

# Montana Greenhouse Gas Inventory and Projections

Revisions February 1, 2007

## Appendix E: Fossil Fuel Sector

Greenhouse gas (GHG) emissions are released during the production, processing, transmission, distribution, and consumption of fossil fuels. This Appendix reports GHGs emitted as a result of these activities, both combustion emissions from fuel consumption in the production, processing, and transport of fossil fuels,<sup>1</sup> as well as fugitive emissions from coal mining and oil and gas systems. Fugitive emissions are releases of methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) gases released via leakage and venting at coal mines, oil and gas fields, processing facilities, and pipelines. Nationally, fugitive emissions from natural gas systems, petroleum systems, and coal mines accounted for 2.8% of total US GHG emissions in 2004 on a CO<sub>2</sub> equivalent basis.<sup>2</sup>

### *Industry Overview*

Oil production in Montana peaked in 1968 at 49 million barrels annually.<sup>3</sup> Montana currently ranks 10<sup>th</sup> in oil production among US states, accounting for about 1% of US crude oil production. Montana's proved crude oil reserves sit at 364 million barrels, 1% of US proved reserves. Montana has 4 petroleum refineries, with a combined crude oil distillation capacity of 66 million barrels annually.<sup>4</sup> Alberta crude oil is the primary crude oil source for these refineries: in recent years, Alberta has provided 75% for the crude oil processed by Montana refineries, with 4% coming from Montana and 21% from Wyoming.<sup>5</sup>

Montana's currently produces more natural gas than it consumes. For example, in 2002, Montana produced 86 billion cubic feet (Bcf) and consumed 70 Bcf. Natural gas price increases since 2000 have resulted in increased Montana gas production. Coal bed methane has not yet become a significant source of natural gas production in the state, but is expected to play a larger role in the near future.<sup>6</sup> There is interest in coal-to-liquids development in Montana, as indicated by Governor Brian Schweitzer's October 2, 2006 announcement of plans for a coal-to-liquids plant near Roundup.<sup>7</sup> Still, any commercial scale coal-to-liquids production appears to be a number of years away.<sup>8</sup>

---

<sup>1</sup> Note that any GHG emissions resulting from energy consumed in the mining of coal are excluded from this sector, due to lack of disaggregated data for this activity. Instead, these GHG emissions are aggregated within the emissions reported for the industrial sector (see Appendix B).

<sup>2</sup> "The US Inventory of Greenhouse Gas Emissions and Sinks", US EPA, 2005.

<sup>3</sup> "Understanding Energy in Montana", DEQ Report for the EQC, October 2004, Accessed at <[www.leg.mt.gov/content/publications/lepo/2005\\_deq\\_energy\\_report](http://www.leg.mt.gov/content/publications/lepo/2005_deq_energy_report)>

<sup>4</sup> US DOE Energy Information Administration website.

<sup>5</sup> "Understanding Energy in Montana", DEQ Report for the EQC, October 2004.

<sup>6</sup> "Understanding Energy in Montana", DEQ Report for the EQC, October 2004, Accessed at <[www.leg.mt.gov/content/publications/lepo/2005\\_deq\\_energy\\_report](http://www.leg.mt.gov/content/publications/lepo/2005_deq_energy_report)>

<sup>7</sup> On-line news sources – CBS, Reuters, Billings Gazette, etc. Accessed December 15, 2006.

<sup>8</sup> Montana Governor Brian Schweitzer Hot Topics Accessed at <http://governor.mt.gov/hottopics/faqsynthetic.asp> Accessed January 15, 2007.

Montana has six operational coal mines which produced 40 million short tons of coal in 2005.<sup>9</sup> Of Montana’s six coal mines, one is underground, while five are surface mines.

**Oil and Gas Industry Emissions**

Emissions of carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) occur at many stages of production, processing, transmission, and distribution of fossil fuels. With over 4,000 oil wells and over 5,000 gas wells in the state, 3 operational gas processing plants, 4 oil refineries, and over 10,000 miles of gas pipelines<sup>10</sup>, there are significant uncertainties associated with estimates of the state’s GHG emissions from the fossil fuels sector. This is compounded by the fact that there are no regulatory requirements to track CO<sub>2</sub> or methane emissions. As a result, greenhouse gas emissions can only be estimated based on industry-wide averages reported at the state level.

