Freight Locomotive Emissions Overview

General Overview

Technology

Locomotive Regulations and Emissions

Greenhouse Gases

Health Risk Impacts
General Overview
Environmental Benefits of Freight Rail

• Freight rail moves goods in Chicago and nationwide with the least environmental impact of any over land mode.

• If 10% of national long-haul freight were diverted to rail, over one billion gallons of fuel would be saved annually.

• Railroads can move one ton of freight 480 miles on one gallon of diesel fuel.

• Railroads have increased fuel efficiency 94% since 1980.

CREATE is an excellent example of a public-private transportation project that would reduce emissions, increase fluidity and enhance goods movement.
## Inherent Efficiencies of Rail

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<table>
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<tr>
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<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>1 double-stacked train equals up to 280 trucks</td>
</tr>
<tr>
<td><strong>Fuel Efficiency</strong></td>
<td>Trains are <strong>2-4 times more fuel efficient</strong> than trucks on a ton-mile basis</td>
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<tr>
<td><strong>GHG Emissions</strong></td>
<td>Trains <strong>emit 1/3 the GHG emissions</strong> of trucks on a ton-mile basis</td>
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<tr>
<td><strong>NOx Emissions</strong></td>
<td>Trains are <strong>2-3 times cleaner</strong> than trucks on a ton-mile basis</td>
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State of Illinois - PM2.5 by Source Category (2005)

Area Sources 118,441
Point Sources 10,436
Non-Rail Off-Road 8,961
On-Road Sources 4,888
Locomotives & Rail 2,006

Total 144,732 tpy

Source: 2005 State of Illinois Emissions Inventory
Appendix A, Table A-1
Chicago Area - PM2.5 by Source Category (2005)

Source: 2005 State of Illinois Emissions Inventory
Appendix B, Table B-1
Technology
Investments in New Clean Technology (typical)

- **Emission Reductions**
  - Purchasing newer lower emitting more fuel efficient line haul locomotives reducing fleet age”
  - Aggressive manual locomotive shutdown policies
  - Accelerated installation of idling control devices
  - Specific fuel conservation training for locomotive engineers
  - Remote Sensing Feasibility evaluation to spot problem units

- **Research & Development**
  - Hybrid & Fuel Cell locomotives
  - Tested an Oxidation Catalyst on 3800 hp line-haul unit
  - Testing of low emission medium HP locomotives
  - Fume Hood Evaluation Program at Roseville
  - Cargo handling equipment: LNG hostlers and electric cranes
Comparative Markets: Locomotives & Trucks

- Diesel engine technology is driven by over-the-road truck market
  - 211 Class 8 trucks have been sold for every one locomotive since 1972 (i.e. - over 200k truck engines vs. ~1k locomotive engines)
- Engine technologies cannot be quickly/simply “scaled up”
- Engine technologies “cascade down” through normal market forces:
  - Automotive → Truck → Locomotive, Stationary, and Marine
  - Example: Electronic Fuel Injection
- Introduced into the auto market in early 1980’s
- Entered truck market in late 1980’s
- Entered locomotive market in 1994 (took 6+ years to mature)
Liquefied Natural Gas Switcher Locomotive

1200 sustainable horsepower, spark ignited (4 operating in the US)
Gen Set Switcher Locomotive

2000 sustainable horsepower (300+ operating in the US)
Diesel Particulate Filter (DPF) R&D

- BNSF & UPRR co-funded a $5+ million R&D project investigating performance durability and applicability of DPF to older switching locomotives
- R&D work was performed by Southwest Research Institute ("SwRI") through AAR

- Field testing of two (one UP and one BNSF) 1500 HP switchers equipped with DPFs recently completed
- +/-70% PM removals; limited potential use
What are Others Saying?

Union Pacific Combines Strategic Energy Conservation and Technology to Reduce Emissions

Friday, Jan. 18, 2008

OMAHA, Neb. — While automakers showcase prototypes of environmentally friendly vehicles during the North American International Motor Show, Union Pacific’s green initiatives today are helping to reduce emissions through a mix of strategic energy conservation and new technology programs:

- Acquired newer locomotives and implemented new energy-conservation strategies.
- Installed and implemented new devices to help conserve energy.
- Tested and implemented new devices in locomotive operations.

