

**ELK CREEK MINE AREA METHANE EMISSIONS REPORT TO COLORADO PUBLIC UTILITIES COMMISSION**  
**by Ruby Canyon Environmental for 3 MW LLC and Vessels Carbon Solutions Inc.**  
**October 19, 2020**

The Project being reported captures and destroys fugitive mine methane by electricity generation and thermal oxidation at the Elk Creek Mine Area.

Engines and Thermal Oxidizer(s)										
Item	Description	Units	2012	2013	2014	2015	2016	2017	2018	2019
Estimated total methane emissions with no methane capture - Modeled <sup>1</sup>	Amount of methane that would have escaped to the atmosphere using modeled emissions (High Case) <sup>1</sup>	Cubic feet of methane	1,585,947,450	1,529,162,484	1,476,535,496	1,429,683,938	4,298,039,936	4,077,631,870	3,877,761,324	3,693,267,248
Estimated total methane emissions with no methane capture - Modeled	Amount of methane that would have escaped to the atmosphere using modeled emissions (High Case) <sup>1</sup>	Metric tons of methane	30,457	29,366	28,356	27,456	82,540	78,308	74,469	70,926
Estimated Baseline Emissions - Modeled <sup>1</sup>	Emissions that would have been emitted to the atmosphere.	Metric tons of carbon dioxide equivalent	2,558,376	2,466,773	2,381,877	2,306,299	6,933,395	6,577,843	6,255,422	5,957,804
Estimated Baseline Emissions - Actual Measured Flow <sup>2,3</sup>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	59,570	338,607	688,064	728,812	642,491	605,211	489,617	478,102
Estimated methane emissions that remain and are still emitted - Modeled		Metric tons of carbon dioxide equivalent	2,498,806	2,128,165	1,693,813	1,577,486	6,290,904	5,972,632	5,765,805	5,479,702
Modeled	Daily Amount of Automobiles Emitting Same Amount of Emissions <sup>4</sup>		556,169	536,255	517,799	501,369	1,507,260	1,429,966	1,359,874	1,295,175
Modeled	Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions <sup>5</sup>		3,322,566	3,203,601	3,093,347	2,995,193	9,004,409	8,542,654	8,123,924	7,737,408
Measured	Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided <sup>4</sup>		12,950	73,610	149,579	158,437	139,672	131,568	106,438	103,935
Measured	Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided <sup>5</sup>		77,364	439,750	893,590	946,510	834,404	785,988	635,866	620,912

Note 1: Assessment of Eligibility for the Renewable Energy Standard of Electricity Generated by 3 MW LLC From the Combustion of the Short-Lived Climate Pollutant, Methane, Emitting from the Elk Creek Mine Area of the Somerset Coal Field, Colorado. <sup>10</sup>  
 October 19, 2020 - Filed with Colorado Public Utilities Commission

Note 2: These emission estimations are based on calculated total methane values and the Colorado greenhouse gas neutrality calculator. The calculator template can be provided by request from the Colorado Energy Office.

<https://www.colorado.gov/energyoffice>

Note 3: These emission estimations are based on the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report 20-year global warming potential of methane.

[https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5\\_Chapter08\\_FINAL.pdf](https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf)

Note 4: One passenger vehicle emits about 0.013 tons of CO2 per day.

<https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#:~:text=typical%20passenger%20vehicle%3F-,A%20typical%20passenger%20vehicle%20emits%20about%204.6%20metric%20tons%20of,8%2C887%20grams%20of%20CO2.>

Note 5: 0.002 metric ton CO2/acre/day sequestered by one acre of average U.S. forest

