

Summary

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Minnesota Steel GHG Inventory: Summary of Annual Emissions														
2	Proposed Integrated Iron Mine, Taconite, DRI, and Steel Plant														
6	CMS estimates emissions for electricity, natural gas, on-site diesel fuel, commuting, and transportation of finished steel are summarized here and detailed in the attached worksheets.			Richard Heede Climate Mitigation Services 18-Jun-07			Here we also summarize estimates made by the Minnesota Pollution Control Agency and by Barr Engineering for MSI. CMS relies on their estimates of emissions from limestone, soda ash, and other plant-specific sources.								
12	Summary of Emissions from the MSI Plant														
14	Table 1			MN PCA estimate			MSI estimate			CMS estimate					
17		Physical units		Emissions		Emissions		Emissions		Percent	Variance				
18		various		tonnes CO2-e		tonnes CO2-e		tonnes CO2-e		of CMS	(CMS-MSI)/MSI				
19	Electricity	indirect	MWh/yr				1,845,000	MV	3,464,063	MWh					
20	Carbon dioxide	indirect							2,393,667						
21	Methane	indirect							518						
22	Nitrous oxide	indirect							12,031						
23	Total Electricity				1,077,498		1,538,915		2,406,217		49.4%		56.4%		
25	Natural Gas	direct	million cf/yr												
26	Concentrator	direct	25		1,464		1,300		1,279						
27	Pellet Plant	direct	1,222		71,536		61,400		62,592						
28	DRI	direct	37,218		2,178,748		1,868,100		1,906,279						
29	Melt Shop	direct	608		83,069		71,300		31,167						
30	Rolling Mill	direct	810						41,509						
31	Other natural gas	direct	not estimated												
32	Total Natural Gas		39,884		2,334,817		2,002,100		2,042,824		41.9%		2.0%		
34	Diesel fuel	direct	gallons/yr												
35	Mining & crushing equip	direct	4,087,330		45,222		42,500		41,500						
36	Concentrator	direct	56,324		623		600		572						
37	Pelletizer	direct	58,880		651		700		598						
38	DRI	direct	82,819		916		900		841						
39	Steel mill	direct	58,888		652		700		598						
40	Total diesel		4,344,241		48,065		45,400		44,108		0.90%		-2.8%		
42	Limestone	direct	tonnes/yr												
43	Pelletizer	direct	41,804		18,306		18,400		18,353						
44	Steel mill	direct	30,537		13,372		13,500		13,436						
45	Total Limestone		72,341		31,679		31,900		31,789		0.65%		-0.3%		
47	Soda Ash	direct	tonnes/yr												
48	Pelletizer	direct	41,804		17,349		17,400		17,374		0.36%		-0.1%		
50	Non CO2 Carbon-containing inputs	direct													
51	Pellets (pelletizer)	direct			(1,300)		(1,300)		(1,300)						
52	Pellets (DRI process)	direct			1,300		1,300		1,300						
53	Direct-reduced iron (DRI process)	direct			(424,700)		(424,700)		(424,700)						
54	Direct-reduced iron (steel mill)	direct			424,700		424,700		424,700						
55	Total Non-CO2 inputs				-		-		-		0.00%				
57	Other	direct	tonnes/yr												
58	Powder coating (pelletizer)	direct	67,185		32,100		32,100		32,100						
59	Concentrate (pelletizer)	direct	3,800,410		20,300		20,300		20,300						
60	Carbon, as Anthracite (steel mill)	direct	12,185		40,600		40,600		40,600						
61	Electrodes (steel mill)	direct	4,375		14,600		14,600		14,600						
62	Casting powder (steel mill)	direct	1,000		900		900		900						
63	Steel production	direct	2,500,000		(14,300)		(14,300)		(14,300)						
64	Slag	direct	304,517		(3,400)		(3,400)		(3,400)						
65	Total Other		na		90,800		90,800		90,800		1.86%		0.0%		
67	Explosives	direct			not estimated		not estimated		4,735		0.10%				
69	Commuting		gallons/yr		not estimated		not estimated								
70	Gasoline & diesel (gallons)	indirect	347,088						3,080		0.06%				
72	Transportation of finished steel	indirect	gallons/yr		not estimated		not estimated								
73	If Scenario 2a: 500 miles by rail	indirect	4,541,758						45,264	(not included in total)					
74	If Scenario 3a: Trucking 500 miles	indirect	23,489,956						234,105		4.80%				
77	Total Direct and Indirect Emissions				3,600,207		3,726,515		4,875,032		100.0%		30.8%		
79	CMS			kg C per kg steel prod'n	0.532		kg CO2 per kg steel prod'n	1.95							

Summary

Cell: B19

Comment: Rick Heede:

MSI's estimated emissions from the consumption of electricity differs from CMS's estimate as well as that of the State of Minnesota's Pollution Control Agency. The Minnesota Department of Natural Resources & US Army Corps of Engineers Draft Environmental Impact Statement (February 2007) does not discuss emissions of greenhouse gases -- direct or indirect -- from any proposed project sources.

The MN PCA estimates emissions from the electric arc furnace (EAF) only.

