

# Montana Greenhouse Gas Inventory and Projections

Revisions February 1, 2007

## Appendix A. Electricity Use and Supply

For at least the last 15 years, electricity generation has been a major export industry for Montana. The State exported 41% of the electricity it produced in 2000, and the inventory analysis indicates that exports in 2005 were about 40%. Export levels have varied between 37% and 47% since 1990,<sup>1</sup> depending on many factors including water levels for hydro-electric generation, economics and availability of power in neighboring regions, and Montana's own electricity demand. Montana electricity generation has been primarily a mix of coal and hydroelectricity. Generation from these two sources has been almost equal in some years, but recently coal sources have dominated. In 2004, coal accounted for 65% of generation, hydro for 33%, fuel oil for 2%, with the remaining sources (natural gas, biomass, and wind) contributing less than 0.5%. Coal-fired power plants produce as much as twice the CO<sub>2</sub> emissions per Megawatt-hour of electricity as natural gas-fired power plants, which dominate other states' production. In 2004, Montana emitted approximately 0.69 MtCO<sub>2</sub>/MWh from electricity generation, compared to a national average of 0.65 MtCO<sub>2</sub>/MWh.<sup>2</sup>

As noted earlier, one of the key questions for the State to consider is how to treat GHG emissions that result from consumption of electricity that is produced outside the State. In other words, should the State consider the GHG emissions associated with the State's electricity consumption or its electricity production, or some combination of the two? Since this question still needs to be resolved, this section examines electricity-related emissions from both a production and consumption basis.

This appendix describes Montana's electricity sector in terms of net consumption and production, including the assumptions used to develop the reference case projections. It then describes Montana's electricity trade and potential approaches for allocating GHG emissions for the purpose of determining the State's inventory and reference case forecasts. Finally, key assumptions and results are summarized.

We considered two sources of data in developing the inventory of CO<sub>2</sub> emissions from Montana power plants – 1) EIA's State Energy Data (SED) provides data on energy consumption, which then need to be multiplied by emission factors (ie., tons of CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> per unit of energy consumed) to calculate total GHG emissions and 2) U.S. EPA's Clean Air Markets Data<sup>3</sup> provides data on GHG emissions from larger plants (greater than 25 MW capacity) based on data from emissions monitors at the plants. We used the EIA's State Energy Data (SED) rather than EPA data because of its coverage of all power plants and because of inconsistencies that we found in the EPA data. Although the two sources provided similar estimates for CO<sub>2</sub> emissions in recent years, the EPA database shows emissions from to be up to 10% greater than SED in previous years (1997 and 1999). We discussed this with EPA and learned that EPA data tend to be conservative (i.e., overestimate emissions) because the data are reported as part of a

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<sup>1</sup> eGRID2002 software (US EPA, <http://www.epa.gov/cleanenergy/egrid/whatis.htm>).

<sup>2</sup> EPA GHG Inventory

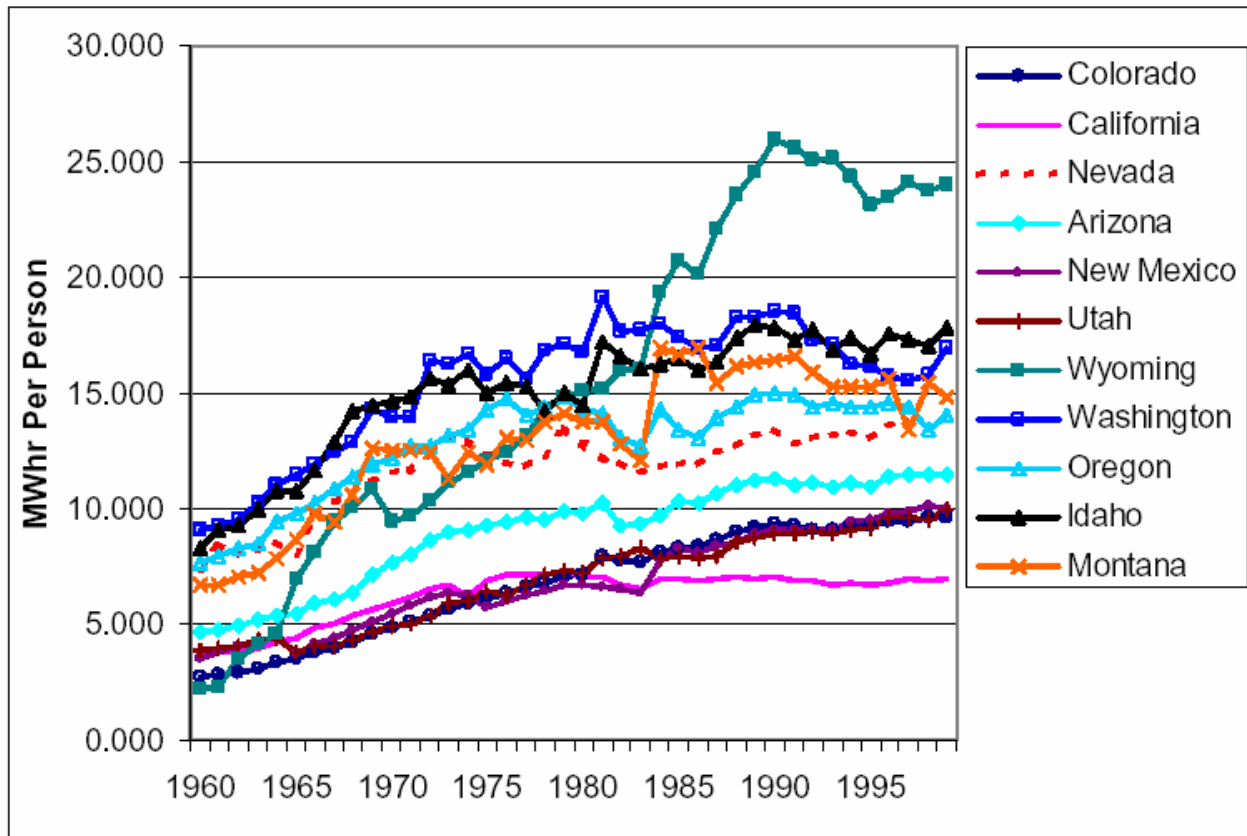
<sup>3</sup> <http://cfpub.epa.gov/gdm/>

