Freight Locomotive Emissions Overview

July 13, 2010
Chicago, Illinois

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**

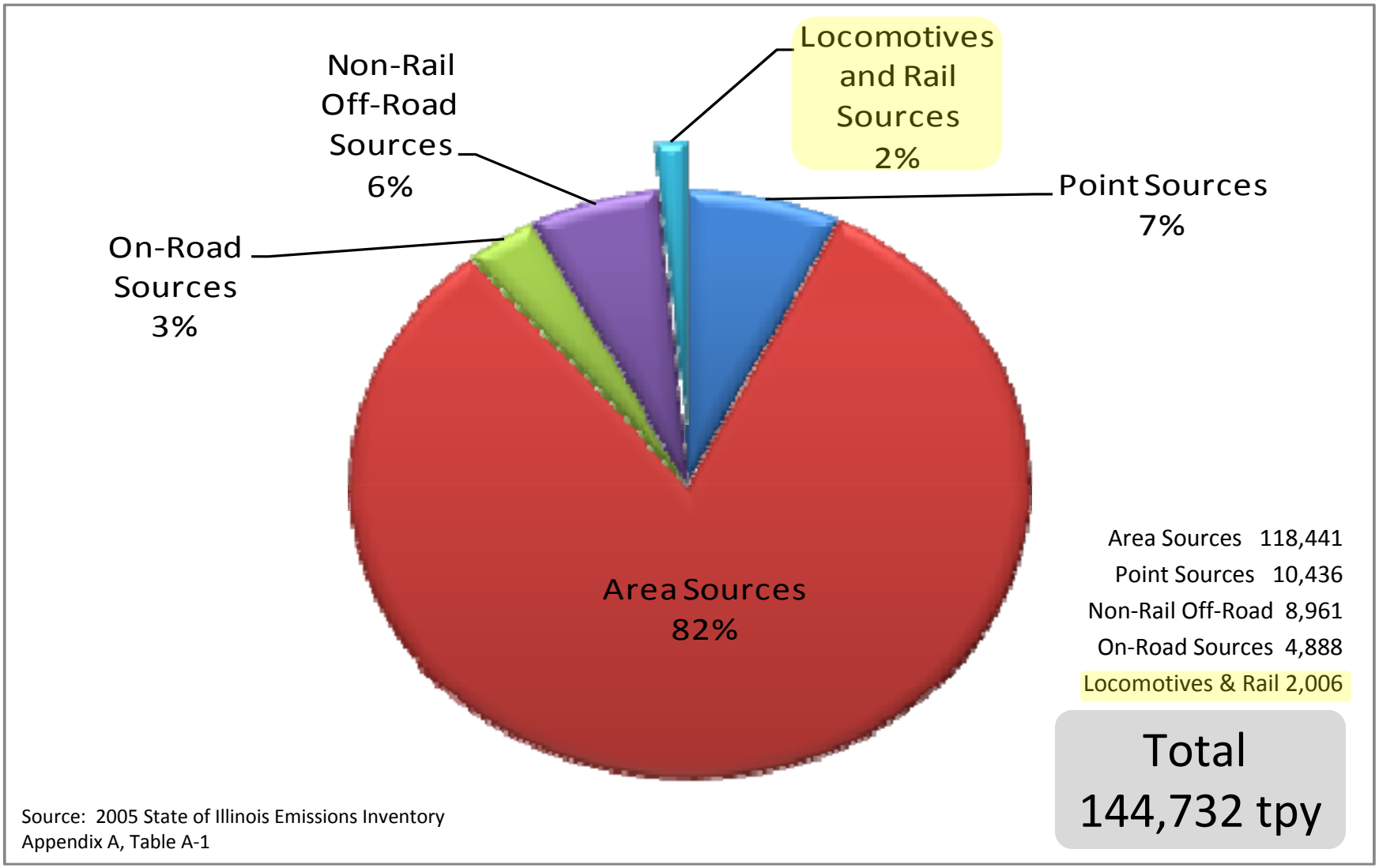
CREATE is an excellent example of a public-private transportation project that would reduce emissions, increase fluidity and enhance goods movement.

