Minnesota Steel GHG Inventory: Summary of Annual Emissions

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

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.

Summary of Emissions from the MSI Plant

Table 1		Physical units	MN PCA estimate Emissions	MSI estimate Emissions	CMS estimate Emissions	Percent	Variance
		various	tonnes CO2-e	tonnes CO2-e	tonnes CO2-e	of CMS	(CMS-MSI)/MSI
Electricity	indirect	MWh/yr		1,845,000 MV	3,464,063 MWh		
Carbon dioxide	indirect				2,393,667		
Methane	indirect				518		
Nitrous oxide	indirect				12,031		
Total Electricity			1,077,498	1,538,915	2,406,217	49.4%	56.4%
Natural Gas	direct	million cf/yr					
Concentrator	direct	25	1,464	1,300	1,279		
Pellet Plant	direct	1,222	71,536	61,400	62,592		
DRI	direct	37,218	2,178,748	1,868,100	1,906,279		
Melt Shop	direct	608	83,069	71,300	31,167		
Rolling Mill	direct	810			41,509		
Other natural gas	direct	not estimated					
Total Natural Gas		39,884	2,334,817	2,002,100	2,042,824	41.9%	2.0%
Diesel fuel	direct	gallons/yr					
Mining & crushing equip	direct	4,087,330	45,222	42,500	41,500		
Concentrator	direct	56,324	623	600	572		
Pelletizer	direct	58,880	651	700	598		
DRI	direct	82,819	916	900	841		
Steel mill	direct	58,888	652	700	598		
Total diesel		4,344,241	48,065	45,400	44,108	0.90%	-2.8%
Limestone	direct	tonnes/yr					
Pelletizer	direct	41,804	18,306	18,400	18,353		
Steel mill	direct	30,537	13,372	13,500	13,436		
Total Limestone		72,341	31,679	31,900	31,789	0.65%	-0.3%
Soda Ash	direct	tonnes/yr					
Pelletizer	direct	41,804	17,349	17,400	17,374	0.36%	-0.1%
Non CO2 Carbon-containing inputs	direct						
Pellets (pelletizer)	direct		(1,300)	(1,300)	(1,300)		
Pellets (DRI process)	direct		1,300	1,300	1,300		
Direct-reduced iron (DRI process)	direct		(424,700)	(424,700)	(424,700)		
Direct-reduced iron (steel mill)	direct		424,700	424,700	424,700		
Total Non-CO2 inputs			-	-	-	0.00%	
Other	direct	tonnes/yr					
Powder coating (pelletizer)	direct	67,185	32,100	32,100	32,100		
Concentrate (pelletizer)	direct	3,800,410	20,300	20,300	20,300		
Carbon, as Anthracite (steel mill)	direct	12,185	40,600	40,600	40,600		
Electrodes (steel mill)	direct	4,375	14,600	14,600	14,600		
Casting powder (steel mill)	direct	1,000	900	900	900		
Steel production	direct	2,500,000	(14,300)	(14,300)	(14,300)		
Slag	direct	304,517	(3,400)	(3,400)	(3,400)		
Total Other		na	90,800	90,800	90,800	1.86%	0.0%
Explosives	direct		not estimated	not estimated	4,735	0.10%	
Commuting		gallons/yr	not estimated	not estimated			
Gasoline & diesel (gallons)	indirect	347,088			3,080	0.06%	
Transportation of finished steel	indirect	gallons/yr	not estimated	not estimated			
If Scenario 2a: 500 miles by rail	indirect	4,541,758			45,264	(not included in total)	
If Scenario 3a: Trucking 500 miles	indirect	23,489,956			234,105	4.80%	
Total Direct and Indirect Emissions			3,600,207	3,726,515	4,875,032	100.0%	30.8%

CMS	kg C per kg steel prod'n	0.532	kg CO2 per kg steel prod'n	1.95

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."

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.

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.

