range	Assumed Existing Diesel Type
10	A	<150,000	Tier 2
10	B	>150,000 and <300,000	Tier 2
10	C	>300,000 and <450,000	Tier 2
10	D	>450,000 and < 600,000	Tier 2
10	E	>600,000 and <750,000	Tier 2

8.3 Investment Data. In order to upgrade a diesel locomotive from tier 2 to tier 3, the cost would be upwards of $750k, plus an additional $100k in after-treatment. An entirely new locomotive would cost $3 million for a tier 3 and $4 million for tier 4. We could go in an entirely different direction instead and change the fuel option to alternative fuels. An entirely new fueling station would cost somewhere around $1 billion.

8.4 Upgrade Strategy. We will be purchasing a new Tier 4 locomotive fleet. While the locomotives are being built, the old fleet will remain running until it is ready to be retired and allow the new Tier 4 locomotive to take over. We chose this option because we believe

the Tier 4 will meet the required standards for locomotives for a longer time, and in the long run will save money. When the new locomotives are complete, we will then sell the old tier 2 fleet to put money towards the new ones. Locomotive fleets groups A-D will be sold to foreign countries whose emission standards are lower. Group E could either be sold as scrap metal or rebuilt and sent off to a foreign country as well. This transition from tier 2 to tier 4 will subsidize the cost of buying a whole new fleet of locomotives.

8.5 Upgrade Schedule and Costs. Upgrading the locomotive to tier 4 will cost about $4 million dollars and will be completed in about a month. Because we have yet to sell the old train, we are unsure of how much money we will receive for it, but the price will likely be within the $1 million dollar range because the new owner will have to pay the cost in order to upgrade the fleet to meet standards. The transition from tier 2 to tier 4 locomotives will likely take 2 years. This is because of manufacturing time as well as accounting for the selling of the tier 2 fleet .During this time, both tier 2 and tier 4 locomotives will be working together in order to maximize the amount of time each locomotive is on the tracks. With each new tier 4 that comes off the assembly line, a tier 2 will be decommissioned and sold.

SECTION 9 SUMMARY

This report discusses transportation logistics and the possible options regarding freight, fuel, and emissions in Pittsburgh. Several logistic options are presented including rail, truck, and barge all of which would be viable solutions. Project objectives consists of both a cost effective solution which meets EPA requirements. The solution must maintain or increase the city's freight capacity. Over 165,000 tons of freight move in and out of Pittsburgh each day. It is critical that this amount remains at a sustainable level. GE Corporation is the project sponsor. GE transportation is known for being highly reputable in efficiency among the most common types of travel. The project objective is to research and evaluate fleet shipping upgrades for the Pittsburgh freight initiative. Freight requirements are to take into 165,000 tons of commodities passing through the city each day. Three transportation modes are to be taken into consideration which are trucks, barges, and railroad. The solution that deemed to be most economical was the purchase of all new Tier IV trains and additionally two barges that will help to increase commerce in Pittsburgh's ports. Tier IV trains will drastically reduce the emissions produced and assuring that these trains will be meet EPA requirements for a significant time. This solution makes the most sense long term for the city of Pittsburgh in terms of emissions and economics.