Inherent Efficiencies of Rail

versus

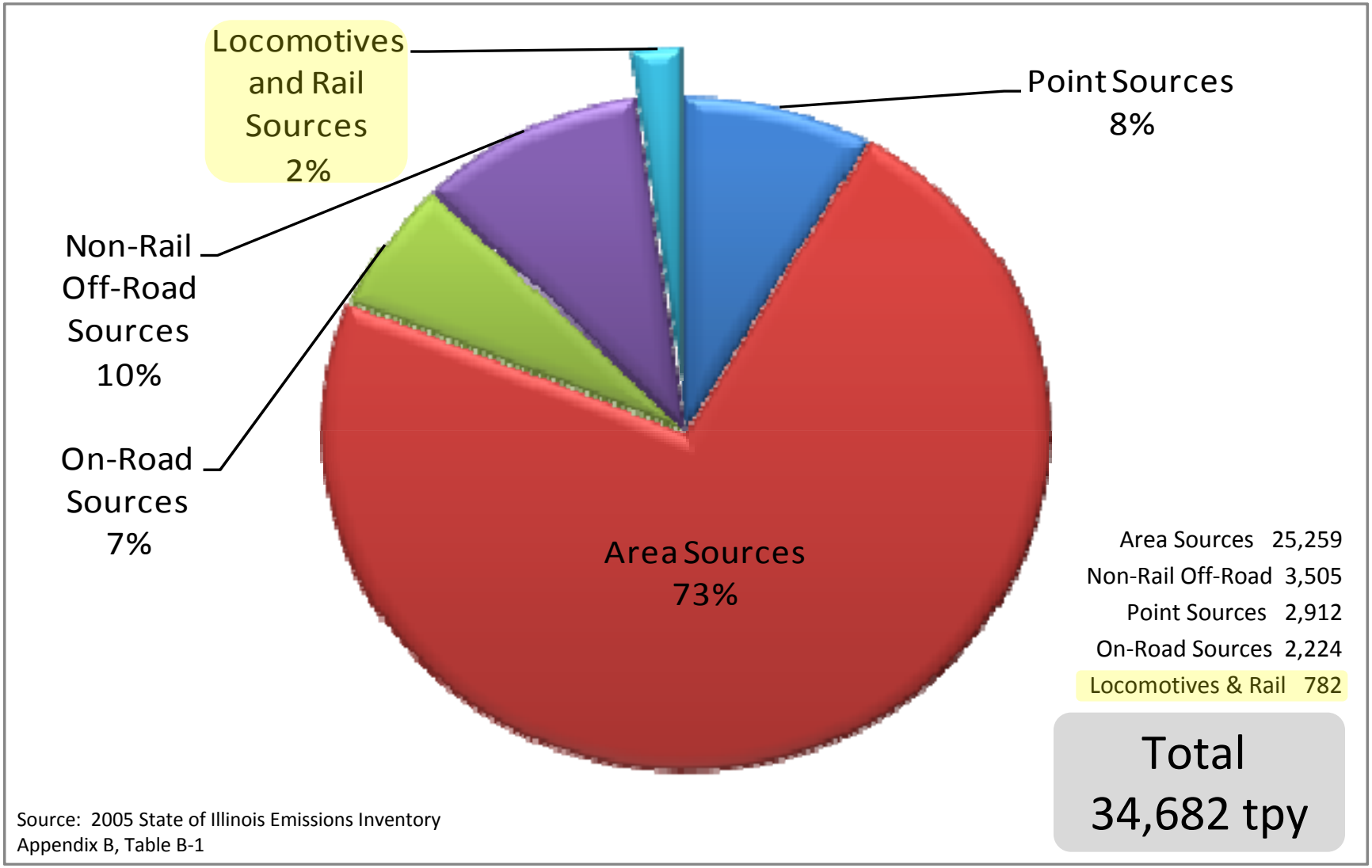
Capacity	1 double-stacked train equals up to 280 trucks
Fuel Efficiency	Trains are **2-4 times more fuel efficient** than trucks on a ton-mile basis
GHG Emissions	Trains **emit 1/3 the GHG emissions** of trucks on a ton-mile basis
NOx Emissions	Trains are **2-3 times cleaner** than trucks on a ton-mile basis

State of Illinois - PM2.5 by Source Category (2005)



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)