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 tones 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	Methane	Methane	Nitrous	Nitrous	Total GHG/MWh
	tonnes CO2/MWh	tonnes CH4/MWh	tonnes CO2-e/MWh	tonnes N2O /MWh	tonnes N2O /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

	Carbon Dioxide	Methane	Methane	Nitrous	Nitrous	Total Electricity		
	tonnes CO2/yr	tonnes CH4/yr	tonnes CO2-e/yr	tonnes N2O /yr	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			Methane	Nitrous
	lbs/kWh	tons/MWh	tonnes/MWh	lbs/MWh	lbs/MWh
Minnesota	1.520	0.762	0.69100	0.01570	0.02470

Table 7 — Conversion to tonnes per MWh

Carbon Dioxide			Methane	Nitrous
lbs/kWh	tons CO2/MWh	tonnes CO2/MWh	tonnes CH4/MWh	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

Table 8

Total electricity demand and estimated annual emissions

	Power demand	Throughput	Throughput	Power Demand	Carbon coeff. MAPP region	CO2 emissions total plant (?)	CO2 emissions per tonne	CH4 & N2O emissions
	MWh/tonne	tons	tonnes	MWh	tonnes CO2/MWh	tonnes	tonne CO2/tonne	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)

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.

Minnesota Steel GHG Inventory: Annual Natural Gas Emissions

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

The emissions estimates by CMS and MSI are in good agreement; CMS carbon coefficent for nautural 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.

Estimated energy and emissions from mining equipment and diesel fuel

Table 1

	Consumption of Natural Gas			CO2 coefficient	CO2 emissions
	Nm^3/yr	Million cf/yr		tonnes CO2/million cf	tonnes CO2
Plant Segment	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 be attributed to the end-user and inlcuded 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

Table 2

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

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

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.

Minnesota Steel GHG Inventory: Mining Equipment: Annual Diesel Emissions

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

The emissions estimates by CMS and MSI are in good agreement; CMS carbon coefficent for diesel fuel is slightly higher.

Richard Heede
Climate Mitigation Services
23-May-07

Estimated energy and emissions from mining equipment and diesel fuel

Table 1

	Diesel fuel consumed	Emissions factor	CO2 emissions	CO2 emissions	CO2 emissions
	Gallons	lb CO2/gallon	lbs CO2	tons CO2	tonnes CO2
Mining & crushing equipment	4,087,330	22.384	91,490,795	45,745	41,500
Concentrator	56,324	22.384	1,260,756	630	572
Pelletizer	58,880	22.384	1,317,970	659	598
DRI	82,819	22.384	1,853,820	927	841
Steel mill	58,888	22.384	1,318,149	659	598
Total diesel consumption and emissions	4,344,241		97,241,491	48,621	44,108

Note: CMS does not include emissions from several Scope 3 sources that could be be attributed to the end-user and inlcuded 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
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

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	Emissions intensity	Emissions/trip-ton	One-way emissions for annual output: 2.5 million tons	One-way emissions for annual output: 2.5 million tons	Emissions for vehicle return trip	Total emissions for shipping finished steel 500 miles
		Btu/ton-mile	kg CO2/ton-mile	kg CO2/500 miles	kg CO2	tonnes CO2	tonnes CO2 (circuitry energy)	tonnes CO2
Scenario 1a	Barge (low est.)	220	0.0161	8.0	20,102,668	20,103	16,685	**36,788**
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: 15-mile commute	15-mile commute	30-mile commute	30-mile commute	Emissions for two commuting distances and occupancy variables: 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

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 requierd for shipping steel. Future researh 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 transportion 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 transportion 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,

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, althgouh 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, adn 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 closes 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.

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 Vicinty 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:
ww.aef.org.uk/downloads//Howdoesairtravelcompare.doc

Minnesota Steel GHG Inventory: Emissions from the Use of Explosives

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

CO2-e emissions from the use of explosives in removing overburden and blasting ore deposits and in related operations are relative small but *direct* 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.