Fortunately, the State Greenhouse Gas Inventory Tool (SGIT) developed by the US EPA facilitates development of an estimate of state-level fugitive greenhouse gas emissions from gas and oil systems.<sup>11</sup> Methane emission estimates are calculated by multiplying emissions-related activity levels (e.g. miles of pipeline, number of compressor stations) by aggregate emission factors. Key information sources for the activity data are the EIA, Gas Facts, and Energize Montana. Methane emissions were estimated using SGIT, with reference to the EIIP guidance document.

Table E1 provides an overview of the required data and data sources used to calculate inventory estimates.

**Table E1. Approach to Estimating Historical Carbon Dioxide and Methane Emissions from Natural Gas and Oil Systems**

	<b>Approach to Estimating Historical Emissions</b>	
<i>Activity</i>	<i>Required Data for SGIT</i>	<i>Data Source</i>
Natural Gas Drilling and Field Production	Number wells	EIA
	Miles of gathering pipeline	Gas Facts <sup>12</sup>
Natural Gas Processing	Number gas processing plants	EIA <sup>13</sup>
Natural Gas Transmission	Miles of transmission pipeline	Gas Facts <sup>12</sup>
	Number of gas transmission compressor stations	EIIP <sup>14</sup>
	Number of gas storage compressor stations	EIIP <sup>15</sup>

<sup>9</sup> Energy Information Administration data.

<sup>10</sup> Data from the Energy Information Administration and the American Gas Association’s annual publication “Gas Facts”.

<sup>11</sup> Methane emissions were calculated using SGIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 5. “Methods for Estimating Methane Emissions from Natural Gas and Oil Systems”, March 2005.

<sup>12</sup> No Gas Facts available for 1991 and 1993, so a linear relationship was assumed to extrapolate from the previous and subsequent year.

<sup>13</sup> EIA reported data for 1995 and 2004.

<sup>14</sup> Number of gas transmission compressor stations = miles of transmission pipeline x 0.006 EIIP. Volume VIII: Chapter 5. March 2005.

<sup>15</sup> Number of gas storage compressor stations = miles of transmission pipeline x 0.0015 EIIP. Volume VIII: Chapter 5. March 2005.

	Number of LNG storage compressor stations	Unavailable, assumed negligible.
Natural Gas Distribution	Miles of distribution pipeline	Gas Facts <sup>12</sup>
	Total number of services	Gas Facts
	Number of unprotected steel services	Ratio estimated from 2002 data <sup>16</sup>
	Number of protected steel services	Ratio estimated from 2002 data <sup>16</sup>
Natural Gas Industry (fuel use)	Annual amount of energy consumed	EIA <sup>17</sup>
Coal Bed Methane – Entrained CO <sub>2</sub>	Average % CO <sub>2</sub>	Industry and Government Contacts
Oil Production	Annual production	EIA <sup>18</sup>
Oil Refining (fuel use)	Annual amount of energy consumed	EIA <sup>19</sup>
Oil Refining	Annual amount refined	EIA <sup>20</sup>
Oil Transport	Annual oil transported	Unavailable, assumed oil refined = oil transported

### Coal Production Emissions

Methane occurs naturally in coal seams, and is typically vented during mining operations for safety reasons. Coal mine methane emissions are usually considerably higher, per unit of coal produced, from underground mining than from surface mining.

Methane emissions from coal mines in this inventory are as reported by the EPA, and include emissions from underground coal mines, surface mines, and post-mining activities.<sup>21</sup> As Montana currently has only one underground mine, coal mine methane emissions are a small contribution to total fossil fuel emissions. Note that any GHG emissions resulting from energy consumed in the mining of coal are excluded from this sector, due to lack of disaggregated data. Instead, these GHG emissions are aggregated within the emissions reported from the industrial sector (see Appendix B).