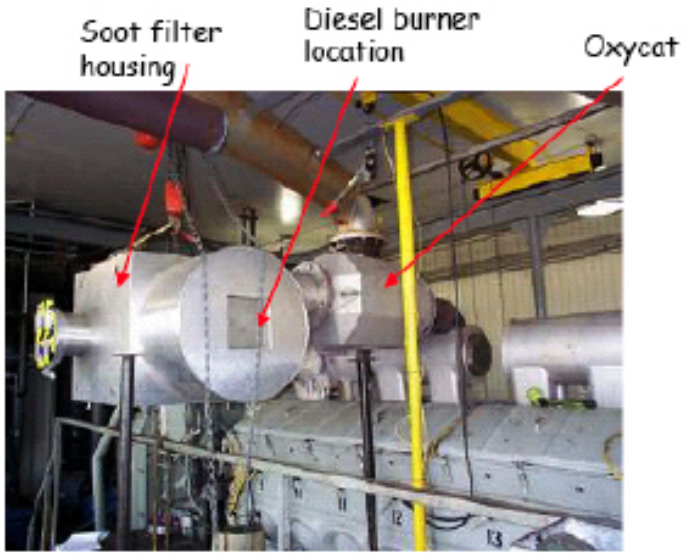
Liquefied Natural Gas Switcher Locomotive

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?

Centredaily.com

YOUR LIFE. YOUR PAPER. YOUR HOME PAGE

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

-digit

sters

neers

Union Pacific Genset

THE SUN

SAN BERNARDINO AND THE INLAND EMPIRE

New technologies hold promise

November 15, 2008

Our view: Efforts to cut diesel pollution around a San Bernardino rail yard are on track.

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

Pat Morris said the city will aid BNSF's efforts to seek grants to help purchase greener locomotive technology.

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

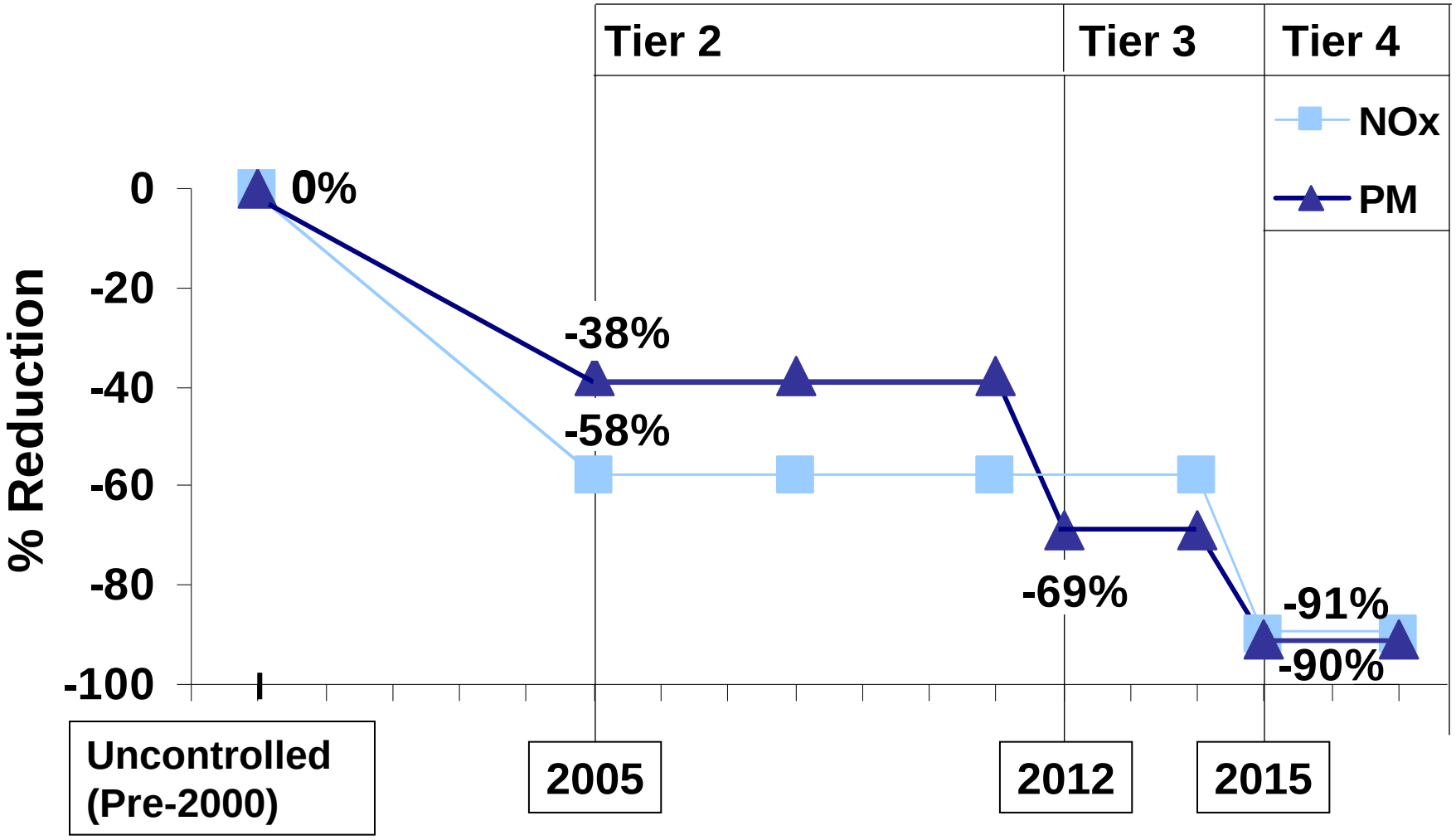
Aggressive new standards from the EPA adopted March 2008

