General Electric

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Basic Information

- Tier 2 emissions standards are currently enforced
- Smog is causing complaints from residents
- Tier 4 emissions standards must be met by 2017
  - Eliminating approximately 70% of the NO\textsubscript{x} and PM emitted from the engines of the locomotives
- Must find a way to make a durable yet inexpensive locomotive that will produce Tier 4 emissions standards
What is NO\textsubscript{x} and PM?

- **NO**
  - Created when oxygen and nitrogen is heated to extreme temperatures
    - Higher temperatures will produce more NO\textsubscript{x}
    - Longer exposure to high temperatures will produce more NO

- **PM**
  - A mixture of dirt, dust, soot and liquid droplets
    - Responsible for the dark grey smoke that comes out of the exhaust pipe
Mission Statement

Our mission is to create a Tier 4 emissions locomotive that will last for approximately thirty years and will return the initial investment within ten years.
Pittsburgh

- 165,000 tons of freight coming in or out each day
- Each train will go 1000 miles round trip
- Mineral trains
  - 5 trains
  - 3 locomotives each
- Freight Trains
  - 15 trains
  - 2 locomotives each
- 50 locomotives total
Criteria

1. Cost
2. Delivery Speed
3. Durability
4. Ecofriendly
5. Community Perception
## Decision Matrix

<table>
<thead>
<tr>
<th>Judging Criteria</th>
<th>Weight</th>
<th>Sell Tier 2 and buy Tier 4 locomotives</th>
<th>Overhaul on Tier 2 and then aftertreatment</th>
<th>Sell tier 2, buy tier 3 and use of aftertreatment</th>
<th>Change to natural gas with Tier 2 locomotives</th>
<th>Change to natural gas with Tier 4 locomotives</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>x5</td>
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<td>Point Total</td>
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<td>23</td>
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</table>
Initial Expenses

Upgrade to Tier 4 Only:

Receive $75 million for selling Tier 2 locomotives

Costs $200 million to Buy tier 4 locomotives

Total expenses: $125 million
Initial Expenses

Change to Liquid Natural Gas:
$1 Billion to buy a new fueling station
$50 million to upgrade locomotives
Total Expenses: $1.05 billion

Change to Liquid Natural Gas and Upgrade to Tier 4:
Total Expenses $1.175 billion
Cost of Fuel Per Day

- Cost of Diesel: $3 per gallon
- Cost of Liquid Natural Gas: $0.40 per gallon

Original Costs with Tier 2: $933,884.25
Upgrade to Tier 4 Only: $889,410.90
Change to Liquid Natural Gas: $400,947.64
Change to Liquid Natural Gas and Upgrade to Tier 4: $381,847.74
Return Time

Upgrade to Tier 4 Only:
Will spend $44,473.35 less every day
It will take approximately 7.7 years to break even.

Change to Liquid Natural Gas:
Will spend $532,936.61 less every day
It will take approximately 5.4 years to break even.
Return Time

Change to Liquid Natural Gas and Upgrade to Tier 4:

Will spend $552,036.51 less every day

It will take approximately 5.8 years to break even.

This option saves the most money and only takes about 5 months more than only changing to liquid natural gas so this is the option we chose.
## Emissions

<table>
<thead>
<tr>
<th>Options</th>
<th>Current</th>
<th>Liquid Natural Gas</th>
<th>Tier 4 Locomotives</th>
<th>Tier 4 Locomotives and Liquid Natural Gas</th>
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<tbody>
<tr>
<td>$\text{NO}_x$</td>
<td>5.50 g/hp*hr</td>
<td>2.86 g/hp*hr</td>
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<td>Particulates</td>
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<td>0.08 g/hp*hr</td>
<td>0.03 g/hp*hr</td>
<td>0.01 g/hp*hr</td>
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Works Cited

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http://www3.epa.gov/airquality/nitrogenoxides/health.html

http://www3.epa.gov/ttn/ncatc1/dir1/fnoxdoc.pdf

http://www.gettransportation.com/locomotives

https://www.eia.gov/petroleum/gasdiesel/

http://airnow.gov/index.cfm?action=pubs.factsht