<https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#pineforests>

Engines and thermal oxidizer(s)										
Item	Description	Units	2012	2013	2014	2015	2016	2017	2018	2019
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines and thermal oxidizer(s).	Cubic feet of methane	36,927,679	209,904,155	1,094,870,843	719,212,254	710,446,302	598,614,241	353,616,259	296,377,375
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines and thermal oxidizer(s).	Metric tons of methane	709	4,031	21,026	13,812	13,644	11,496	6,791	5,692
<b>Estimated Baseline Emissions<sup>1,2</sup></b>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	59,570	338,607	688,064	728,812	642,491	605,211	489,617	478,102
<b>Estimated Project Emissions<sup>1,2</sup></b>	Calculated emissions that escaped while the Project was operating. Emissions are a result of: 1) Carbon dioxide emissions resulting from the combustion of methane in the Project engines/thermal oxidizer(s) and, 2) Methane emissions resulting from the incomplete combustion of the mine gas in the Project engines/thermal oxidizer(s).	Metric tons of carbon dioxide equivalent	3,384	19,007	99,446	64,376	93,099	85,065	61,367	58,271
<b>Estimated Emission Reductions<sup>1,2</sup></b>	Calculated emission reductions (baseline emissions minus project emissions).	Metric tons of carbon dioxide equivalent	56,186	319,600	588,618	664,437	549,392	520,146	428,250	419,831
<b>Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided<sup>3</sup></b>			12,214	69,478	127,960	144,443	119,433	113,075	93,098	91,268
<b>Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided<sup>4</sup></b>			72,968	415,065	764,439	862,905	713,497	675,514	556,169	545,234

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Note 4: 0.002 metric ton CO2/acre/day sequestered by one acre of average U.S. forest

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Engines										
Item	Description	Units	2012	2013	2014	2015	2016	2017	2018	2019
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines.	Cubic feet of methane	4,650,000	52,390,000	238,910,000	264,170,000	251,080,000	245,740,000	237,649,936	256,073,342
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines.	Metric tons of methane	89	1,006	4,588	5,073	4,822	4,719	4,564	4,918
<b>Estimated Baseline Emissions<sup>1,2</sup></b>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	7,501	84,513	385,398	426,147	339,825	302,545	302,545	413,085
<b>Estimated Project Emissions<sup>1,2</sup></b>	Calculated emissions that escaped while the Project was operating. Emissions are a result of: 1) Carbon dioxide emissions resulting from the combustion of methane in the Project engines and, 2) Methane emissions resulting from the incomplete combustion of the mine gas in the Project engines.	Metric tons of carbon dioxide equivalent	390	4,396	20,046	22,165	50,487	52,332	50,609	54,533
<b>Estimated Emission Reductions<sup>1,2</sup></b>	Calculated emission reductions (baseline emissions minus project emissions).	Metric tons of carbon dioxide equivalent	7,111	80,117	365,352	403,981	289,338	250,213	251,936	358,553
<b>Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided<sup>3</sup></b>			1,546	17,417	79,424	87,822	62,900	54,394	54,769	77,946
<b>Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided<sup>4</sup></b>			9,235	104,048	474,484	524,651	375,764	324,952	327,189	465,653

Note 1: These emission estimations are based on calculated total methane values and the Colorado greenhouse gas neutrality calculator. The calculator template can be provided by request from the Colorado Energy Office.

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Thermal oxidizer(s)										
Item	Description	Units	2012	2013	2014	2015	2016	2017	2018	2019
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project thermal oxidizer(s).	Cubic feet of methane	32,277,679	157,514,155	855,960,843	455,042,254	459,366,302	352,874,241	115,966,323	40,304,033
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project thermal oxidizer(s).	Metric tons of methane	620	3,025	16,438	8,739	8,822	6,777	2,227	774
<b>Estimated Baseline Emissions<sup>1,2</sup></b>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	52,069	254,094	302,666	302,666	302,666	302,666	187,071	65,017
<b>Estimated Project Emissions<sup>1,2</sup></b>	Calculated emissions that escaped while the Project was operating. Emissions are a result of: 1) Carbon dioxide emissions resulting from the combustion of methane in the Project thermal oxidizer(s) and, 2) Methane emissions resulting from the incomplete combustion of the mine gas in the Project thermal oxidizer(s).	Metric tons of carbon dioxide equivalent	2,994	14,611	79,400	42,210	42,612	32,733	10,757	3,739
<b>Estimated Emission Reductions<sup>1,2</sup></b>	Calculated emission reductions (baseline emissions minus project emissions).	Metric tons of carbon dioxide equivalent	49,075	239,483	223,266	260,455	260,054	269,933	176,314	61,278
<b>Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided<sup>3</sup></b>			<b>10,668</b>	<b>52,062</b>	<b>48,536</b>	<b>56,621</b>	<b>56,534</b>	<b>58,681</b>	<b>38,329</b>	<b>13,321</b>
<b>Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided<sup>4</sup></b>			<b>63,733</b>	<b>311,017</b>	<b>289,955</b>	<b>338,254</b>	<b>337,733</b>	<b>350,562</b>	<b>228,979</b>	<b>79,582</b>