- 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



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

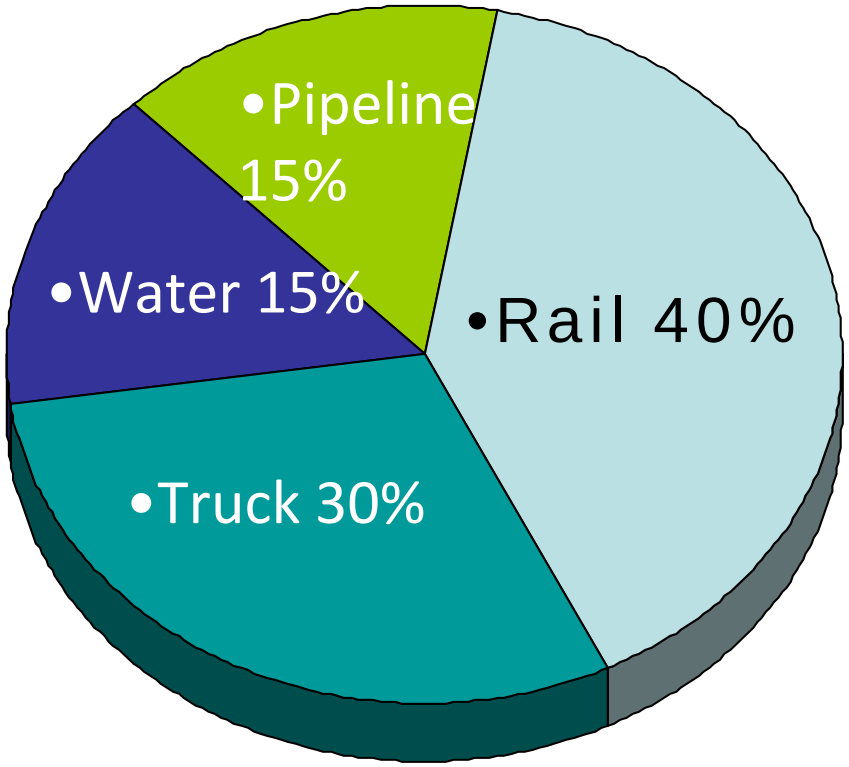
- Co-Benefits
  - Reduced PM and NOx emissions, and highway congestion
- The US EPA Smartway program encourages shippers to use freight rail
  - "For shipments over 1,000 miles, using intermodal transport cuts fuel use and greenhouse gas emissions by 65 percent, relative to truck transport, alone."
- Dilemma
  - EPA's Tier 4 Regulations will actually drive fuel consumption up (NOx reductions) which will in turn increases CO_2 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