Table 1

Preliminary estimate of emissions from use of explosives in taconite mining

MSI mined tonnage of taconite ore per year (tonnes)	13,100,000	tonnes
Emissions rate used for this tentative estimate (kg CO2-e/tonne mined)	0.361	kg CO2-e/tonne
Estimated emissions from the use of explosives (kg CO2-e)	4,734,507	kg CO2-e
Estimated emissions from the use of explosives (tonnes CO2-e)	4,735	tonnes CO2-e

MSI will be in a position to revise this preliminary estimate in due course.

Australian Greenhouse Office (2006) Methods and Workbook, p. 20, shows emissions factors for ANFO, Heavy ANFO, and Emulsion explosives
ANFO = 0.167 tonne CO2/tonne ANFO

Calculation of benchmark emissions rate from the use of explosives in mining

Table 2

Anvil Hill Saleable Production of Coal, Use of Explosives, and Calculation of Emissions Intensity of Explosives

	year 2	year 5	year 10	year 15	year 20	project total	average
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
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
Explosives tonnes/yr	6,571	17,042	17,000	17,345	13,789	302,645	15,132
Explosives tonnes CO2-e/yr	1,099	2,851	2,844	2,902	2,307	50,633	2,532
Explosives kg/tonne prod'n	2.702	2.136	2.632	3.260	4.632	2.842	2.842
Explosives kg CO2-e/t saleable coal	0.452	0.357	0.440	0.545	0.775	0.475	0.476
Explosives kg CO2-e/tonne ROM coal	0.343	0.272	0.335	0.415	0.589	0.361	0.361
Total Anvil Hill Emissions tCO2-e	84,177	226,889	198,409	174,630	119,333	3,351,478	167,574
Explosives CO2 percent of total	1.31%	1.26%	1.43%	1.66%	1.93%	1.51%	1.51%

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

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 teh subject in the Drafdt EIS. CMS thus applies a factor drived 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 pausity 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/woorkbook/

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.

Curriculum Vitae for

Richard Heede

17 May 2007

Professional History

2002–: Climate consultant, researcher

February 2003–: Principal, Climate Mitigation Services, a consultancy focused on "climate stewardship from inventories to solutions:" comprehensive emissions inventories, protocols, boundary setting, and identification of technologies and strategies to reduce emissions. Client sectors include municipalities, colleges and universities, corporations, international NGOs, architects, and homeowners. Sample projects: *ExxonMobil Emissions Inventory 1882-2002: Methods & Results*, for Friends of the Earth Trust, London, Dec03; *Energy and Climate Plan for the Town of Telluride, Colorado: Audit and Policy Recommendations*, Jun04. *Black Hydrogen: An Assessment of the U.S. Department of Energy's Plans for Nuclear Hydrogen Production*, for Greenpeace USA. Comprehensive GHG emissions inventory for the City of Aspen's Canary Initiative: *Aspen Greenhouse Gas Emissions 2004*. Evaluated supply chain emissions from the annual delivery of 6 million tonnes of liquefied natural gas: *LNG Supply Chain Greenhouse Gas Emissions for the Cabrillo Deepwater Port: Natural Gas from Australia to California.* Currently engaging with the faculty, students, administration, alumni of an Ivy-league university on carbon management; estimating GHG emissions from conventional vs organic milk; emissions from a large proposed integrated iron mine & steel plant in the Mesabi Iron Range in Minnesota, a community-wide inventory for Frisco, Colorado, and the energy and climate impact of second homes in the Aspen area.

October 2002–: researching cryospheric dynamics, paleoclimatology, risk management and cultural change for a semi-fictional environmental thriller (in progress).

1984–2002: Rocky Mountain Institute.

January-July 2002: Researched, wrote, designed, and published *Cool Citizens: Everyday Solutions to Climate Change: Household Solutions Brief*, its methodological background report: *Residential carbon dioxide emissions profile and calculations of climate mitigation measures*, and *Household Climate Neutral Strategy: Emissions Reduction Measures*.