### *Future Fossil Fuel Industry Emissions*

<sup>16</sup> Gas Facts reported unprotected and protected steel services for 2002, but only total services for other years. Therefore the ratio of unprotected and protected steel services in 2002 was assumed to be the ratio for all other years (0.4891 for protected services and 0.0045 for unprotected services). This yields more congruent results than the EIIP guidance of using multipliers of 0.2841 total services for protected steel services, and 0.0879 for unprotected steel services.

<sup>17</sup> Energy Information Administration reports natural gas lease fuel, plant fuel, pipeline and distribution use, and refinery gas.

<sup>18</sup> Data extracted from the Petroleum Supply Annual for each year.

<sup>19</sup> Data on refinery gas consumption from EIA's State Energy Data.

<sup>20</sup> Refining assumed to be equal to the total input of crude oil into PADD IV times the ratio of Montana's refining capacity to PADD IV's total refining capacity. No data for 1995 and 1997, so linear relationship assumed from previous and subsequent years.

<sup>21</sup> Emissions from EPA *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004* (April 2006) <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

Estimating potential future GHG emissions from oil and gas systems and coal mining requires estimation of production, processing, and transport of these fossil fuels. Future projections of methane emissions from oil and gas systems are calculated based on two key drivers:

- Consumption – projections of natural gas consumption in Montana.
- Production – projected production of coal, natural gas, and oil, including unconventional sources, are included in the fossil fuel scenarios below.

Due to the high levels of uncertainty surrounding future fossil fuel activity in Montana, particularly around the development of ‘unconventional’ sources and the GHG emissions associated with these, two scenarios were developed for future fossil fuel emissions – the reference case and the high fossil fuel production scenario (these two cases were also developed for the electric sector). For each case, simple assumptions were made to develop projections for fossil fuel activities, relying to the extent possible on existing proposals and announcements regarding oil, gas, and coal projects in Montana.

*Reference Case*

Projected emissions for the reference case are generally based on an assumption of a continuation of recent trends in production and processing trends in the State, or on an assumption of emission levels holding flat at current levels (where trends are hard to discern or no new facilities are planned). Simple assumptions were made for activities with minimal impact on the inventory, such as gas processing and coal mine methane. Assumptions for the reference case projections are outlined in Table E2.

**Table E2. Key Assumptions and Methods for Reference Case Projections for Montana**

<i>Activity</i>	<i>Key Assumptions</i>
Natural Gas Drilling and Field Production	Emissions follow trend of natural gas production, which continues to grow at 4.5% annually until 2010, then holds flat until 2020. <sup>22</sup>
Natural Gas Processing	With only 3 gas processing plants in the state (declining from 8 in 1995), gas processing emissions projected to hold flat until 2020. <sup>23</sup>
Natural Gas Transmission	Emissions continue to grow at an average of 0.5% annually. <sup>24</sup>
Natural Gas Distribution	Distribution emissions projected to follow growth in natural gas consumption, based on AEO regional projections. <sup>25</sup>
Coal Bed Methane	Assumes very limited CBM activity (production system emissions accounted for in natural gas drilling and field

<sup>22</sup> Assumption based on calculations from EIA data, supported by discussion in “Understanding Energy in Montana”, DEQ Report for the EQC, October 2004, Accessed at [www.leg.mt.gov/content/publications/lepo/2005\\_deq\\_energy\\_report](http://www.leg.mt.gov/content/publications/lepo/2005_deq_energy_report). Based on EIA data, marketed natural gas production averaged 4.5% growth annually between 1990 and 2005.

<sup>23</sup> Assumption based on EIA gas processing data. Historically, natural gas production, processing, and transmission have grown at differing rates; therefore, projected growth rates also differ.

<sup>24</sup> Natural gas transmission emissions grew at an average annual rate of 0.51% between 1990 and 2002.

<sup>25</sup> Assumption based on regional projections from the EIA’s Annual Energy Outlook 2006 (AEO2006).

	production, above.) Entrained CO2 estimates assumed negligible given minimal CBM activity.
Oil Production	Emissions follow trend of state oil production, which is projected to grow at 5% annually until 2010, then hold flat until 2020. <sup>26</sup>
Oil Refining	Assumes little growth in state refining, emissions projected to hold flat at 2004 levels.
Oil Transport	Emissions follow trend of state oil refining, as above.
Coal Mining Methane	Emissions held flat at 2004 levels <sup>27</sup>
Coal-to-Liquids	Assumes no commercial production.