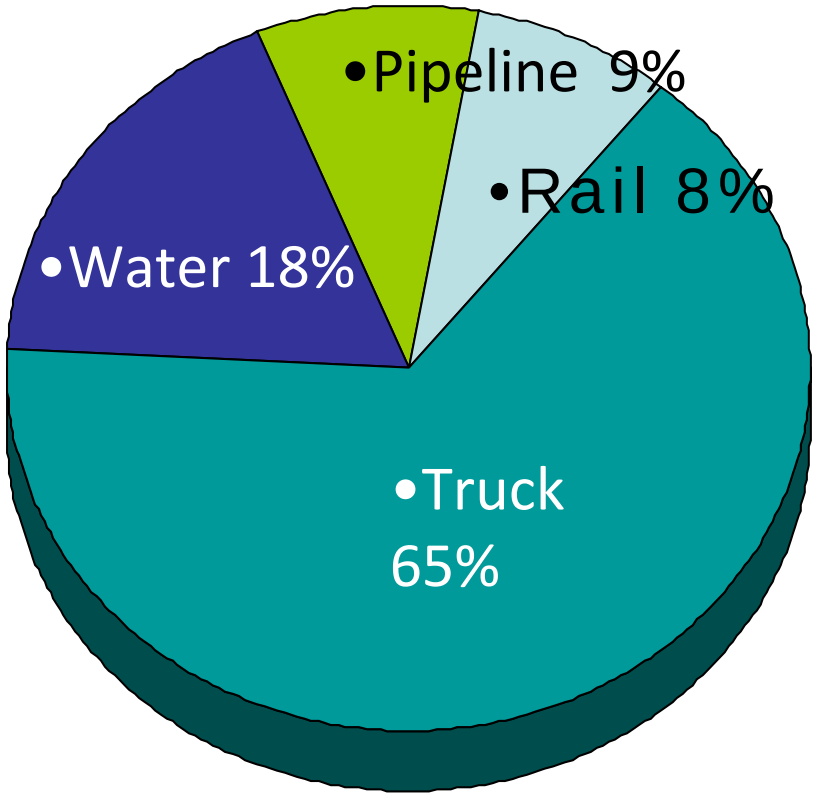
- U. S. Freight Ton-Miles by Mode*



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

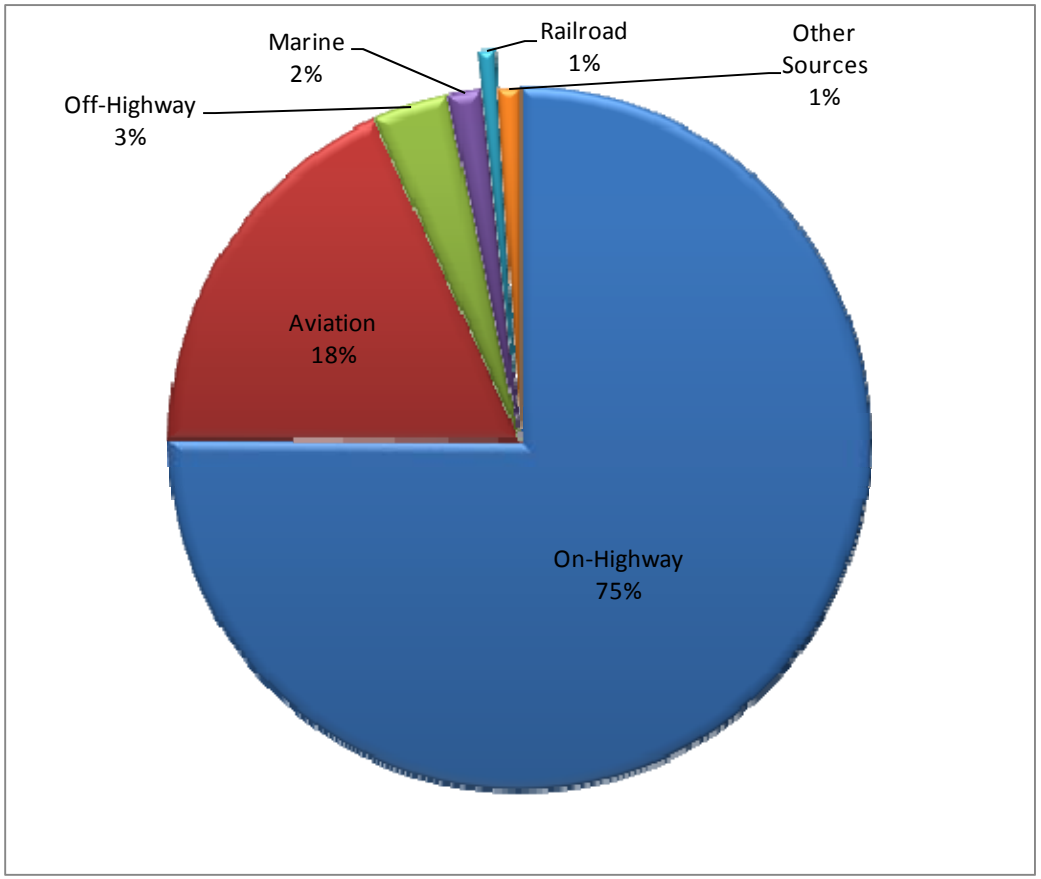
- Energy Consumption by Mode**

2005



- **Source: U. S. Department of Transportation (2005)

State of Illinois - GHG by Transport Type (2005)



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