2000-2001: Manager, *Oberlin College: Climate Neutral by 2020*. Principal investigator and co-author of final report & appendices, conducted a comprehensive GHG emissions inventory for year 2000, led building audits, identified profitable measures to reduce emissions, and developed (with Dr. Joel Swisher) three cost-effective scenarios for climate neutrality (net zero emissions) by the year 2020, and coordinated the publication of *Oberlin College: Climate Neutral by 2020* reports.

1999–2000: Climate Services Manager for RMI's Natural Capitalism Practice. Attended COP-5 climate negotiations in Bonn. Delivered an invited paper on energy-saving building design and retrofit at an Electricité de France-sponsored conference in Paris. Researched personal opportunities to cool global warming, a subject of numerous radio interviews and featured at rmi.org. Team Leader of the joint RMI/Oberlin College *Climate Neutral by 2020* project.

1994–1999: Research Scholar. Invited as an "energy oracle" to the World Business Council on Sustainable Development Scenario Unit workshop, Oslo, 1998 (which led to WBCSD's *Energy 2050*, April 1999). Authored, illustrated, designed, and managed the production of *Homemade Money: How to Save Energy and Dollars in Your Home*, a 276-page homeowners' guide to cost-effective energy-saving measures in new and existing homes. Advised a local government committee on how to best strengthen building energy codes. Launched, funded, and drafted several titles in RMI's *Home Energy Brief* series (titles: Lighting, Water Heating, Refrigerators & Freezers, Washing Machines & Dryers & Other Appliances, Windows, Home Office Equipment, and Home Cooling). Edited the electronic edition of *The Energy Directory Kit* and its companion volume *A Creator's Manual*. Headed RMI's marketing of all its new books and briefs. Assessed the environmental impacts of a major resort on Maui, Hawai'i. Wrote testimony recommending to the Hawaii Land Use Commission and Maui Planning Commission denial of the land use zoning change request for a proposed 232 MW oil-fired power plant.

1992–1994: Energy Program Director and Energy Outreach Coordinator. Co-authored (with Linda Baynham) a small book entitled *The Energy Directory: A Guide to Energy-Efficient Products and Services in the Roaring Fork Valley*. Invited participant, Fondation de la Progres de l'Homme's *State of the World Conference*, Montreal, March 1993, and Paris, Sep. 1993. Provided expert review of OECD's draft of a manual of energy efficiency strategies and policies for eastern European member states, Paris, Oct. 1993.

1991–1992: Energy Program Acting Director and Energy Outreach Coordinator. Responsible for managing a staff of three researchers (plus two support staff), three foundation grants, seven research projects, and a $320,000 budget. Helped write several grant proposals that brought in grants totaling $560,000 to the Institute.

1989–1991: Senior Research Associate with RMI's Competitek Group. Co-authored (with Amory Lovins) a path-breaking report on electricity-saving office equipment (computers, components, printers, copiers, communications, & imaging equipment).

1987–1989: Research Associate with the Global Security Program. Researched U.S. and global security concerns regarding imports of critical and strategic materials: oil, manganese, cobalt, and the platinum group metals. The Security team proposed policy initiatives — oil efficiency, cobalt recycling, improved design and processing, platinum recovery, and government stockpile changes — to reduce U.S. vulnerability to supply interruptions. Attended ISODARCO in Venice, 1987, and the Greek North-South Dev. Forum, Athens, 1988.

1984–1987: Research Associate with the Energy Program. Project: comprehensive and oft-quoted study of Federal subsidies to the U.S. energy sector; RMI's analysis and publications led to invited Congressional testimony before House and Senate Subcommittees, *Wall Street Journal* op-ed (with Amory Lovins), and some non-measurable influence on the Tax Reform Act of 1986. Heede also advised Douglas Koplow, then of Harvard and the Alliance to Save Energy (Washington, DC), during Mr. Koplow's research for an update of energy subsidies for fiscal year 1989.

1982-1983: National Center for Atmospheric Research.