BNSF Railway is sounding more and more like the little engine that could, delving into new technologies that hold the promise of reducing diesel emissions that are believed
What are Others Saying?

Smokestacks on Rails - GETTING CLEAN AIR SOLUTIONS FOR LOCOMOTIVES ON TRACK (©2006 Environmental Defense)

“. . . Gen-set - With funding from Union Pacific, the National Railway Equipment Corporation has developed another type of cleaner switcher engine. Their new Gen-Set Switcher (GSS) technology replaces the traditional switcher engine with three 700 horsepower generator sets that meet EPA Tier 3 standards for nonroad engines. The combination of smaller engines meets the energy needs of the switcher locomotives while meeting emissions standards more protective than the ones currently in place for locomotives. The multi-engine approach allows the switcher to reduce emissions of NOx and particulate matter by up to 80% and achieve a 40% reduction in fuel consumption over existing, unregulated switchers. It is the first emissions reducing rail technology being developed by a rail company itself . . .”
Locomotive Regulation and Emissions
New US EPA Locomotive Standards

Aggressive new standards from the EPA adopted March 2008
- Tier 3: 69% reduction in PM and 58% reduction in NOx from uncontrolled levels take effect in 2012
- Tier 4: 90% reduction in PM and NOx from uncontrolled levels take effect in 2015

The technology to comply w/ Tier 3 and Tier 4 standards does not yet exist and is not yet commercially available
- Technologies for compliance still under development
  - Selective Catalytic Reduction (SCR): fueling infrastructure if urea-based
  - Diesel Particulate Filter (DPF): maintenance and replacement
  - Exhaust Gas Recirculation (EGR)
EPA Line-haul Locomotive Standards - Reductions (percent) from Uncontrolled Levels

Tier 2 | Tier 3 | Tier 4
---|---|---
-38% | -69% | -91%
-58% | -90%

Prepared by California Environmental Associates
60-Day Movement of One Class 1 Line-haul Locomotive
US Railroad Intermodal Flows (car loads) for 2002
GHG slides
Freight Rail is a Key Strategy to Reduce GHG Emissions

- Co-Benefits
  - Reduced PM and NOx emissions, and highway congestion
- The US EPA Smartway program encourages shippers to use freight rail
  - “For shipments over 1,000 miles, using intermodal transport cuts fuel use and greenhouse gas emissions by 65 percent, relative to truck transport, alone.”
- Dilemma
  - EPA’s Tier 4 Regulations will actually drive fuel consumption up (NOx reductions) which will in turn increases CO₂ emissions
On-going Commitment to Improved Performance will Reduce Rail GHG Emissions

- Locomotive Monitoring Systems
  - Real time “coaching” for optimum train speed based on terrain and other data - results in fuel savings
- Members of USEPA SmartWay Transport Program
  - Incentive-based program designed to substantially reduce annual CO2 and NOx emissions from freight
- Idling Reduction
  - Installation of start stop devices and employee training
Rail Efficiency

• U. S. Freight Ton-Miles by Mode*

- Rail 40%
- Truck 30%
- Water 15%
- Pipeline 15%

• Energy Consumption by Mode**

- Truck 65%
- Water 18%
- Pipeline 9%
- Rail 8%

*Source: U. S. Bureau of Transportation Statistics (2005)

**Source: U. S. Department of Transportation (2005)
State of Illinois - GHG by Transport Type (2005)

<table>
<thead>
<tr>
<th>Activity</th>
<th>CO2 tpy</th>
<th>Percent</th>
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<tbody>
<tr>
<td>On-Highway</td>
<td>57,499,301</td>
<td>73.2%</td>
</tr>
<tr>
<td>Aviation</td>
<td>13,871,872</td>
<td>17.7%</td>
</tr>
<tr>
<td>Off-Highway</td>
<td>2,689,517</td>
<td>3.4%</td>
</tr>
<tr>
<td>Marine</td>
<td>1,179,460</td>
<td>1.5%</td>
</tr>
<tr>
<td>Railroad</td>
<td>589,730</td>
<td>0.8%</td>
</tr>
<tr>
<td>Other Sources</td>
<td>733,473</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