regulatory program, and that during early years of the data collection program, missing data points were sometimes assigned a large value as a placeholder. We applied SGIT emission factors to EIA's SED to develop the historic inventory of GHG emissions in the electricity sector.

## Electricity Consumption

At about 14,000 kWh/capita (2004 data), Montana has relatively high electricity consumption per capita. By way of comparison, the per capita consumption for the U.S. was about 12,000 kWh per year.<sup>4</sup> Figure A1 shows Montana's rank compared to other western states from 1960-1999; while showing greater variation than most states, Montana's per capita consumption has been relatively high (4<sup>th</sup> out of 11).

**Figure A1. Electricity Consumption per capita in Western States, 1960-1999**



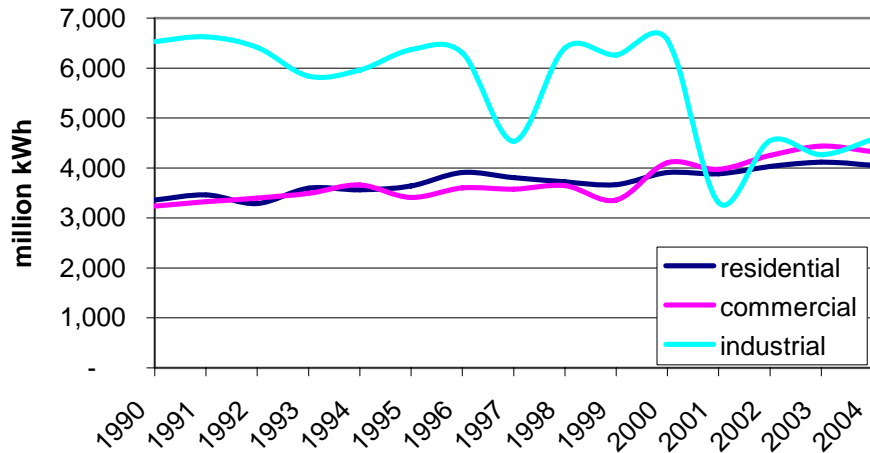
Source: Northwest Power Council, 5<sup>th</sup> Power Plan, Appendix A

As shown in Figure A2, electricity sales in the industrial sector of Montana have varied significantly over time, with a large decrease in 2001 due to the high prices and uncertainty of

<sup>4</sup> Census bureau for U.S. population, Energy Information Administration for electricity sales.

the electricity crisis.<sup>5</sup> Industrial sector sales have slowly increased since that year. The commercial and residential sectors have seen a more consistent trend of increases since 1990, with some variation year to year.<sup>6</sup>

**Figure A2. Electricity Consumption by Sector in Montana, 1990-2004**



In 2004, Montana had 44 entities involved in providing electricity to state customers. The State’s four investor-owned utilities serve approximately 63% of the customers, and 44% of the electricity sales, as illustrated in Table A1. The State’s 30 electric cooperatives serve 33% of the customers and 26% of sales. Five power marketers (Conocco Inc, Energy West Resources, Granite Power Energy, Hinson Power Company and PPL Energy Plus) provided electricity to less than 0.05% of retail customers, but accounted for over 22% of sales. Power marketers either produce energy or deliver electricity to customers so that the electricity produced is not sold directly to retail customers, but instead is sold to delivery companies. Three federal entities (Bonneville Power Administration, U.S. Bureau of Indian Affairs – Mission Valley Power, and Western Area Power Administrator) plus the city of Troy municipal utility account for the remaining 8% of sales and 4% of customers.