The Barr Engineering Company estimate for MSI differs from CMS's estimate in three respects:

1. Barr uses a carbon coefficient for the regional Mid-Continent Power Pool (0.831 kg CO₂ per kWh), whereas CMS uses Minnesota's state-wide average carbon coefficient (0.691 kg CO₂/kWh);
2. Barr cites "vendor data" for its estimated annual MWh demand; CMS is not in a position to evaluate whether vendors supplied power demand for major electricity-using equipment or all of the integrated plant's thousands of motors and other electrical equipment; CMS, in contrast, bases its power demand on the stated power demand of 450 MW adjusted for plant down-times (nine percent per a full year);
3. CMS includes emissions of methane and nitrous oxide from Minnesota's complement of power plants supplying its grid, even though minor compared to emissions of carbon dioxide.

See the "Electricity" worksheet for details.

Cell: F23

Comment: Rick Heede:

The Minnesota Pollution Control Agency estimated indirect emissions resulting from MSI's procurement of electricity, but only for the EAF (electric arc furnace) only. The PCA estimate is based on the carbon-intensity of 391 kg CO₂-eq per tonne of steel manufactured. Source cited: Northstar Steel. Also mentioned Northstar's mid-1990s electric-intensity of 400 kWh/tonne.

Worrell et al, LBNL 1999, p. 1, reports US average intensity of 480 kWh/tonne for all US plants.

Worrell, Ernst, Nathan Martin, & Lynn Price (1999) Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector, LBNL, 57 pp.

Cell: J23

Comment: Rick Heede:

The CMS estimate suggests an overall emissions intensity for electricity use of 1.03 tonne CO₂-e per tonne of steel, or 0.282 tC-e/tonne. Note: this is for electricity only, and includes significant electricity used in pellet plant, DRI, caster, etc.

Cell: B25

Comment: Rick Heede:

MSI's estimated emissions from the consumption of natural gas is in close agreement with CMS's estimate as well as that of the State of Minnesota's Pollution Control Agency. The Minnesota Department of Natural Resources & US Army Corps of Engineers Draft Environmental Impact Statement (February 2007) does not discuss emissions of greenhouse gases -- direct or indirect -- from any proposed project sources.

The minor differences between the estimates are chiefly due to using different carbon coefficients.

See the "Natural Gas" worksheet for details.

Cell: F29

Comment: Rick Heede:

Natural gas emissions estimate for "steel plant."

Cell: H29

Comment: Rick Heede:

Natural gas emissions estimate for "steel plant."

Summary

Cell: B31

Comment: Rick Heede:

CMS does not have data from MSI on gas consumption in other plant buildings, such administrative offices; presumably such use is either minor and/or included in the total gas usage estimate.

Cell: B35

Comment: Rick Heede:

Haul trucks, front end loaders, mining shovels, and on-site locomotives

Cell: B42

Comment: Rick Heede:

CMS has not reviewed or updated the emissions estimate from the use of limestone in MSI proposed project. CMS uses the emissions estimate submitted by MSI's consulting engineers Barr Engineering Company or the average of Barr's estimate and that of the Minnesota Pollution Control Agency review of Barr's estimates.

Cell: B47

Comment: Rick Heede:

CMS has not reviewed or updated the emissions estimate from the use of soda ash in MSI's proposed project. CMS uses the emissions estimate submitted by MSI's consulting engineers Barr Engineering Company or the average of Barr's estimate and that of the Minnesota Pollution Control Agency review of Barr's estimates.

Cell: B57

Comment: Rick Heede:

CMS has not reviewed or updated the emissions estimate from other sources in MSI's proposed project. CMS uses the emissions estimate submitted by MSI's consulting engineers Barr Engineering Company or the average of Barr's estimate and that of the Minnesota Pollution Control Agency review of Barr's estimates.

Cell: B60

Comment: Rick Heede:

Barr (2007) MSI CO2 Emission Footprint and Comparison, Attachment A and footnote 8: "Coal (as anthracite) consumption rate of 4 kg per 1,189 kg DRI feed." CMS has reviewed the Barr conversion of anthracite to CO2 emissions, or the origin of anthracite coal, or the carbon coefficient applied.

Cell: B67

Comment: Rick Heede:

CMS has made a preliminary estimate of emissions of CO2-e from the use of explosives in removing overburden, blasting the ore, and related mining operations. MSI has not, to our knowledge, published data on the quantity of explosives required for the proposed project. Nor is such information contained in the Draft EIS.

Note: CMS has used an emissions rate calculated from from the use of explosives in an open cast mine in New South Wales, Australia, in lieu of having data from MSI. No doubt teh company or its emgineering company will revise our preliminary estimate in due course. See the attached worksheet for details.

Cell: B69

Comment: Rick Heede:

CMS estimates energy and emissions from the commuting of MSI anticipated workforce of 700 employees for production, support, and administration. (Draft EIS, p. EX-2). CMS assumes double-occupancy for a commuting trip of 15 miles each way for each shift using an average household vehicle getting a fuel economy of 18.6 mpg.

See the "Transportation & Commuting" worksheet for details.

Cell: B72

Comment: Rick Heede:

CMS estimates energy and emissions from the transportation of 2.5 million tonnes of finished steel per annum. CMS calculates emissions from a number of alternative transportation options -- none of which are discussed as a preferred alternative in the Draft EIS. CMS models emissions from the use of barges, large semi-tractor trailers, rail, "lakers" across the Great Lakes, and container ships across the Pacific to one potential market (China). CMS assumes a transportation distance of 500 miles in each scenario for easy comparison of transportation emission rates.