### *High Fossil Fuel Scenario*

Unlike the reference case, the high fossil fuel scenario assumes that regional fossil fuel production and processing activities increase rapidly and that a number of unconventional oil, gas, and coal activities gain considerable traction over the next 15 years in the State. Renewed interest in a number of unconventional technologies is already apparent in response to concerns about energy security and high energy prices, along with increased activity in neighboring states and internationally.

This scenario assumes the following additional activities occur in Montana by 2020:

- Coal bed methane development begins in 2006 and proceeds fairly rapidly, based on estimates from the Montana Environmental Impact Statement.<sup>28</sup> In this scenario, total natural gas production triples between 2005 and 2010, and increases an additional 74% above 2010 levels by 2020.<sup>29</sup>
- Montana refining capacity increases, both through expansion of existing refineries and the addition of a new refinery, for refining of Athabasca crude from Alberta's oil sands.<sup>30</sup>
- Two new natural gas transmission lines cross the State.
- Two commercial coal-to-liquids plants are operating in Montana.

<sup>26</sup> Assumption based on "Understanding Energy in Montana", DEQ Report for the EQC, October 2004, Accessed at [www.leg.mt.gov/content/publications/lepo/2005\\_deq\\_energy\\_report](http://www.leg.mt.gov/content/publications/lepo/2005_deq_energy_report) and supported by Tom Richmond of the Montana Board of Oil and Gas.

<sup>27</sup> Note that coal mine methane emissions are a very small portion of total fossil fuel industry emissions.

<sup>28</sup> 'Final Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans', January 2003, U.S Dept. of the Interior and the State of Montana. Assumes Year 1 in this document is 2005, as advised by Jeff Blend, MT DEQ, November 9, 2006.

<sup>29</sup>From 'Final Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans'. CBM well projections (pg 4-117) and assumption that the average CBM production well in Montana produces 125,000 cubic feet per day, pg 4-111.

Conventional natural gas projections outlined in Table E3.

<sup>30</sup> Additional oil production, beyond the growth projected in the reference case, was not included in the high fossil fuel scenario. It is possible that additional oil production could occur but the overall GHG emissions associated with the increased oil production in Montana are low compared with GHG emissions from increased oil refining, petroleum product consumption, or energy consumed in coal to liquids refining.

- Coal mining increases modestly with coal-to-liquids development in the State.

Table E3 outlines the key assumptions for the high fossil fuel case, both from conventional and unconventional sources.

**Table E3. Key Assumptions and Methods for High Fossil Fuel Scenario Projections**

<i>Activity</i>	<i>Key Assumptions and Methods</i>
Natural Gas Drilling and Field Production	Conventional natural gas increases at 6.5% annually until 2010, then holds flat (as in reference case) until 2020 <sup>31</sup> .
Natural Gas Processing	Emissions follow trend of conventional natural gas production, as above. <sup>32</sup>
Natural Gas Transmission	Assumes two new natural gas transmission lines cross the State, operational in 2012 and 2016. <sup>33</sup>
Natural Gas Distribution	<i>Same as reference case.</i>
Coal Bed Methane	Assumes CBM production growth as predicted in the Montana Environmental Impact Statement, <sup>34</sup> averaging almost 80% annual growth in the first five years, and slowing to about 6% average annual growth between 2012 and 2020. Note that levels of entrained CO <sub>2</sub> above pipeline specification in CBM wells has not been included <sup>35</sup>
Oil Production	<i>Same as reference case</i> <sup>36</sup>
Oil Refining	Assumes additional refining capacity of 50,000 bbl/day at existing refineries, and a new 100,000 bbl/day refinery, <sup>37</sup> for an average annual growth of 4.4% between 2005 and 2020.
Oil Transport	Emissions follow trend of state oil refining, as above.
Coal Mining Methane	Emissions hold flat at 2004 levels until startup of coal-to-liquids plants, as below. <sup>38</sup>
Coal-to-Liquids	Assumes first 22,000 bbl/day coal-to-liquids plant in 2015, second 22,000 bbl/day plant by 2020. <sup>39</sup>

<sup>31</sup> Personal communication with Paul Cartwright, Montana DEQ. January 8, 2007.