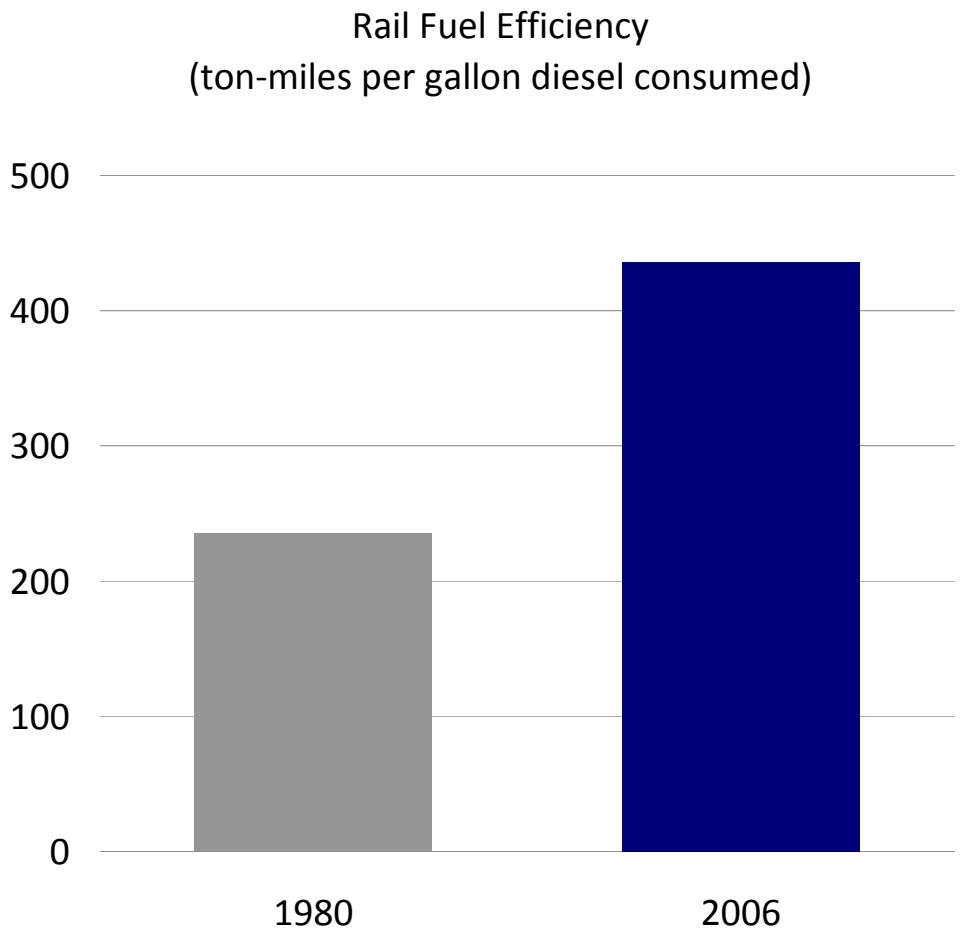
Total
76,563,353 tpy

Source: Illinois and DOT Calculations of Prime Supplier Sales Volumes from EIA website (http://tonto.eia.doe.gov/dnav/pet/pet_cons_prim_dcu)SIL-a.htm).
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



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

US EPA Air Quality Index (AQI)

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:

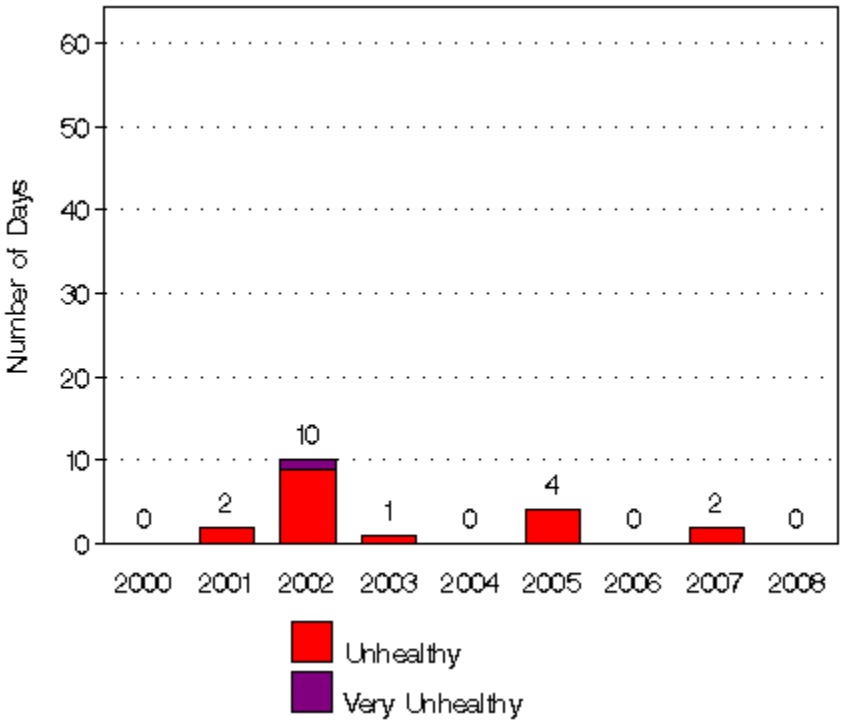
- AQI value of **50** represents good air quality with little potential to affect public health
- AQI value of **100** generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health
- AQI value over **300** represents hazardous air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

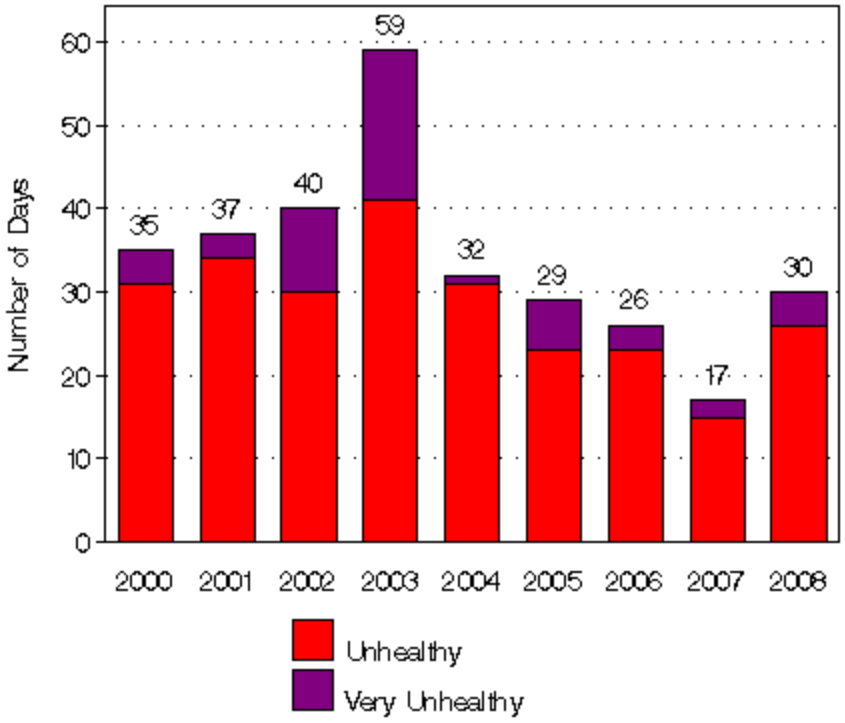
US EPA Air Quality Index (AQI) - Comparison