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Engines and thermal oxidizer(s)				
Item	Description	Units	2019	2019-2023
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines and thermal oxidizer(s).	Cubic feet of methane	<b>296,377,375</b>	<b>1,481,886,877</b>
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines and thermal oxidizer(s).	Metric tons of methane	<b>5,692</b>	<b>28,458</b>
<b>Estimated Baseline Emissions<sup>1,2</sup></b>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	<b>478,102</b>	<b>2,390,510</b>
<b>Estimated Project Emissions<sup>1,2</sup></b>	Calculated emissions that escaped while the Project was operating. Emissions are a result of: 1) Carbon dioxide emissions resulting from the combustion of methane in the Project engines/thermal oxidizer(s) and, 2) Methane emissions resulting from the incomplete combustion of the mine gas in the Project engines/thermal oxidizer(s).	Metric tons of carbon dioxide equivalent	<b>58,271</b>	<b>291,357</b>
<b>Estimated Emission Reductions<sup>1,2</sup></b>	Calculated emission reductions (baseline emissions minus project emissions).	Metric tons of carbon dioxide equivalent	<b>419,831</b>	<b>2,099,153</b>
<b>Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided<sup>3</sup></b>			<b>91,268</b>	
<b>Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided<sup>4</sup></b>			<b>545,234</b>	
<b>Carbon Neutrality</b>	Is the project carbon neutral (are project emissions less than baseline emissions)?	N/A	<b>Yes</b>	<b>Yes</b>

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Engines				
Item	Description	Units	2019	2019-2023
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines.	Cubic feet of methane	<b>256,073,342</b>	<b>1,280,366,712</b>
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project engines.	Metric tons of methane	<b>4,918</b>	<b>24,588</b>

<b>Estimated Baseline Emissions<sup>1,2</sup></b>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	<b>413,085</b>	<b>2,065,427</b>
<b>Estimated Project Emissions<sup>1,2</sup></b>	Calculated emissions that escaped while the Project was operating. Emissions are a result of: 1) Carbon dioxide emissions resulting from the combustion of methane in the Project engines and, 2) Methane emissions resulting from the incomplete combustion of the mine gas in the Project engines.	Metric tons of carbon dioxide equivalent	<b>54,533</b>	<b>272,664</b>
<b>Estimated Emission Reductions<sup>1,2</sup></b>	Calculated emission reductions (baseline emissions minus project emissions).	Metric tons of carbon dioxide equivalent	<b>358,553</b>	<b>1,792,763</b>
<b>Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided<sup>3</sup></b>			<b>77,946</b>	
<b>Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided<sup>4</sup></b>			<b>1,276</b>	

<b>Carbon Neutrality</b>	Is the project carbon neutral (are project emissions less than baseline emissions)?	N/A	<b>Yes</b>	<b>Yes</b>
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Thermal Oxidizer(s)				
Item	Description	Units	2019	2019-2023
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that <u>would have escaped</u> to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project thermal oxidizer(s).	Cubic feet of methane	<b>40,304,033</b>	<b>201,520,165</b>
<b>Estimated Total Methane Emissions</b>	Amount of methane emissions that would have escaped to the atmosphere in the absence of the Project and calculated by the volume of methane sent to the Project thermal oxidizer(s).	Metric tons of methane	<b>774</b>	<b>3,870</b>
<b>Estimated Baseline Emissions<sup>1,2</sup></b>	Calculated emissions that would have been emitted to the atmosphere in the absence of the Project.	Metric tons of carbon dioxide equivalent	<b>65,017</b>	<b>325,083</b>
<b>Estimated Project Emissions<sup>1,2</sup></b>	Calculated emissions that escaped while the Project was operating. Emissions are a result of: 1) Carbon dioxide emissions resulting from the combustion of methane in the Project thermal oxidizer(s) and, 2) Methane emissions resulting from the incomplete combustion of the mine gas in the Project thermal oxidizer(s).	Metric tons of carbon dioxide equivalent	<b>3,739</b>	<b>18,693</b>
<b>Estimated Emission Reductions<sup>1,2</sup></b>	Calculated emission reductions (baseline emissions minus project emissions).	Metric tons of carbon dioxide equivalent	<b>61,278</b>	<b>306,389</b>
<b>Daily Amount of Automobiles Emitting Same Amount of Emissions Avoided<sup>3</sup></b>			<b>13,321</b>	
<b>Daily Amount of Forest Acres to Sequester Same Amount of Daily Emissions Avoided<sup>4</sup></b>			<b>79,582</b>	
<b>Carbon Neutrality</b>	Is the project carbon neutral (are project emissions less than baseline emissions)?	N/A	<b>Yes</b>	<b>Yes</b>