<sup>32</sup> While natural gas processing has been declining in recent years, increased production of conventional gas and coal bed methane will likely result in some increased gas processing in the State.

<sup>33</sup> E-mail communication with Jeff Blend, Montana DEQ, December 15<sup>th</sup>, 2006. Distance across Montana, north to south, estimated at 400 miles using google maps.

<sup>34</sup> 'Final Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans', January 2003, U.S Dept. of the Interior and the State of Montana. Assumes Year 1 in this document is 2006, based on direction from Jeff Blend, MT DEQ, November 9, 2006.

<sup>35</sup> Depending on entrained CO<sub>2</sub> levels in Montana CBM, this could be a significant source of CO<sub>2</sub>.

<sup>36</sup> Personal communication with Paul Cartwright, Montana DEQ. January 8, 2007. Unless a new oil pipeline is projected for the State, there are no signals to indicate higher sustained oil production growth.

<sup>37</sup> Personal communication, Paul Cartwright, Montana DEQ, January 9, 2007.

<sup>38</sup> Based on coal-to-liquids data provided by Diane Kearney, EIA, using methodology described in D. Gray and G. Tomlinson, Coproduction: A Green Coal Technology, Technical Report MP 2000-28 (Mitretek, March 2001), a 22,000bbl/day CTL plant will require approximately 4 million short tons coal per year.

<sup>39</sup> Coal-to-liquids plant capacity estimates and assumption that CTL development will have to be paired with some level of carbon capture and storage (likely enhanced oil recovery) based on input from Paul Cartwright, Montana DEQ, Jan 09 2007. Assumed 30% of CO<sub>2</sub> is sequestered due to losses underground from enhanced oil recovery (Paul C, DEQ), backed by IEA. 2004. *Prospects for CO<sub>2</sub> Capture and Storage*, p. 81, which reports the proportion retained in EOR varying between 20%–67%. Greenhouse gas emissions intensity estimate provided by Diane Kearney at EIA. Model plant based on methodology described in D. Gray and G. Tomlinson, Coproduction: A Green Coal Technology, Technical Report MP 2000-28 (Mitretek, March 2001). Assumes 40% of emissions attributed to co-gen plant, thus not included in Appendix E. Note that any potential fugitive emissions from CTL are not included due to a lack of data.

## Results – Reference Case

Table E4 displays the estimated methane emissions from the fossil fuel industry in Montana from 1990 to 2005, with reference case projections to 2020. Emissions from this sector grew by 40% from 1990 to 2005, and are projected to increase modestly, by a further 7%, between 2005 and 2020. The oil and natural gas industries are the largest contributors to fossil fuel greenhouse gas emissions in Montana currently. A trend that is further reflected in the reference case projections for Montana.

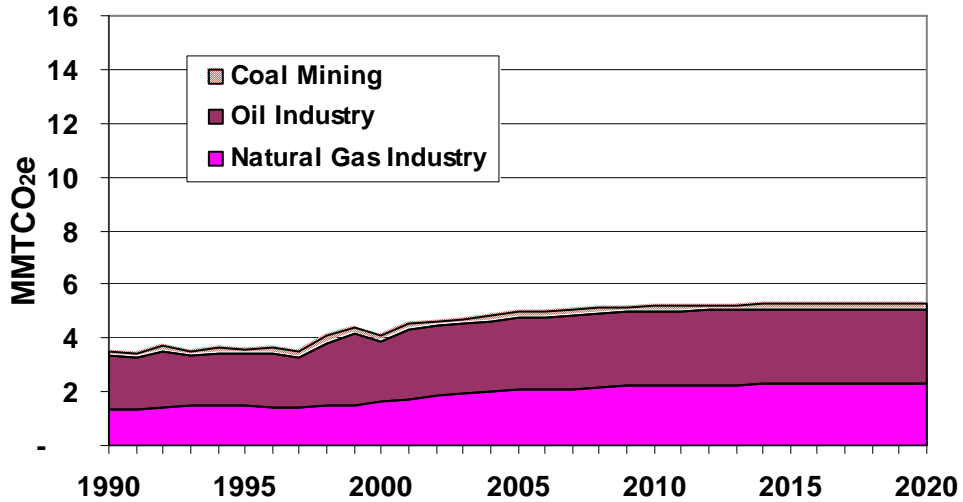
**Table E4. GHG Emissions and Reference Case Projections for the Fossil Fuel Industry in Montana**