Summary

Neither MSI, nor its consulting engineering company (Barr Engineering), nor the Draft EIS estimates emissions from product transportation, presumably considering such emissions to be beyond its defined boundary of emission sources. CMS considers such emissions unavoidable and attributable to MSI's proposed project.

See the "Transportation & Commuting" worksheet for details.

Electricity

Minnesota Steel GHG Inventory: Annual Electricity Emissions

Proposed Integrated Iron Mine, Taconite, DRI, and Steel Plant

Electricity demand calculations differ. The CMS estimate is based on company's total demand in MW times hours of operation per year (91%). The MSI estimate is based on "vendor information" on a plant-by-plant basis.

Richard Heede
Climate Mitigation Services
18-Jun-07

MSI uses a higher carbon intensity factor for MAPP power (0.83 tonnes CO2/MWh) than CMS's use of Minnesota's state average carbon intensity (0.69 tonnes CO2-e/MWh).

CMS estimate

Total electricity demand and estimated annual emissions

Table 1	Emissions coefficients (from Table 6)					
	Carbon Dioxide tonnes CO2/MWh	Methane tonnes CH4/MWh	Methane tonnes CO2-e/MWh	Nitrous tonnes N2O /MWh	Nitrous tonnes N2O /MWh	Total GHG/MWh tonnes CO2-e/MWh
GWP, CO2 multiplier	1		21		310	
CO2 coefficients	0.6910	0.00001	0.00015	0.00001	0.00347	0.6946

Table 2	Total estimated emissions, by GHG gas					Total Electricity		
	Carbon Dioxide tonnes CO2/yr	Methane tonnes CH4/yr	Methane tonnes CO2-e/yr	Nitrous tonnes N2O /yr	Nitrous tonnes CO2-e/yr	tonnes CO2-e/yr	MtCO2-e/yr	MtC-e/yr
Tonnes CO2, CH4, N2O, CO2-e	2,393,667	25	518	39	12,031	2,406,217	2.406	0.657
Percent of total by gas	99.48%		0.02%		0.50%			(Million tonnes CO2-e/yr)

Table 3	Annual power demand calculation	
Assume 450 MW continuous	450	MW
Operating hours per year	7,390	hrs/yr
Delivered electricity	3,325,500	MWh/yr
T&D losses (conservative)	4%	percent
Required generation	3,464,063	MWh/yr

Table 4	Expected operating hours per year		Percent of yr
Full year	8,760	hrs	100%
Off: 10 days	240	hrs	2.7%
Off: 7 holidays	168	hrs	1.9%
Off: 8 hrs/week	416	hrs	4.7%
Additional downtim	546	hrs	6.2%
Annual down time	1,370	hrs	15.6%
Net operating time	7,390	hrs	84.4%

Table 5	MSI required generation of US total	
U.S. electricity generation, 2005	3,883	TWh
MSI, required generation	3.46	TWh
MSI, percent of total US	0.089%	

GHG emissions coefficients for Minnesota power

Table 6	US Energy Information Administration				
	Carbon Dioxide lbs/kWh	Methane tons/MWh	Methane tonnes/MWh	Nitrous lbs/MWh	Nitrous lbs/MWh
Minnesota	1.520	0.762	0.69100	0.01570	0.02470

Table 7	Conversion to tonnes per MWh				
	Carbon Dioxide lbs/kWh	Methane tons CO2/MWh	Methane tonnes CO2/MWh	Nitrous tonnes CH4/MWh	Nitrous tonnes N2O /MWh
	1.520	0.760	0.689	0.0000071	0.0000112

Note: Due to EIA rounding, CMS uses EIA's calculation for CO2/MWh above

EIA, Table 1. 1998-2000 Average State-level Carbon Dioxide Emissions Coefficients for Electric Power

MSI estimate

Total electricity demand and estimated annual emissions

Table 8	Total electricity demand and estimated annual emissions							
	Power demand MWh/tonne	Throughput tons	Throughput tonnes	Power Demand MWh	Carbon coeff. MAPP region tonnes CO2/MWh	CO2 emissions total plant (?) tonnes	CO2 emissions per tonne tonne CO2/tonne	CH4 & N2O emissions tCO2-e/MWh
EAF	0.400	2,500,000	2,267,985	1,000,000	0.8341	834,100	0.368	not estimated
LMF	0.035	2,500,000	2,267,985	87,500	0.8341	72,984	0.032	not estimated
Caster	0.115	2,500,000	2,267,985	287,500	0.8341	239,804	0.106	not estimated
DRI	0.100	2,800,000	2,540,143	280,000	0.8341	233,548	0.092	not estimated
Pellet Plant	0.050	3,800,000	3,447,337	190,000	0.8341	158,479	0.046	not estimated
Total				1,845,000		1,538,915	0.644	not estimated

Conveyors	not estimated
Admin, offices, rsrch bldgs, etc	not estimated
Grid losses	not estimated
Methane emissions	not estimated
Nitrous oxide emissions	not estimated

Note: MSI uses the EPA's datum for MAPP carbon emissions (0.834 tonne CO2/MWh)
CMS uses the EIA's state-wide emissions factor for Minnesota (0.691 tonne CO2/MWh)

Electricity

Cell: H14

Comment: Rick Heede:

MSI's estimated emissions from the consumption of electricity differs from CMS's estimate as well as that of the State of Minnesota's Pollution Control Agency. The Minnesota Department of Natural Resources & US Army Corps of Engineers Draft Environmental Impact Statement (February 2007) does not discuss emissions of greenhouse gases -- direct or indirect -- from any proposed project sources.