Cooperative fellowship between NCAR and the University of Colorado Dept of Geography to map global recoverable fossil fuels and publish a masters thesis on possible resource limits to global climate change. Principal findings: a) no resource limits on fossil carbon exist given foreseeable economic conditions and the rapid progress of exploration and extraction technology; b) severe and costly climatic changes are highly likely; and c) the least costly way to reduce the carbon intensity of the world's economies is to vigorously pursue the diffusion of energy-efficient equipment and techniques. Advisors: Drs. Will Kellogg, Roger Barry, and Ken Erickson. Additional advisor: Gilbert White.

1981-1983: University of Colorado.

Student reference librarian at the University of Colorado's Geology, Physics & Mathematics, Engineering, and Norlin Reference Libraries.

1979-1984: Omega Research.

Founded this small independent company to conduct research and writing for corporations, non-profit organizations, and individual clients. Research expertise in natural resources, mining and minerals, economics, climate, energy, and land use.

Software and mindware

Advanced Microsoft Word, Excel, and Powerpoint skills. Dwindling Norwegian and German. Superior writing and communication skills. Highly numerate. Attentive to detail. Good management experience. Excellent at listening, clarifying objectives, and resolving conflicting ideas and perspectives. Good appreciation of human nature and human potential. High personal work standards. Practiced at the art of the long view. Persistent preference for cutting-edge work.

Education

1980-1983: University of Colorado (MA).

Masters of Geography. Published a Cooperative thesis with the National Center for Atmospheric Research: *A World Geography of Recoverable Carbon Resources in the Context of Possible Climatic Change*; 140 pp, 5 maps. Coursework emphasized environmental economics, energy resources, resource policy, and climate change. GPA: 4.0.

1971-1976: University of Colorado (BA, BA).

Multi-disciplinary course of study in civil and environmental engineering, physics, mathematics, economics, geology, geography, social psychology, political science, and philosophy, with emphasis on energy futures and global environmental issues, and particular focus on energy efficiency, resources, and climate change.

Two BAs: Environmental Studies, and Philosophy. Minor in Economics. GPA: 3.2.

Personal

Born in Oslo, Norway, 7 March 1952. Sailed to the U.S. in June 1967.

Married 1989-1996. Daughter: Shana Breeze Heede, born 17 June 1990.

Designed and built a super-efficient passive solar rammed earth home in Snowmass, CO, 1992, 39.28 N, 107.00 W, elev. 2300 m: 10.7 kWh/m^2-yr, 4.8 kgC/m^2-yr (heat + electricity).

Passions: parenting, relationships, skiing, flying, literature, science, environmental policy, corporate sustainability, science fiction, creative writing (currently writing an environmental thriller), innovation, futurism, human evolution, social psychology, spiritual development, philosophy, & music.

Other activities

Advisor to Helio International's (Paris) Global Energy Sustainability Observatory regarding the selection of sensible indicators and the creation of a network of global observers to report on progress toward energy sustainability. www.helio-international.org

Advisor to Sustainable Cities Trust, Christchurch, regarding Green Development issues, building efficiency, and climate mitigation/carbon reduction strategies.

Advisor to the City of Newcastle's Australian Municipal Energy Improvement Facility (AMEIF) unit pursuant to their goal to reduce corporate and city-wide emissions of greenhouse gases. www.ncc.nsw.gov.au/services/environment/ameif/

Advisor to the Climate Neutral Network, Portland, OR. www.climateneutral.com.

Associate, Real Living Solutions, Vancouver, Canada, www.real-livingsolutions.com

Publications

Heede, Richard (2007) *Cabrillo Deepwater LNG: Testimony to the California State Lands Commission*, written and oral testimony, Oxnard, 9April, commissioned by the California Coastal Protection Network and Environmental Defense Center (Santa Barbara), 10 pp.

Heede, Richard (2007) *From the Dairy Farm to the Consumer: Organic vs Conventional Milk: Comparing Supply Chain Emissions*, commissioned by Sustainable Settings, Carbondale.