Number of Unhealthy Days in Recent Years

Cook County, IL

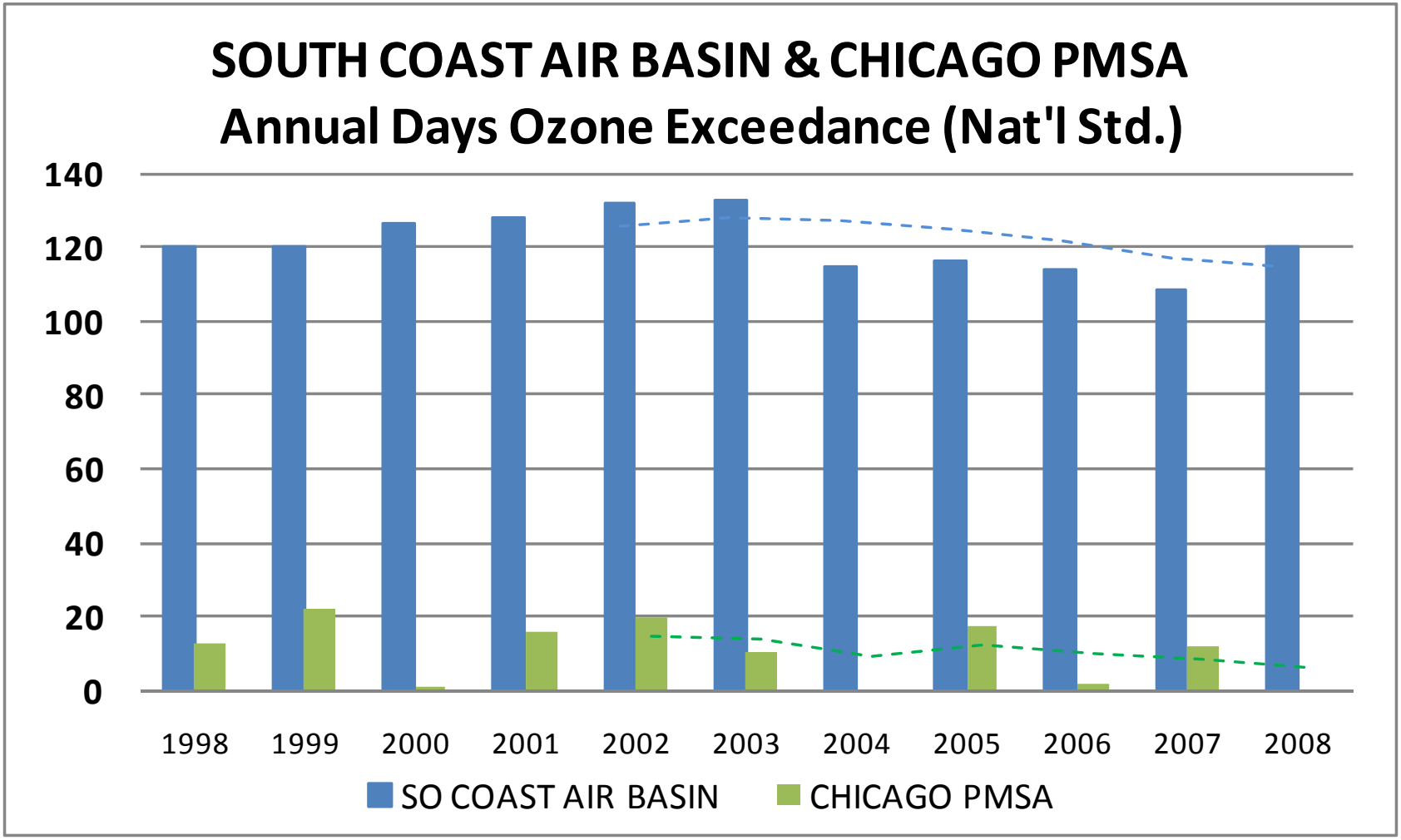


Los Angeles County, CA



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.wci_byyearhealth.sas&geocode=06037%2017031&condition=none&citycounty=county

Annual Ozone Exceedance - Comparison



Source: U. S. EPA Monitor Trends Report – Criteria Air Pollutants http://www.epa.gov/air/data/montrnd.html
California Air Resources Board Ozone Trend Summary http://www.arb.ca.gov/adam/php_files/aqdphp/trends2.php

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