The MN PCA estimates emissions from the electric arc furnace (EAF) only.

The Barr Engineering Company estimate for MSI differs from CMS's estimate in three respects:

1. Barr uses a carbon coefficient for the regional Mid-Continent Power Pool (0.831 kg CO₂ per kWh), whereas CMS uses Minnesota's state-wide average carbon coefficient (0.691 kg CO₂/kWh);
2. Barr cites "vendor data" for its estimated annual MWh demand; CMS is not in a position to evaluate whether vendors supplied power demand for major electricity-using equipment or all of the integrated plant's thousands of motors and other electrical equipment; CMS, in contrast, bases its power demand on the stated power demand of 450 MW adjusted for plant down-times (nine percent per a full year);
3. CMS includes emissions of methane and nitrous oxide from Minnesota's complement of power plants supplying its grid, even though minor compared to emissions of carbon dioxide.

Cell: J30

Comment: Rick Heede:

Data from Dick Cordes, Minnesota Pollution Control Agency, personal communication 9May07.

Cell: H39

Comment: Rick Heede:

This is a preliminary calculation based on EIA state-level data of emissions per kWh of generation. CMS may revise this calculation if the regional grid emissions coefficients are used, eg, MAPP (Mid-Continent Power Pool). See EPA's eGRID for MAPP data.

Cell: H50

Comment: Rick Heede:

Updated State-level Greenhouse Gas Emission Coefficients for Electricity Generation 1998-2000 April 2002 Energy Information Administration Table 1. 1998-2000 Average State-level Carbon Dioxide Emissions Coefficients for Electric Power.

Cell: H57

Comment: Rick Heede:

Data on MSI projected annual consumption of electricity to be procured from MAPP (Mid-Continent Power Pool), its carbon intensity, and CO₂ emissions from Barr Engineering publications for MSI.

Barr references estimates of power demand per plant from vendor engineering estimates or spec sheets.

Barr Engineering Company (2007) Minnesota Steel Industries CO₂ Emissions Footprint and Comparison, Minneapolis, 6 pp. 27 April 2007.

Barr Engineering Company (2007) Minnesota Steel Industries Estimated CO₂ Emissions from Electricity Usage, Minneapolis, 5 pp. 17 May 2007.

	A	B	C	D	E	F	G	H	I	J	K
1	Minnesota Steel GHG Inventory: Annual Natural Gas Emissions										
2	Proposed Integrated Iron Mine, Taconite, DRI, and Steel Plant										
3											
4											
5											
6	The emissions estimates by CMS and MSI are in good agreement; CMS carbon coefficient for natural gas is slightly higher (based on 1,030 rather than 1,009 Btu/cf).			Richard Heede Climate Mitigation Services 23-May-07				CMS includes a combustion factor of 0.995 of carbon in natural gas oxidized to carbon dioxide.			
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14	Estimated energy and emissions from mining equipment and diesel fuel										
15	Table 1										
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Table 1

Plant Segment	Consumption of Natural Gas		CO2 coefficient tonnes CO2/million cf	CO2 emissions tonnes CO2
	Nm ³ /yr	Million cf/yr		
	CF per Nm ³ :	37.324448		
Concentrator	668,872	25.0	51.219	1,279
Pellet Plant	32,741,041	1,222.0	51.219	62,592
DRI	997,150,000	37,218.1	51.219	1,906,279
Melt Shop	16,302,800	608.5	51.219	31,167
Rolling Mill	21,712,610	810.4	51.219	41,509
Other natural gas use	not estimated	not estimated		
Total Natural Gas Use and Emissions	1,068,575,323	39,884		2,042,824

delete later: Kevin: Ciborowski estimate in US tons = 2,334,817
 CMS estimate (above) in US tons = 2,251,805

Note: CMS does *not* include emissions from several Scope 3 sources that could be attributed to the end-user and included in this inventory, such as:

- 1 Energy and emissions of CO2 and fugitive methane from transporting ~40 Bcf/yr of natural gas to the MSI mine and plant;
- 2 Emissions of CO2 and methane from gas production sites, oil /gas separation facilities, gas processing, and pipeline systems;
- 3 These sources, if included, would add ~15 to ~25 percent to the direct, on-site emissions as calculated above.

Derivation of emissions coefficient & combusted CO2

Carbon Coefficient		CO2 per Carbon	Potential CO2	Combusted CO2	Combustion factor per IPCC, EPA
g C per kBtu	g C per cf		g CO2 per cf kg CO2 per kcf t CO2/million cf	g CO2 per cf kg CO2 per kcf t CO2/million cf	
14.470	14.049	3.664191	51.477	51.2192	0.995

EIA (2006) Annual Energy Review 2005			
If	1,030	btu per cf	
Then	1,000	Btu equal	0.970874 cubic feet

Teragram per quadrillion Btu
 Tg per QBtu = kg C per million Btu = g C per kBtu

Note: 1 g CO2 = 0.0022046 lb CO2
 and 51.219 g = 0.1129190 lb CO2

tonnes CO2/million cf = kg CO2/thousand cf = g CO2 per cf

Natural Gas

Cell: F18

Comment: Rick Heede:
Temperature corrected, following Barr Engineerig Company's note.