Heede, Richard (2007) *Aspen's ZGreen Initiative: Forty GHG emissions reduction measures for Aspen residents, citizens, and visitors*, commissioned by Aspen's Dept. of Environmental Health, Apr07, four worksheets.

Heede, Richard (2007) *Aspen Greenhouse Gas Emissions 1990-2100: Four Scenarios*, commissioned by City of Aspen's Canary Initiative, Jan07, 4 pp., plus four spreadsheets.

Heede, Richard (2006) *Traffic Scenarios for the Entrance to Aspen and Commuting to 2030*, commissioned by City of Aspen's Canary Initiative, Nov06, 8 pp., plus eight spreadsheets.

Heede, Richard (2006) *LNG Supply Chain Greenhouse Gas Emissions for the Cabrillo Deepwater Port: Natural Gas from Australia to California*, commissioned by California Coastal Protection Network and Environmental Defense Center (Santa Barbara), May06, 28 pp., plus spreadsheets (4pp) and cell notes (16 pp).

Heede, Richard (2006) *Aspen Greenhouse Gas Emissions 2004*, for the City of Aspen's Canary Initiative, commissioned by Aspen City Council, Climate Mitigation Services, January, 96 pp, including suite of 14 spreadsheets.

Atlee, Jennifer (2006) *Energy and Sustainable Development in the USA*, Helio International, Paris, 35 pp., www.helio-international.org/reports/2006.cfm. Heede served as reviewer and report coordinator for both the USA and Mexico reports.

Heede, Richard (2005) "Energy and Carbon Savings in a typical Las Vegas Hotel: lighting and shower upgrades," spreadsheet calculations of total annual savings, commissioned by Pineapple Hospitality & Laurie David's "Earth to America" television special, Turner Broadcasting, Nov05.

Heede, Richard (2005) *Supplemental Declaration on behalf of Friends of the Earth v Mosbacher et al, United District Court, San Francisco Division*, for Shems Dunkiel Kassel & Saunders PLLC, Burlington, VT, Dec05, 55 pp.

Heede, Richard (2004) *Declaration and greenhouse gas emissions estimate of the Export-Import Bank of the United States and the Overseas Private Investment Corporation energy portfolios 1990-2004*, for Shems Dunkiel Kassel & Saunders PLLC, Burlington, Jan05, 76 pp.

Heede, Richard (2004) *Black Hydrogen: An Assessment of the U.S. Department of Energy's Plans for Nuclear Hydrogen Production*, commissioned by Greenpeace USA, Climate Mitigation Services, Snowmass, CO, 64 pp.

Heede, Richard, David Houghton, & August Hasz (2004) *Energy and Climate Plan for the Town of Telluride, Colorado: Audit and Policy Recommendations*, June 2004, Climate Mitigation Services and Resource Engineering Group, Snowmass, CO. 46 pp.

Heede, Richard (2003) *ExxonMobil Corporation: Emissions Inventory 1882-2002: Spreadsheet*, Climate Mitigation Services, Snowmass, Colorado, commissioned by Friends of the Earth Trust Limited, London; 13 tabloid worksheets, 72 pp, 5 charts, 1.3 MB. www.foe.co.uk/campaigns/climate/resource/exxonmobil_climate_footprint.html

Heede, Richard (2003) *ExxonMobil Corporation: Emissions Inventory 1882-2002: Methods & Results*, Climate Mitigation Services, Snowmass, Colorado, commissioned by Friends of the Earth Trust Limited, London; 30 pp., 4 charts, references, 8.6 MB.

Heede, Richard (submitted) "The Road Less Traveled (Still): Oberlin College: Climate Neutral by 2020," *International Journal of Sustainability in Higher Education*, 10 pp.

Heede, Richard (2002) "Household Solutions Brief," *Cool Citizens: Everyday Solutions to Climate Change*, Brief #1, 18 pp. Rocky Mountain Institute, Snowmass, CO. Posted at www.rmi.org/sitepages/pid173.php, with "The Climate Neutral Household" chart.