(Million Metric Tons CO <sub>2</sub> e)	1990	2000	2005	2010	2015	2020
<b>Fossil Fuel Industry</b>	<b>3.5</b>	<b>4.1</b>	<b>5.0</b>	<b>5.2</b>	<b>5.3</b>	<b>5.3</b>
Natural Gas Industry	1.4	1.7	2.0	2.3	2.3	2.4
<i>Total Fuel Use (CO<sub>2</sub>)</i>	<i>0.2</i>	<i>0.6</i>	<i>0.7</i>	<i>0.8</i>	<i>0.8</i>	<i>0.8</i>
<i>Total Methane Emissions (CH<sub>4</sub>)</i>	<i>1.1</i>	<i>1.1</i>	<i>1.3</i>	<i>1.5</i>	<i>1.5</i>	<i>1.6</i>
<i>Total Entrained (CO<sub>2</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Production	0.3	0.4	0.7	0.8	0.8	0.8
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>0.1</i>	<i>0.1</i>	<i>0.2</i>	<i>0.3</i>	<i>0.3</i>	<i>0.3</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.2</i>	<i>0.3</i>	<i>0.4</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>
Processing	0.2	0.1	0.1	0.1	0.1	0.1
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.2</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>
<i>Entrained Gas (CO<sub>2</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Transmission	0.7	1.0	1.0	1.1	1.1	1.1
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>0.1</i>	<i>0.4</i>	<i>0.4</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.6</i>	<i>0.6</i>	<i>0.6</i>	<i>0.6</i>	<i>0.7</i>	<i>0.7</i>
Distribution	0.1	0.1	0.2	0.2	0.3	0.3
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.1</i>	<i>0.1</i>	<i>0.2</i>	<i>0.2</i>	<i>0.3</i>	<i>0.3</i>
Oil Industry	2.0	2.2	2.7	2.8	2.8	2.8
Production	0.1	0.1	0.3	0.3	0.3	0.3
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.1</i>	<i>0.1</i>	<i>0.3</i>	<i>0.3</i>	<i>0.3</i>	<i>0.3</i>
Refineries	1.8	2.1	2.4	2.4	2.4	2.4
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>1.8</i>	<i>2.1</i>	<i>2.4</i>	<i>2.4</i>	<i>2.4</i>	<i>2.4</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Coal-to-Liquids (CO <sub>2</sub> )	0.0	0.0	0.0	0.0	0.0	0.0
Coal Mining (CH <sub>4</sub> )	0.2	0.2	0.2	0.2	0.2	0.2

Note that CH<sub>4</sub> in the above table refers to the type of emission e.g. fugitive methane emission. All values in the above table are reported as million metric tons carbon dioxide equivalent (CO<sub>2</sub>e). Distribution fuel use is included with transmission fuel use. Oil production fuel use is included in industrial fuel use (Appendix B).

Figure E1 displays the reference case methane emissions from coal mining, and natural gas and oil production, processing, and transport in the State, on a CO<sub>2</sub> equivalency basis.

**Figure E1. Fossil Fuel Industry Reference Case Emission Trends  
(Million metric tons CO<sub>2</sub>e)**



### Results – High Fossil Fuel Case

Table E5 displays the estimated greenhouse gas emissions for the high fossil fuel scenario for Montana. For the high fossil fuel scenario, representing fairly rapid fossil fuel development, GHG emissions are projected to increase by a further 216% from 2005 to 2020. In this scenario, increased refining production and coal-to-liquids development have the most dramatic impact on increasing GHG emissions for the State. Also significant are the projected GHG emissions from natural gas transmission and coal bed methane production.