Cell: I41

Comment: Rick Heede:
One-half of one percent of the carbon in natural gas is assumed to not combust to CO₂, hence a 99.5 percent combustion factor.

Cell: G47

Comment: Rick Heede:
US Energy Information Administration (2006) Annual Energy Review 2005, Table A4: Approximate Heat Content of Natural Gas, p. 360. Value for 2005.

	A	B	C	D	E	F	G	H	I	J	K
1	Minnesota Steel GHG Inventory: Mining Equipment: Annual Diesel Emissions										
2	Proposed Integrated Iron Mine, Taconite, DRI, and Steel Plant										
3	Richard Heede										
4	Climate Mitigation Services										
5	23-May-07										
6	The emissions estimates by CMS and MSI are in good agreement; CMS carbon coefficient for diesel fuel is slightly higher.										
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Note: CMS does not include emissions from several Scope 3 sources that could be attributed to the end-user and included in this inventory, such as:

- 1 Energy and emissions from transporting 4.3 million gallons of diesel fuel to the MSI mine and plant;
- 2 Leakage of volatilized fuel in storage tanks at the site;
- 3 Emissions of CO2 and, to a lesser extent, methane from oil refineries, production platforms, pipeline systems, and fuel storage tanks;
- 4 These sources, if included, would have added ~20 to ~30 percent to the direct, on-site emissions as calculated above.

Emissions coefficients

Table 2		Heat Content	Carbon Coefficient	Emission Coefficient	Emission Coefficient	Emission Coefficient
		btu/gallon (net)	kg C/million Btu	lb CO2/gallon	kg carbon per Btu	kg CO2 per Btu
Diesel		128,700	19.95	22.384	0.00001995	0.00007310
Gasoline		115,400	19.34	19.564	0.00001934	0.00007087
Biodiesel		117,093		4.824	-	-
Residual (bunker)		138,400	21.49	26.033	0.00002149	0.00007874
		TEBD, Table B.4	TEBD, Table B.16			

Current diesel	If 60% fossil diesel	And 40% biodiesel
Gallons	Gallons	Gallons
4,344,241	2,606,545	1,737,696

Table 3		Mitigating CO2 Emissions with Biodiesel			Total Emissions	Net savings
	Current diesel	If 60% fossil diesel	And 40% biodiesel	60/40		
	tonnes CO2	tonnes CO2	tonnes CO2	tonnes CO2	tonnes CO2	tonnes CO2
	44,108	26,465	3,802	30,267	13,841	
				Percent savings:		31.4%

Note: This is merely indicative and not a reliable estimate of emissions savings likely with use of biodiesel. CMS assumes that 40 percent of annual diesel fuel consumption can be replaced with biodiesel. While biodiesel use has been successfully used in heavy machinery, CMS has not modeled fuel consumption by month, or estimated months of reliable biodiesel use

Diesel

Cell: E17

Comment: Rick Heede:

Diesel fuel consumption data from Peter Ciborowski, Minnesota Pollution Control Agency. CMS assumes this data is originally from MSI permit application and accurately reflects anticipated diesel fuel demand by haul trucks, front end loaders, mining shovels, and on-site locomotives.

Cell: C20

Comment: Rick Heede:

Haul trucks, front end loaders, mining shovels, and on-site locomotives

Cell: E38

Comment: Rick Heede:

TEBD, Table B.4.

Cell: F38

Comment: Rick Heede:

TEBD, Table B.16.

Cell: G38

Comment: Rick Heede:

Standard values used by EIA and EPA, except the biodiesel coefficient based on NREL analysis and calculated by CMS.

Cell: F54

Comment: Rick Heede:

CMS applies the 1998 NREL conclusion that net carbon savings with biodiesel saves 78.45 percent compared to fossil diesel.

Minnesota Steel GHG Inventory: Annual Transportation Emissions

Proposed Integrated Iron Mine, Taconite, DRI, and Steel Plant

CMS estimates emissions of CO2 from the transportation of 2.5 million tons (tonnes?) of finished steel for a distance of 500 miles from Nashwauk to market; Gary Indiana is 500 trucking miles down the road.

Richard Heede
Climate Mitigation Services
22-May-07

CMS uses several sources for the energy intensity of various transportation modes modeled below. We have estimated high and low intensities for barge, rail and truck. Two multi-modal scenarios rely on three-quarter barge and rail modes plus one-quarter truck.

Estimated energy and emissions from transportation of finished steel

Table 1	Energy intensity Btu/ton-mile	Emissions intensity kg CO2/ton-mile	Emissions/trip-ton kg CO2/500 miles	One-way emissions for annual output		Emissions for vehicle return trip tonnes CO2 (circuitry energy)	Total emissions for shipping finished steel 500 miles tonnes CO2
				2.5 million tons kg CO2	2.5 million tons tonnes CO2		
				Scenario 1a Barge (low est.)	220		
Scenario 1b Barge (high est.)	417	0.0305	15.2	38,103,693	38,104	31,626	69,730
Scenario 2a Rail (low est.)	344	0.0251	12.6	31,433,262	31,433	13,831	45,264
Scenario 2b Rail (high est.)	660	0.0482	24.1	60,308,004	60,308	26,536	86,844
Scenario 3a Truck (low est.)	2,100	0.1535	76.8	191,889,102	191,889	42,216	234,105
Scenario 3b Truck (high est.)	3,420	0.2500	125.0	312,505,110	312,505	68,751	381,256
CMS assumes a 25,000-tonne boat							
Scenario 4 Shipping by "laker"	139	0.0109	5.5	13,674,787	13,675	-	13,675
CMS assumes a 70,000-tonne ship							
Scenario 5 Bluewater ship	69	0.0055	2.7	6,826,074	6,826	-	6,826
one-quarter truck + three-quarter barge							
Scenario 6 Multi-modal	690	0	25	63,049,277	63,049	23,068	86,117
one-quarter truck + three-quarter rail							
Scenario 7 Multi-modal	783	0	29	71,547,222	71,547	20,927	92,474