Heede, Richard (2002) "Household Solutions: Residential Carbon Dioxide Emissions Profile and Calculations of Reduction Measures," *Cool Citizens: Everyday Solutions to Climate Change*, 42 pp. Rocky Mountain Institute, Snowmass. www.rmi.org/sitepages/pid173.php.

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Heede, Richard, & Joel Swisher (2002) *Oberlin College: Climate Neutral by 2020*, for David Orr (chair of Oberlin's Dept. of Environmental Studies), and funded by Educational Foundation of America. Rocky Mountain Institute, Snowmass, CO. Main Report, 118 pp, Appendices, 286 pp. Available on CD-ROM from CMS.

Heede, Richard (2001) "The Road Less Traveled (Still): Oberlin College: Climate Neutral by 2020," Greening of the Campus Conference, Ball State University, Indiana, *Proceedings*, 10 pp.

Heede, Richard (2000) *Measuring Energy Sustainability: Evaluating Your Country's Energy Development: A Manual for Users of Helio's Indicators*, Global Energy Observatory, Helio International, Paris, 136 pp; posted at www.heliointernational.org.

Heede, Richard (1999) *Household Opportunities to Cool Global Warming*, Affordable Comfort Conference, Chicago, April 1999.

Heede, Richard (1998) *Maui Electric Company's Proposed 232 MW Waena Generating Station*, invited testimony against its construction by the Maui Tomorrow Citizens' Coalition, Rocky Mountain Institute, Snowmass, CO. Submitted to the State of Hawaii Land Use Commission, and the County of Maui Planning Commission.

Heede, Richard (1998) *Stories of Personal Environmental Opportunities*, commissioned by Center for a New American Dream, Washington, DC, October, 15 pp.

Heede, Richard (1998) U.S. Energy and Carbon Dioxide Savings from Water Heater Energy Factor Improvement, commissioned paper, Snowmass, CO, April, 8 pp.

Heede, Richard (1997) *Grand Wailea Resort (Maui): Environmental Factors*, Rocky Mountain Institute, Snowmass, CO.

Heede, Richard (1997) *Summary of Carbon Emissions by Major Fossil Fuel Producers, 1992-1996*, commissioned by Greenpeace (Amsterdam), 10 pp.

Heede, Richard, & L. Hunter Lovins (1996) *Environmentally Sustainable Energy Choices*, Renew America, Washington, DC, 6 pp.

Heede, Richard (1995) *Homemade Money: How to Save Energy and Dollars in Your Home*, Brick House Publishing Company, Amherst, NH, 76 illustrations, 276 pp.

Cureton, Maureen, Richard Heede, & David Reed (1995) *The Energy Directory Kit*, Rocky Mountain Institute, Snowmass, CO.

Heede, Richard (1994) "The Environmental Kitchen," *Harrowsmith Canada,* Aug94, pp. 60-64.

Yoon, Daniel, & Richard Heede (1994) "Keeping Warm and Staying Cool," *Garbage*, February, pp. 52-57.

Heede, Richard, & Linda Baynham (1993) *The Energy Directory: A Guide to Energy-Efficient Goods and Services in the Roaring Fork Valley*, Rocky Mountain Institute, Snowmass, 80 pp.

Heede, Richard (1993) "Energy Policy Recommendations for the Clinton Administration," Environmental Action Foundation *Newsletter*, Washington, DC.

Lovins, L. Hunter, Amory B. Lovins, & Richard Heede (1992) "Energy Policy," in *Changing America: Blueprints for the New Administration,* edited by Mark Green of the Citizens Transition Project, Newmarket Press, New York, 1992, pp. 671-686.

Heede, Richard, & Robert Bishop (1991) "Corporate Wealth through Waste," *Sierra magazine*, July/August 1991, pp. 16-18.

Heede, Richard (1991) "Waste Not, Want Not," *Institutional Investor*, p. 12.

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