**Table E5. GHG Emissions and High Fossil Fuel Scenario Projections for the Montana Fossil Fuel Industry.**

<b>(Million Metric Tons CO<sub>2</sub>e)</b>	<b>1990</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>
<b>Fossil Fuel Industry</b>	<b>3.5</b>	<b>4.1</b>	<b>5.0</b>	<b>6.1</b>	<b>11.7</b>	<b>15.7</b>
Natural Gas Industry	1.4	1.7	2.0	2.8	3.3	3.6
<i>Total Fuel Use (CO<sub>2</sub>)</i>	<i>0.2</i>	<i>0.6</i>	<i>0.7</i>	<i>0.8</i>	<i>0.8</i>	<i>0.9</i>
<i>Total Methane Emissions (CH<sub>4</sub>)</i>	<i>1.1</i>	<i>1.1</i>	<i>1.3</i>	<i>2.0</i>	<i>2.5</i>	<i>2.7</i>
<i>Total Entrained (CO<sub>2</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Production	0.3	0.4	0.7	1.4	1.8	1.9
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>0.1</i>	<i>0.1</i>	<i>0.2</i>	<i>0.3</i>	<i>0.3</i>	<i>0.3</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.2</i>	<i>0.3</i>	<i>0.4</i>	<i>1.1</i>	<i>1.5</i>	<i>1.6</i>
Processing	0.2	0.1	0.1	0.1	0.1	0.1
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.2</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>
<i>Entrained Gas (CO<sub>2</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Transmission	0.7	1.0	1.0	1.1	1.2	1.3
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>0.1</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.5</i>	<i>0.5</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.6</i>	<i>0.6</i>	<i>0.6</i>	<i>0.6</i>	<i>0.7</i>	<i>0.7</i>
Distribution	0.1	0.1	0.2	0.2	0.3	0.3
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.1</i>	<i>0.1</i>	<i>0.2</i>	<i>0.2</i>	<i>0.3</i>	<i>0.3</i>
Oil Industry	2.0	2.2	2.7	3.1	4.4	4.4
Production	0.1	0.1	0.3	0.3	0.3	0.3
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.1</i>	<i>0.1</i>	<i>0.3</i>	<i>0.3</i>	<i>0.3</i>	<i>0.3</i>
Refineries	1.8	2.1	2.4	2.8	4.1	4.1
<i>Fuel Use (CO<sub>2</sub>)</i>	<i>1.8</i>	<i>2.1</i>	<i>2.4</i>	<i>2.8</i>	<i>4.1</i>	<i>4.1</i>
<i>Methane Emissions (CH<sub>4</sub>)</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
Coal-to-Liquids (CO <sub>2</sub> )	0.0	0.0	0.0	0.0	3.7	7.3
Coal Mining (CH <sub>4</sub> )	0.2	0.2	0.2	0.2	0.2	0.3

Note that CH<sub>4</sub> in the above table refers to the type of emission e.g. fugitive methane emission. All values in the above table are reported as million metric tons carbon dioxide equivalent (CO<sub>2</sub>e). Distribution fuel use included with transmission fuel use. Oil production fuel use included in industrial fuel use (Appendix B).

Figure E2 displays the reference case methane emissions from natural gas and oil production, processing, and transport, and coal mining in the State, on a CO<sub>2</sub> equivalency basis.