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## 2019 methane captured from abandoned coal mine

This workbook is a summary calculation providing evidence that an active or abandoned coal mine methane destruction project is carbon neutral. If the emission reduction number is positive, this means that the volume of greenhouse gases emitted into the atmosphere from the conversion of fuel to electricity is no greater than the volume of greenhouse gases that would have been emitted into the atmosphere over the next five years, beginning with the planned date of operation of the facility, if the fuel had not been converted to electricity.

### Inputs

#### Emission Reduction (carbon dioxide equivalents)

Baseline Emissions over 5 years  
 Project Emissions over 5 years  
 Uncertainty Deduction  
 Baseline CH4 emitted to atmosphere  
 CH4 from decline curve  
 MCF of methane  
 Methane liberation rate when active  
 Mine sealed or venting (click in cell)  
 Methane drainage (click in cell)  
 Date of closure  
 Degree of sealing  
 Hyperbolic exponent  
 Initial Decline Rate, 1/day  
 Elapsed time of closure  
 Days in reporting period  
 Project Emissions  
 Energy consumed  
 Electricity production per year  
 Avoided grid emissions (click in cell)  
 Destruction device (click in cell)  
 Additional electricity  
 Additional fossil fuel  
 Fossil fuel (click in cell)  
 CO2e from CH4 destruction  
 CH4 destroyed by device  
 CH4 sent to devices  
 Abandoned mine well(s) flow  
 Post-mining gob well flow methane content  
 Emissions from uncombusted CH4  
 Methane sent to devices  
  
 Destruction efficiency  
 Constant  
 Constant  
 CO2 from destruction of CH4  
 Constant  
 Constant (CEF)  
 Constant  
 Choose an IPCC Assessment Report

Parameter	Value	Unit
<b>Total ERs</b>	<b>1,792,763</b>	
BE	2,065,427	MT CO <sub>2</sub> e
PE	272,664	MT CO <sub>2</sub> e
UD	1.0	
BE <sub>MR</sub>	2,065,427	MT CO <sub>2</sub> e
AMM <sub>DC</sub>	35,320	MT CH <sub>4</sub>
MCF <sub>CH4</sub>	366,770	Mcf / year
LR <sub>AMM, MCF</sub>	5,944	Mcf / day
Status	Venting	
Drainage	yes	yes / no
Date of Closure	2/1/2016	
S	1.0	
b	1.88658	
D <sub>i</sub>	0.003519	1/day
t	1,562	days
Rp <sub>days</sub>	365	days
PE	272,664	MT CO <sub>2</sub> e
PE <sub>EC</sub>	0	MT CO <sub>2</sub> e
PROD <sub>elec</sub>	28,207	MWhr / year
Claiming	no	
Device		type
CONS <sub>ELEC</sub>	3	MWhr
CONS <sub>FF</sub>	-	gallons
CEF <sub>FF</sub>		type
PE <sub>MD</sub>	66,121	MT CO <sub>2</sub> e
MD <sub>PJ</sub>	24,097	MT CH <sub>4</sub>
MM <sub>PJ</sub>	24,588	MT CH <sub>4</sub>
PGW <sub>PJ</sub>	256,073	mcf / year
PGW <sub>PJ</sub> C <sub>CH4</sub>	100%	% CH <sub>4</sub>
PE <sub>UM</sub>	206,543	MT CO <sub>2</sub> e
MM <sub>PJ</sub>	24,588	MT CH <sub>4</sub>
	98.00%	
De <sub>i</sub>		EF by device
lb. CH <sub>4</sub> /scf CH <sub>4</sub>	4.23E-02	
MT CH <sub>4</sub> /lb. CH <sub>4</sub>	4.54E-04	
CEF <sub>CH4</sub>	2.744	
kg / MT	1,000	
CEF <sub>ELEC</sub>	0.58	tonnes CO <sub>2</sub> / MWhr
GWP <sub>CH4</sub>	84	
IPCC Report	AR5 (20 year GWP)	AR Report

Note: 93.6% is default destruction efficiency under ARB, but actual engine destruction efficiency is around 98%.