Note: Trip distance is based on trucking distance to Gary, Indiana: 490 miles one way (CMS uses 500 miles in these scenarios)

Table 2	Heat Content	Carbon Coefficient	Emission Coefficient	Emission Coefficient	Emission Coefficient	Conversion factor
	btu/gallon (net)	kg C/million Btu	lb CO2/gallon	kg carbon per Btu	kg CO2 per Btu	gallons/tonne CO2
Diesel	128,700	19.95	22.384	0.00001995	0.00007310	100.34
Gasoline	115,400	19.34	19.564	0.00001934	0.00007087	114.80
Biodiesel	117,093		4.824	-	-	465.61
Residual (bunker)	138,400	21.49	26.033	0.00002149	0.00007874	86.28
	TEBD, Table B.4	TEBD, Table B.16				

Combination Trucks, 2005 5.1 mpg TEBD, Table 5.2

Estimated energy and emissions from worker commuting

Table 3	Fuel Consumption for two commuting distances and occupancy variables				Emissions for two commuting distances and occupancy variables			
	15-mile commute	15-mile commute	30-mile commute	30-mile commute	15-mile commute	15-mile commute	30-mile commute	30-mile commute
	SOV	DOV	SOV	DOV	SOV	DOV	SOV	DOV
Fuel economy:	18.63	18.63	18.63	18.63	18.63	18.63	18.63	18.63
	Gallons/yr	Gallons/yr	Gallons/yr	Gallons/yr	Tonnes CO2/year	Tonnes CO2/year	Tonnes CO2/year	Tonnes CO2/year

Plant Operation									
# of workers:	700	372,732	186,366	745,464	372,732	3,308	1,654	6,615	3,308

Plant Construction									
# of workers:	2,000	1,064,949	532,475	2,129,898	1,064,949	9,451	4,725	18,901	9,451

SOV: Single Occupancy Vehicle
DOV: Double Occupancy Vehicle

Table 4 Air travel calculation		
gCO2/pax-mile	Million pax-miles/yr	Tonnes CO2/year
435	1,000,000	435

Transportation & Commuting

Cell: I18

Comment: Rick Heede:

CMS uses factors for energy inputs to return transport vehicles for routes in which specialty vehicles or empty returns. CBO does not estimate the energy inputs to deadhead return runs, but does estimate energy inputs to “circuitry,” which estimates deviations from a great circle route between destinations. These factors range from 1.22 for trucking, 1.52 for rail, and 1.83 for barge. See notes below. CMS uses these factors for the actual rail distance between Nashwauk and Gary, Indiana (in our shipping scenario) as well as in lieu of data on deadhead return runs required for shipping steel. Future research may cause these factors to be revised.

Congressional Budget Office (1982) Energy Use in Freight Transportation, 80 pp., CBO Staff Working Paper, www.cbo.gov/showdoc.cfm?index=5330&sequence=0

Cell: D19

Comment: Rick Heede:

Congressional Budget Office (1982), p. 8, estimates propulsion energy for barge transportation ranging from a low of 220 Btu per net ton-mile for downstream barging to a high of 580 Btu/ton-mile for upstream barging, and a mode average of 420 Btu per ton-mile. CMS uses CBO’s low estimate, since Nashwauk/Cedar Rapids is upstream from the preponderance of the steel mills’ markets.

Cell: I19

Comment: Rick Heede:

CBO (1982), p. 8, estimates circuitry energy of 1.83 for barge transportation.

Cell: D21

Comment: Rick Heede:

Table 9.5 TEBD 25. Datum for 2003; five-year average 1999-2003 equals 456 Btu per ton-mile of all domestic water-borne commerce (79 of which is by barge if coast-wise is included, but 97 percent of internal). Although all markets are predominantly downstream, CMS uses this datum, and elects to not calculate roundtrip for the barge. Further research may find that upstream barges may have revenue cargo.

US DOE Center for Transportation Analysis (2006) Transportation Energy Data Book Edition 25, Stacy C. Davis & Susan W. Deigel, ORNL, www-cta.ornl.gov/data/Index.html

Cell: I21

Comment: Rick Heede:

CBO (1982), p. 8, estimates circuitry energy of 1.83 for barge transportation.

Cell: D23

Comment: Rick Heede:

Table 9.10 TEBD 25. Datum for 2003; five-year average 1999-2003 equals 350 Btu per ton-mile for Class 1 Freight Railroads.

Cell: I23

Comment: Rick Heede:

CBO (1982), p. 8, uses a “circuitry” factor of 1.44 for trailer-on-flat-car (TOFC) rail transportation.