**Figure E2. Fossil Fuel Industry High Fossil Fuel Scenario Emission Trends (Million metric tons CO<sub>2</sub>e)**

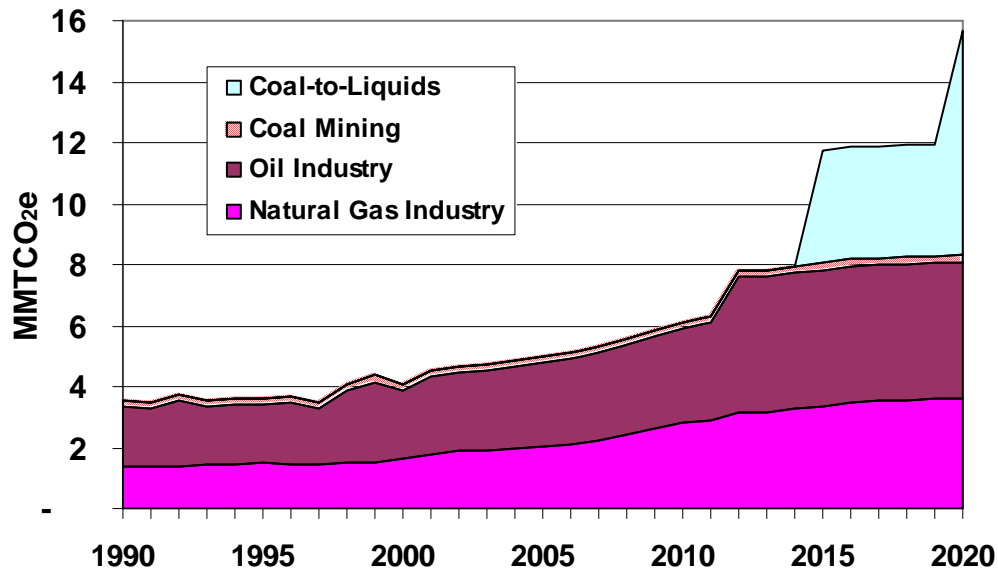


Table E6 presents a summary of GHG emissions from the Montana fossil fuel sector for both the reference case and the high fossil fuel scenario. The difference between the projected emissions in the reference case and the high fossil fuel scenario is a reflection of the uncertainty surrounding future energy developments in Montana. The projected growth between 2005 and 2020 is only 7% in the reference case and 216% in the high fossil fuel case, in which a number of unconventional technologies reach commercial scale production. Under the high fossil fuel scenario, GHG emissions in 2020 are 10 MMtCO<sub>2</sub>e higher than in the reference case, adding approximately 23% to the state’s production-based emissions in that year.

**Table E6. Comparison of Total Fossil Fuel Industry GHG Emission for Reference and High Fossil Fuel Scenario**

(Million Metric Tons CO <sub>2</sub> e)	1990	2000	2005	2010	2015	2020
<b>Fossil Fuel Industry</b>						
Reference Case	<b>3.5</b>	<b>4.1</b>	<b>5.0</b>	<b>5.2</b>	<b>5.3</b>	<b>5.3</b>
Natural Gas Industry	1.4	1.7	2.0	2.2	2.3	2.3
Oil Industry	2.0	2.2	2.7	2.8	2.8	2.8
Coal-to-Liquids	0.0	0.0	0.0	0.0	0.0	0.0
Coal Mining	0.2	0.2	0.2	0.2	0.2	0.2
High Fossil Fuel Scenario	<b>3.5</b>	<b>4.1</b>	<b>5.0</b>	<b>6.1</b>	<b>11.7</b>	<b>15.7</b>
Natural Gas Industry	1.4	1.7	2.0	2.8	3.3	3.6
Oil Industry	2.0	2.2	2.7	3.1	4.4	4.4
Coal-to-Liquids	0.0	0.0	0.0	0.0	3.7	7.3
Coal Mining	0.2	0.2	0.2	0.2	0.2	0.3

## **Key Uncertainties**

Key sources of uncertainty underlying the estimates of historic emissions and both future scenarios are as follows:

- Projections of future production of fossil fuels. These industries are difficult to forecast with the mix of drivers: economics, resource supply, demand, and regulatory procedures. Large price swings, resource limitations, or changes in regulations could significantly affect technological innovation, future production levels, and the associated GHG emissions.
- Current levels of fugitive emissions. These are based on industry-wide averages, and until estimates are available for local facilities significant uncertainties remain.
- Other uncertainties include the fraction of entrained CO<sub>2</sub> in projected CBM production, the actual emissions intensity of any coal-to-liquids production, and potential emission reduction improvements to production, processing, and pipeline technologies.
- In addition, any oil pipeline constraints and/or potential oil pipeline projects which would impact oil transmission pipeline capacity have not been considered.