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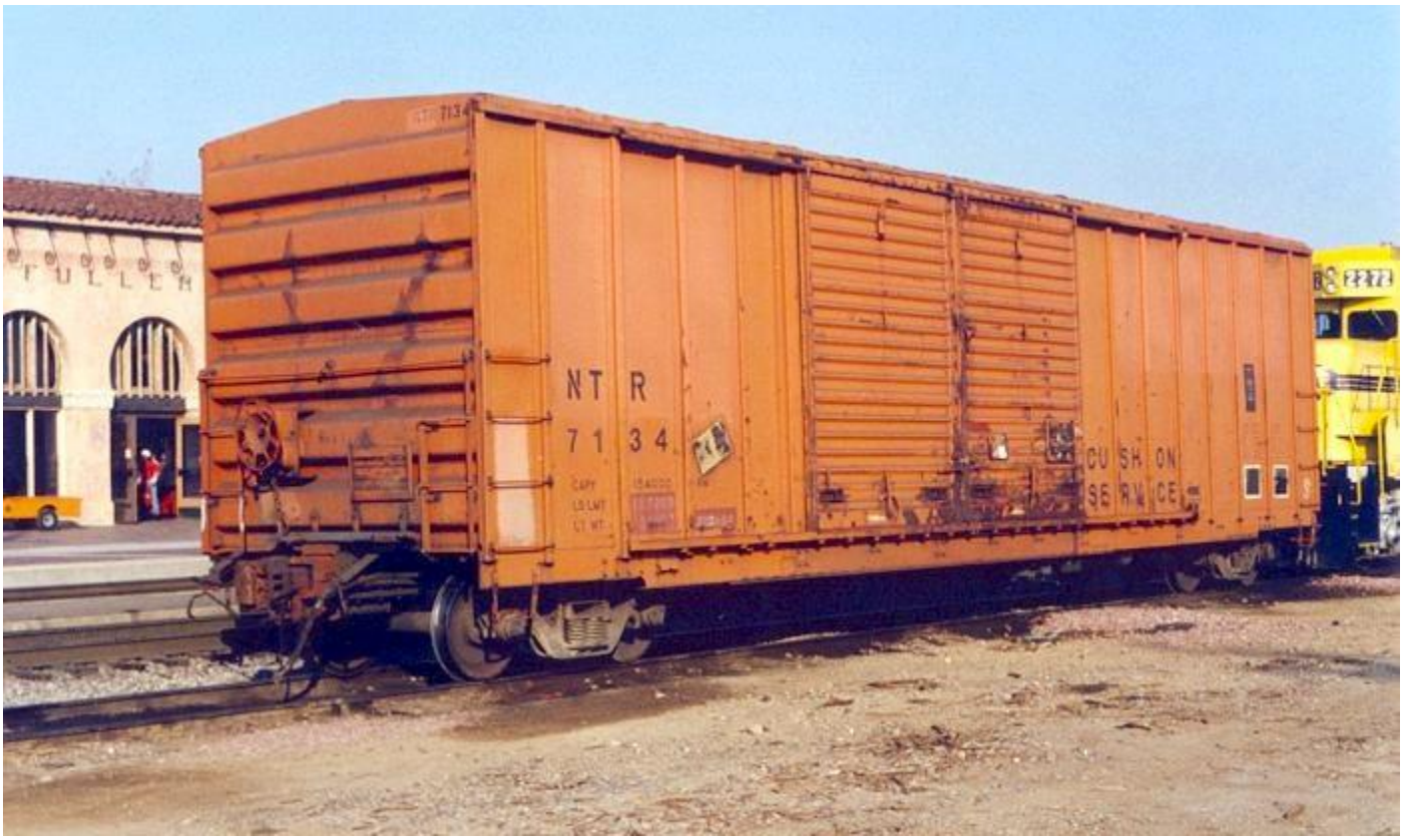
Figure 1. Typical Diesel Truck and Trailer.