## 2019 methane captured from abandoned coal mine

This workbook is a summary calculation providing evidence that an active or abandoned coal mine methane destruction project is carbon neutral. If the emission reduction number is positive, this means that the volume of greenhouse gases emitted into the atmosphere from the conversion of fuel to electricity is no greater than the volume of greenhouse gases that would have been emitted into the atmosphere over the next five years, beginning with the planned date of operation of the facility, if the fuel had not been converted to electricity.

### Inputs

#### Emission Reduction (carbon dioxide equivalents)

Baseline Emissions over 5 years  
 Project Emissions over 5 years  
 Uncertainty Deduction  
 Baseline CH4 emitted to atmosphere  
 CH4 from decline curve  
 MCF of methane  
 Methane liberation rate when active  
 Mine sealed or venting (click in cell)  
 Methane drainage (click in cell)  
 Date of closure  
 Degree of sealing  
 Hyperbolic exponent  
 Initial Decline Rate, 1/day  
 Elapsed time of closure  
 Days in reporting period  
 Project Emissions  
 Energy consumed  
 Electricity production per year  
 Avoided grid emissions (click in cell)  
 Destruction device (click in cell)  
 Additional electricity  
 Additional fossil fuel  
 Fossil fuel (click in cell)  
 CO2e from CH4 destruction  
 CH4 destroyed by device  
 CH4 sent to devices  
 Abandoned mine well(s) flow  
 Post-mining gob well flow methane content  
 Emissions from uncombusted CH4  
 Methane sent to devices  
 Destruction efficiency  
 Constant  
 Constant  
 CO2 from destruction of CH4  
 Constant  
 Constant (CEF)  
 Constant  
 Choose an IPCC Assessment Report

Parameter	Value	Unit
<b>Total ERs</b>	<b>306,389</b>	
BE	325,083	MT CO <sub>2</sub> e
PE	18,693	MT CO <sub>2</sub> e
UD	1.0	
BE <sub>MR</sub>	325,083	MT CO <sub>2</sub> e
AMM <sub>DC</sub>	35,320	MT CH <sub>4</sub>
MCF <sub>CH4</sub>	366,770	Mcf / year
LR <sub>AMM, MCF</sub>	5,944	Mcf / day
Status	Venting	
Drainage	yes	yes / no
Date of Closure	2/1/2016	
S	1.0	
b	1.88658	
D <sub>i</sub>	0.003519	1/day
t	1,562	days
Rp <sub>days</sub>	365	days
PE	18,693	MT CO <sub>2</sub> e
PE <sub>EC</sub>	0	MT CO <sub>2</sub> e
PROD <sub>Elec</sub>	28,206,541	MWhr / year
Claiming	no	
Device		type
CONS <sub>ELEC</sub>	3	MWhr
CONS <sub>FF</sub>	-	gallons
CEF <sub>FF</sub>		type
PE <sub>MD</sub>	10,566	MT CO <sub>2</sub> e
MD <sub>PJ</sub>	3,851	MT CH <sub>4</sub>
MM <sub>PJ</sub>	3,870	MT CH <sub>4</sub>
PGW <sub>PJ</sub>	40,304	mcf / year
PGW <sub>PJ</sub> C <sub>CH4</sub>	100%	% CH <sub>4</sub>
PE <sub>UM</sub>	8,127	MT CO <sub>2</sub> e
MM <sub>PJ</sub>	3,870	MT CH <sub>4</sub>
De <sub>i</sub>	99.5%	EF by device Enclosed flare
lb. CH <sub>4</sub> /scf CH <sub>4</sub>	4.23E-02	
MT CH <sub>4</sub> /lb. CH <sub>4</sub>	4.54E-04	
CEF <sub>CH4</sub>	2.744	
kg / MT	1,000	
CEF <sub>ELEC</sub>	0.58	tonnes CO <sub>2</sub> / MWhr
GWP <sub>CH4</sub>	84	
IPCC Report	AR5 (20 year GWP)	AR Report