Cell: D25

Comment: Rick Heede:

Congressional Budget Office (1982), p. 8, estimates propulsion energy for rail transportation ranging from a low of 370 Btu per net ton-mile for coal trains to a high of 1,000 Btu/ton-mile for trailer-on-flat-car (TOFC), and an average of 660 Btu per ton-mile. CMS uses this average for our high estimate.

Cell: I25

Comment: Rick Heede:

CBO (1982), p. 8, uses a “circuitry” factor of 1.52 for average rail transportation.

Cell: D27

Comment: Rick Heede:

Congressional Budget Service (1982) estimates 2,100 Btu of propulsion energy per ton-mile for average intercity trucking. If,

Transportation & Commuting

as CBO has done for this report, energy inputs to vehicle manufacturing plus construction energy plus maintenance plus circuitry of 1.22, then total trucking uses 3,420 Btu per ton-mile. While this more comprehensive estimate makes a great deal of sense, CMS elects to use CBO's propulsion energy intensity as the low estimate for trucking.

Cell: I27

Comment: Rick Heede:
CBO (1982), p. 8, estimate circuit energy factor of 1.22 for average intercity trucking.

Cell: D29

Comment: Rick Heede:
CMS uses the CBO estimate for total modal energy -- 3,420 Btu per ton-mile -- cited in the above note as the high estimate in this scenario.

Note: The US Energy Information Administration estimates trucking energy as high as 4,800 Btu per ton-mile, although also cites "a combination truck requires 3.1 thousand Btu to haul 1 ton of cargo 1 mile in 1991" Chapter 5. Transportation Sector: www.eia.doe.gov/emeu/efficiency/ee_ch5.htm

Cell: D32

Comment: Rick Heede:
In lieu of energy intensity data for "lakers" plying the trades on the Great Lakes, CMS assumes an energy-intensity twice that used for larger "salties" used for trans-oceanic shipping; CMS thus assumes 309 Btu/ton-mile. Laker boats are restricted in size by the locks, and are typically a ten-to-one beam to length ratio (as opposed to marine ships that are typically ~7to1 due to longer wave distances found at sea). CMS assumes an energy intensity equivalent to a tanker of 25,000 tonnes (~90 kJ/t-km) which converts to 139 Btu per ton-mile.

Bazari, Zabi, & Gill Reynolds (2005) Sustainable Energy in Marine Transportation, Lloyd's Register EMEA, IMarEST Conference, Sustainable Shipping, 1-2 February 2005, ppt. Tankers: ~90 kJ/t-km for 25,000 tonne tankers, ~50 kJ/t-km for 70,000 tonne tankers, and ~25 kJ/t-km for 250,000 tonne tankers.

Cell: I32

Comment: Rick Heede:
See CBO (1982), Table A-4 for estimates of propulsion energy for water transportation, ranging from coastal tanker (278 btu/ton-mile to 678 Btu/ton-mile); barges, US average (325 btu/ton-mile), 440 btu/ton-mile (Rose 1977 est for all domestic water transport (inland, lake, and coastal). None of the energy intensities listed for 1970s and 1980s sources are as low as the datum used by CMS for "lakers" and bluewater shipping. The closest is an estimate by Leilich (1972) of 226 Btu/ton-mile for coastal and lake ship.

Cell: D35

Comment: Rick Heede:
In lieu of energy intensity data of container ships or special carriers, CMS uses the datum for a 70,000-tonne tanker. 50 kJ/t-km converts to 69 Btu/ton-mile.

Bazari, Zabi, & Gill Reynolds (2005) Sustainable Energy in Marine Transportation, Lloyd's Register EMEA, IMarEST Conference, Sustainable Shipping, 1-2 February 2005, ppt. Tankers: ~90 kJ/t-km for 25,000 tonne tankers, ~50 kJ/t-km for 70,000 tonne tankers, and ~25 kJ/t-km for 250,000 tonne tankers.

Cell: I35

Comment: Rick Heede:
A container ship or other trans-oceanic ship will presumably be gainfully employed in both directions.

Cell: E48

Comment: Rick Heede:
TEBD, Table B.4.

Cell: F48

Comment: Rick Heede:
TEBD, Table B.16.

Transportation & Commuting

Cell: G52

Comment: Rick Heede:

Distillate fuel (petroleum diesel) less carbon savings of biodiesel, based on NREL estimate of life-cycle carbon savings: 78.45 percent.

Cell: B70

Comment: Rick Heede:

Draft EIS: Page 6-57, Table 6.14.3 "Planned Major Expansion Projects in the Vicinity of Nashwauk:" Minnesota Steel: 700 jobs created.

Cell: B74

Comment: Rick Heede:

Draft EIS: Page 6-55. During the two peak years of construction, the Minnesota Steel project is anticipated to directly employ over 2,000 people. Indirect and induced impacts from the project could potentially lead to another 1,500 or more spin-off jobs, including temporary, part-time, and full-time jobs created elsewhere in the two counties.