Hopper-Figure T.1

Refrigerator Car-Figure T.2



Box Car-Figure T.3

Intermodal Car-Figure T.4

Tank Car-Figure T.5

Flat Car-Figure T.6

Figure 4.1

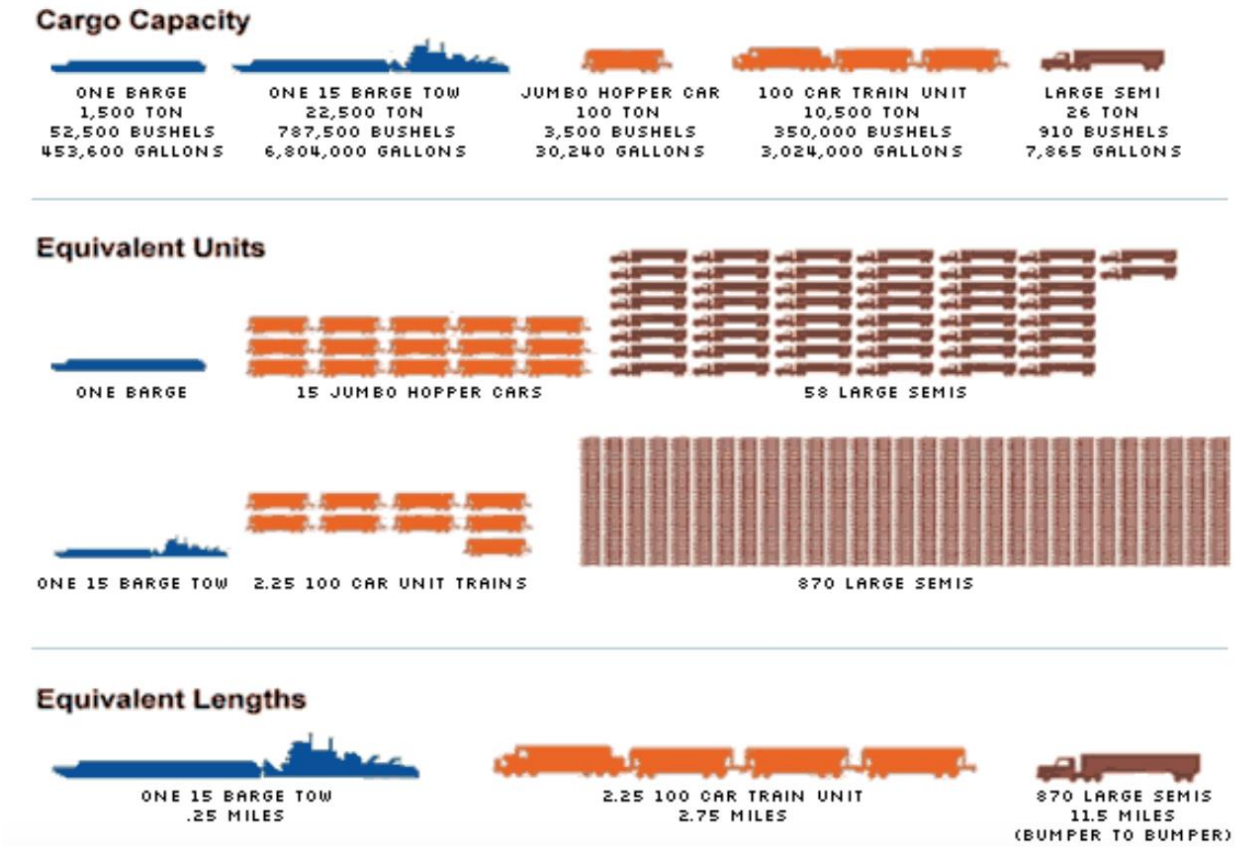

Cargo Capacity
ONE BARGE
1,500 TON
52,500 BUSHELS
453,600 GALLONS
ONE 15 BARGE TOW
22,500 TON
787,500 BUSHELS
6,804,000 GALLONS
JUMBO HOPPER CAR
100 TON
3,500 BUSHELS
30,240 GALLONS
100 CAR TRAIN UNIT
10,500 TON
350,000 BUSHELS
3,024,000 GALLONS
LARGE SEMI
26 TON
910 BUSHELS
7,865 GALLONS
Equivalent Units
ONE BARGE
15 JUMBO HOPPER CARS
58 LARGE SEMIS
ONE 15 BARGE TOW
2.25 100 CAR UNIT TRAINS
870 LARGE SEMIS
Equivalent Lengths
ONE 15 BARGE TOW
.25 MILES
2.25 100 CAR TRAIN UNIT
2.75 MILES
870 LARGE SEMIS
11.5 MILES
(BUMPER TO BUMPER)

Figure 2. Typical Diesel-Electric locomotive.

Figure 3. Typical Inland Water Ways Barge and Tug.