Total 76,563,353 tpy

Note: Emissions factors used in calculations are from USDOE’s Energy Information Administration (EIA) at [http://eia.doe.gov/oiaf/1605/coefficients.html]. This table does not include data for residual fuel or propane as these fuels are used in a variety of activities, this is also why percentages do not sum to 100.
Every ton-mile of Freight that Moves by Rail Instead of Truck Reduces GHG Emissions by Two-Thirds or More

- 3X more fuel efficient than trucks
- 35% more fuel efficient than marine
- Railroads reduce congestion: a single train can take 280 trucks off the highway

86% fuel improvement over 16 years

Rail Fuel Efficiency
(ton-miles per gallon diesel consumed)

<table>
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<tr>
<th>Year</th>
<th>Fuel Efficiency</th>
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<tr>
<td>1980</td>
<td>200</td>
</tr>
<tr>
<td>2006</td>
<td>500</td>
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Health Risk Assessments (HRA’s)
General Background on HRA’s

• Based on maximum risk estimates that assume emissions would stay constant for 70 years

• Assumes that someone would stay outdoors at that specific location 24 hours/day, 350 days/year, for 70 years

• Contains uncertainties related to the computer modeling

• Ignores US EPA conclusion that estimates of cancer risk from diesel emissions are too uncertain to quantify

• Modeling predictions show air concentrations of diesel exhaust outside the rail yard that are similar to those found near freeways and other large transit facilities
General Background on HRA’s

• California is one of the very few places that based risk on the entire mix of constituents in diesel exhaust

• Limited utilization by others

• If so, normally using cancer risk factors for discrete chemicals quantified by EPA (i.e. – benzene, etc.)
US EPA Air Quality Index (AQI) - Definition

What is AQI?
AQI is an index for reporting daily air quality, calculated for the five pollutants regulated by Clean Air Act:

- ground-level ozone
- particulate matter
- carbon monoxide
- sulfur dioxide
- nitrogen dioxide

For each pollutant, US EPA has established national air quality standards to protect public health
How Does the AQI Work?

AQI can be thought of as a yardstick that runs from 0 to 500 (the higher the AQI, the greater the level of pollution and health concern). For example:

• AQI value of **50** represents good air quality with little potential to affect public health
• AQI value of **100** generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health
• AQI value over **300** represents hazardous air quality

AQI values less than 100 are generally thought of as satisfactory. When AQI values are greater than 100, air quality is considered unhealthy - first for sensitive groups of people, then for others as AQI values increase.
US EPA Air Quality Index (AQI) - Comparison

Number of Unhealthy Days in Recent Years

Cook County, IL

Los Angeles County, CA

Source: U. S. EPA AirNow and AirCompare (EPA website) County Comparisons and Historical Profiles – General Population
http://www.epa.gov/cgi-bin/broker?_service=aircomp&_debug=0&_program=dataprog.wcj_byyearhealth.sas&geocode=06037%2017031&condition=none&citycounty=county
Annual Ozone Exceedance - Comparison

SOUTH COAST AIR BASIN & CHICAGO PMSA
Annual Days Ozone Exceedance (Nat'l Std.)

Other Air Quality Indices

PM2.5 is comprised of ammonium sulfate, organic carbon & ammonium nitrate
- LADCO - Chicago rural background PM 2.5 concentration is 12.5 mg/cm*
- MATES - So California background PM 2.5 concentration is 20 mg/cm*

Elemental carbon (EC) is a surrogate for diesel particulate matter (DPM)
- LADCO - Chicago rural background EC concentration is 0.4 mg/cm* (with a maximum of 0.8)
- MATES - Santa Anna & Anaheim EC concentration is 2.0 mg/cm* - Commerce & San Bernardino concentration is 2.7 mg/cm*

EC in Southern California is 3 to 4 times higher than in Chicago

* mg/cm – micrograms per cubic meter