Cell: E82

Comment: Rick Heede:

CMS uses 270 gCO₂ per passenger-km flown, times 1.609 km per mile. Source: www.aef.org.uk/downloads//Howdoesairtravelcompare.doc

	A	B	C	D	E	F	G	H	I	J	K
1											
2		Minnesota Steel GHG Inventory: Emissions from the Use of Explosives									
3		Proposed Integrated Iron Mine, Taconite, DRI, and Steel Plant									
4											
5											
6		CO2-e emissions from the use of explosives in removing overburden and blasting ore deposits and in related operations are relative small but <i>direct</i> source of emissions not estimated by MSI's consulting engineers or in the Draft EIS.			Richard Heede Climate Mitigation Services 2-Jun-07			CMS has no base data from the company on the quantities used per year or per tonne of taconite mined. CMS borrows the CO2-e rate from an open cast coal mine in NSW Australia as a tentative emissions estimate.			
7											
8											
9											
10											
11											
12											
13											
14											
15											
16		Table 1	Preliminary estimate of emissions from use of explosives in taconite mining								
17											
18											
19		MSI mined tonnage of taconite ore per year (tonnes)		13,100,000		tonnes					
20		Emissions rate used for this tentative estimate (kg CO2-e/tonne mined)		0.361		kg CO2-e/tonne					
21		Estimated emissions from the use of explosives (kg CO2-e)		4,734,507		kg CO2-e					
22		Estimated emissions from the use of explosives (tonnes CO2-e)		4,735		tonnes CO2-e					
23											
24											
25											
26											
27											
28											
29		MSI will be in a position to revise this preliminary estimate in due course.									
30											
31		Australian Greenhouse Office (2006) Methods and Workbook, p. 20, shows emissions factors for ANFO, Heavy ANFO, and Emulsion explosives									
32		ANFO = 0.167 tonne CO2/tonne ANFO									
33											
34											
35											
36		Calculation of benchmark emissions rate from the use of explosives in mining									
37											
38		Table 2	Anvil Hill Saleable Production of Coal, Use of Explosives, and Calculation of Emissions Intensity of Explosives								
39			year 2	year 5	year 10	year 15	year 20	project total	average		
40											
41		Production of Saleable Coal tonnes/yr	2,432,000	7,980,000	6,459,995	5,320,017	2,976,928	106,488,764	5,324,438		
42		Run of the mine (ROM) production t/yr	3,200,000	10,500,000	8,499,993	7,000,022	3,917,011	140,116,795	7,005,840		
43		Explosives tonnes/yr	6,571	17,042	17,000	17,345	13,789	302,645	15,132		
44		Explosives tonnes CO2-e/yr	1,099	2,851	2,844	2,902	2,307	50,633	2,532		
45											
46		Explosives kg/tonne prod'n	2.702	2.136	2.632	3.260	4.632	2.842	2.842		
47		Explosives kg CO2-e/t saleable coal	0.452	0.357	0.440	0.545	0.775	0.475	0.476		
48		Explosives kg CO2-e/tonne ROM coal	0.343	0.272	0.335	0.415	0.589	0.361	0.361		
49											
50		Total Anvil Hill Emissions tCO2-e	84,177	226,889	198,409	174,630	119,333	3,351,478	167,574		
51		Explosives CO2 percent of total	1.31%	1.26%	1.43%	1.66%	1.93%	1.51%	1.51%		
52											
53		Note: CMS uses this summary table as a temporary benchmark for roughly estimating CO2-e emissions of the MSI proposed project in lieu of actual data from MSI									
54											
55											
56											
57											

Explosives

Cell: C19

Comment: Rick Heede:

Draft EIS, page EX-2, reports a planned capacity of 13.1 million tonnes of taconite per year. CMS is not aware of estimated tonnes of overburden removal, and uses the annual ore production quantity as the basis for estimating the amount of explosives required.

Note: CMS is not aware of a company estimate of the quantity of explosives anticipated to be used in its mining operations, nor have we found a discussion of the subject in the Draft EIS. CMS thus applies a factor derived from an open cast mine in New South Wales calculated in Table 2 below.

Cell: C21

Comment: Rick Heede:

This emissions rate is based on estimated GHG emissions (in units of kg CO₂-e emitted per tonne of “run of the mine” production of coal averaging ~7 million tonnes per year from a proposed open cast coal mine in New South Wales, Australia. The GHG emissions estimate for this proposed coal mine can be found in See Sustainability Consulting, NSW, for the Centennial Coal Company; www.seesustainability.com.au and www.centennialcoal.com.au.

Note: CMS is using this calculated emissions rate as a preliminary emissions factor due to the paucity of data on the quantity or emissions from MSI’s anticipated use of explosives. MSI will be in a position to revise this preliminary estimate in due course.

Cell: I31

Comment: Rick Heede:

AGO’s Workbook, which contains emissions factors for explosives: ANFO = 0.167 tCO₂/tonne of product, Heavy ANFO = 0.178 tCO₂/t, and Emulsion = 0.166 tCO₂/t.

Australian Greenhouse Office (2006) AGO Factors and Methods Workbook, Dec06, 54pp. www.greenhouse.gov.au/workbook/

Cell: H36

Comment: Rick Heede:

This table calculates an emissions rate for use in the preliminary CMS estimate of GHG emissions from the use of explosives in MSI mining operations in Table 1 above.

Cell: J38

Comment: Rick Heede:

Source: Centennial Coal Company (2006) Final Greenhouse Gas and Energy Assessment for Anvil Hill Project, New South Wales, Australia, by See Sustainability Consulting, Toronto NSW, 10 pp., www.seesustainability.com.au & www.centennialcoal.com.au

Cell: C48

Comment: Rick Heede:

Calculations of the rate of emissions of greenhouse gases per tonne of “run of the mine” (ROM) of coal produced annually by CMS.