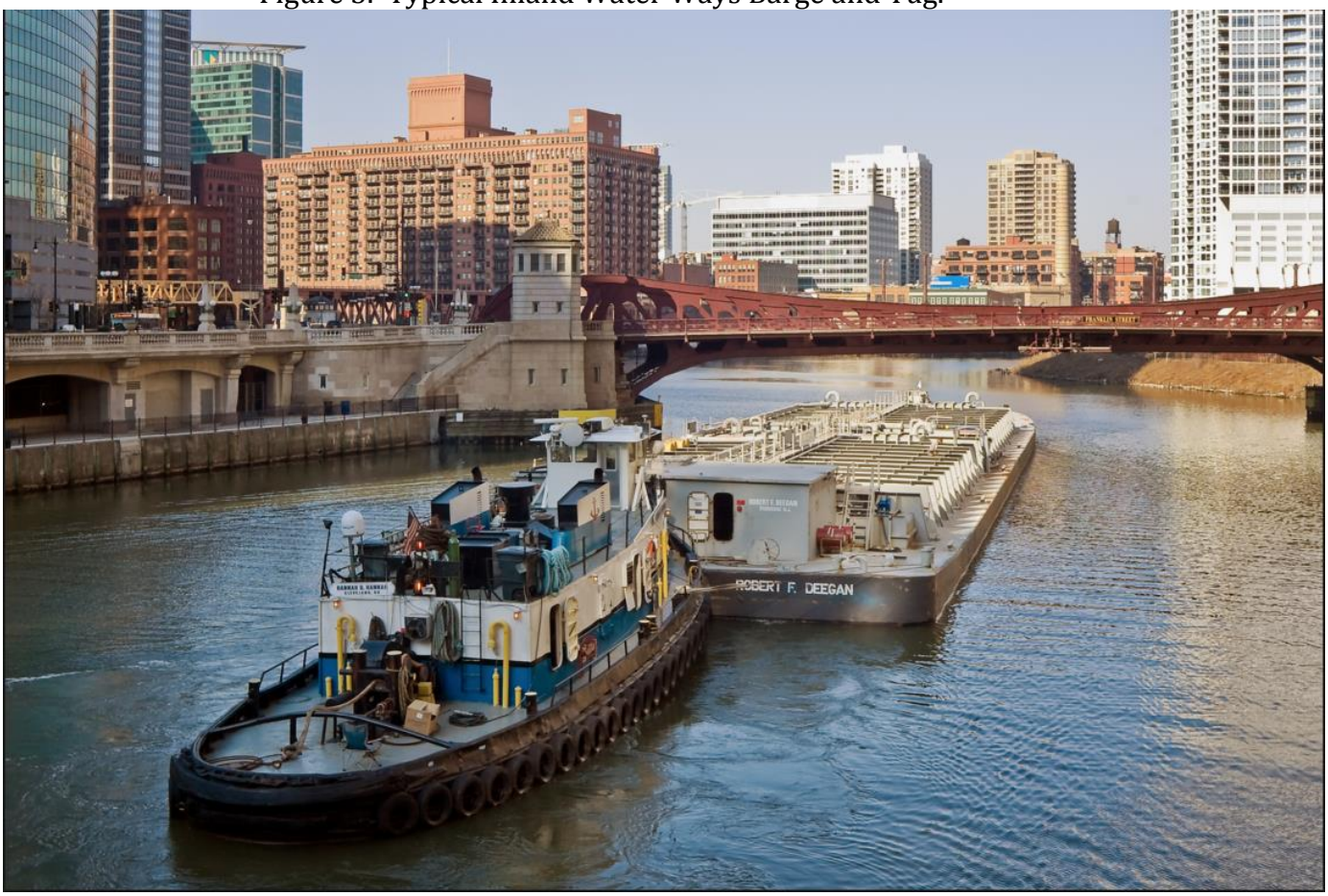


Figure 4. EPA standards of Locomotive Emissions

Year of original manufacture	Tier of standards	Standards (g/bhp-hr)			
		NO_X	PM	HC	CO
1973-1992[a]	Tier 0[b]	8.0	0.22	1.00	5.0
1993[a]-2004	Tier 1[b]	7.4	0.22	0.55	2.2
2005-2011	Tier 2[b]	5.5	[e]0.10	0.30	1.5
2012-2014	Tier 3[c]	5.5	0.10	0.30	1.5
2015 or later	Tier 4[d]	1.3	0.03	0.14	1.5

Figure 5. EPA emissions from GE

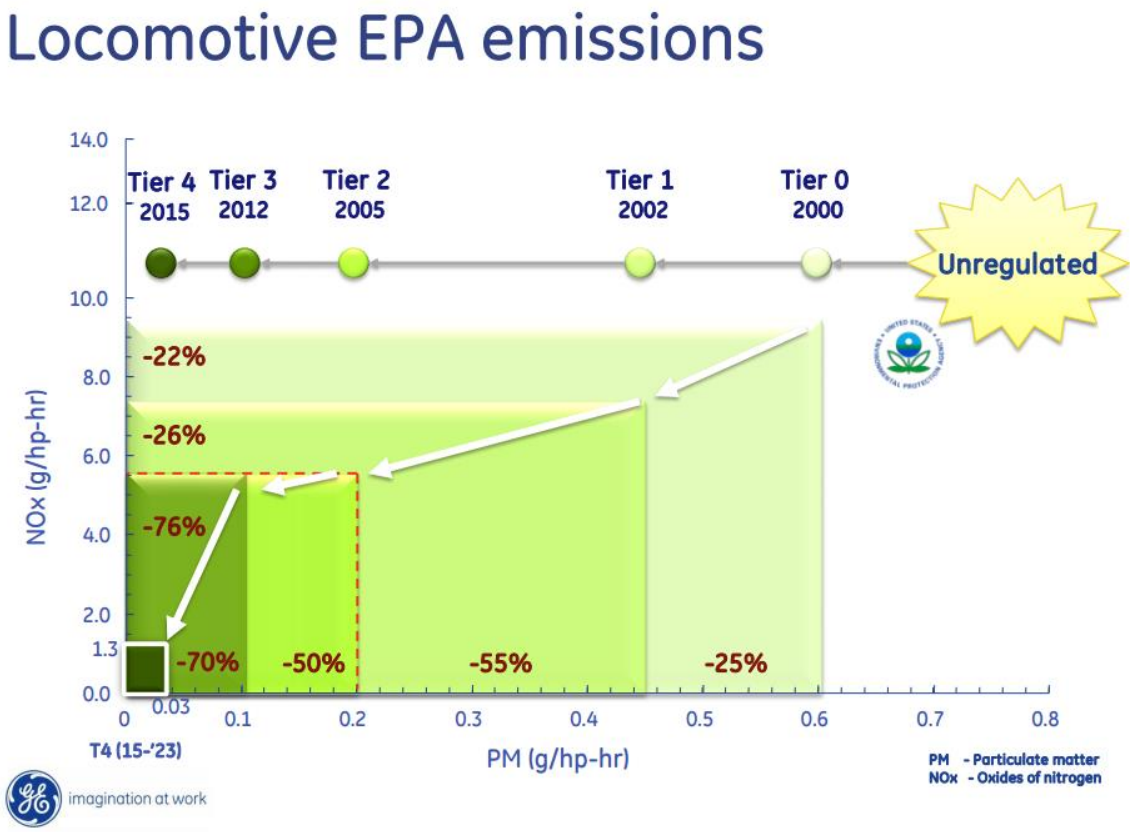


Figure 6. Alternative Fuel Prices

National Average Price Between July 1 and July 15, 2015	
Fuel	**Price**
Biodiesel (B20)	$2.93/gallon
Biodiesel (B99-B100)	$3.55/gallon
Electricity	$0.12/kWh
Ethanol (E85)	$2.36/gallon
Natural Gas (CNG)	$2.12/GGE
Propane	$2.90/gallon
Gasoline	$2.82/gallon
Diesel	$2.93/gallon