<sup>5</sup> MT DEQ 2004. *Understanding Energy in Montana*.  
[http://leg.mt.gov/css/publications/lepo/2005\\_deq\\_energy\\_report/2005deqenergytoc.asp](http://leg.mt.gov/css/publications/lepo/2005_deq_energy_report/2005deqenergytoc.asp)

<sup>6</sup> Electricity consumption figures here only include purchased electricity, and do not include electricity generated and consumed internally by specific industries, such as mining.

**Table A1. Retail Electricity Sales by Montana Utilities (2004)**

	Ownership Type	2004 MWh
Top 5 providers of Retail Electricity, ranked by retail sales		
NorthWestern Energy LLC	Investor-Owned	5,318,700
PPL EnergyPlus LLC	Power Marketer	2,362,601
Flathead Electric Coop Inc	Cooperative	1,274,131
MDU Resources Group Inc	Investor-Owned	610,855
Bonneville Power Admin	Power Marketer	570,960
Total Sales, Top Five Providers		10,137,247
<b>Total, all Montana</b>		<b>12,956,782</b>

Source: EIA state electricity profiles

Overall, total electricity consumption decreased at an average annual rate of 0.1 percent from 1990 to 2004, but this value masks the many trends shown in Figure A2. During this period, the residential sector grew by an average of 1.4 percent per year, the commercial sector by 2.1 percent per year, and the industrial sector dropped by 2.5 percent per year.

A variety of sources were considered for initial projections of growth in electricity sales. Northwestern Energy provided projected retail sales in the Montana Energy Forum report.<sup>7</sup> The projections from the Montana-Dakota Utility (MDU) were provided by the Montana Public Service staff report from load forecasts in MDU's 2005 Integrated Resource Plan.<sup>8</sup> The 5<sup>th</sup> Power Plan from the Northwest Power and Conservation Council (NWPPC) also provided projected electricity growth for its share of Montana. The AEO2006 provides projections of electricity consumption for the Mountain census region. Since this census region includes states such as Arizona and New Mexico, which have much higher projected population and economic growth than Montana, these projections were adjusted to account for Montana's projected population and employment growth. These projections are summarized in Table A2 below.

**Table A2. Electricity Growth Rates, projections**

	Sample Projections					
	Northwestern Energy		MDU	NWPPC	AEO2006*	
	2004-2010	2010-2020	2004-2024	2000-2025	2004-2010	2010-2020
Residential	0.02%	0.2%	0.2%	n/a	1.5%	1.0%
Commercial	2.2%	1.2%	1.0%	n/a	2.9%	1.0%
Industrial	1.5%	0.0%	2.8%	n/a	0.8%	0.2%
<i>Total</i>	<i>1.3%</i>	<i>0.5%</i>	<i>0.90%</i>	<i>0.63%</i>	<i>1.7%</i>	<i>0.7%</i>

\*AEO2006 projections have been adjusted for Montana's projected population and employment growth. Note that the sources do not report their projections based on consistent future timeperiods, also MDU and NWPPC only provided one average growth rate over the timeperiod indicated, rather than annual variations.

<sup>7</sup> <http://www.montanaenergyforum.com/>

<sup>8</sup> Email to CCS from Bob Raney, December 4, 2006.

To develop the projections for the reference case, the growth rates for Northwestern Energy and MDU were applied to each utilities electricity sales in 2005. These utilities accounted for 41 percent and 5 percent of Montana’s electricity sales respectively. Electricity growth for the remaining electricity sales (provided by electricity co-operatives and public utilities) was based on the average rate from the two utilities, Northwestern Energy and MDU (0.2 percent per year for residential, 1.1 percent for commercial and 1.4 percent for industrial). The resulting projections for Montana are shown in Table A3.

**Table A3. Electricity Growth Rates, historic and reference case projections**

	Historic		Projections	
	1990-2005	2002-2005	2005-2010	2010-2020
Residential	1.5%	1.6%	0.1%	0.2%
Commercial	2.2%	1.7%	1.8%	1.1%
Industrial	-2.1%	1.7%	1.5%	1.3%
<i>Total</i>	<i>0.2%</i>	<i>1.7%</i>	<i>1.2%</i>	<i>0.9%</i>

Source: Historic from EIA data, Projections based on growth rates from Northwestern Energy and MDU.

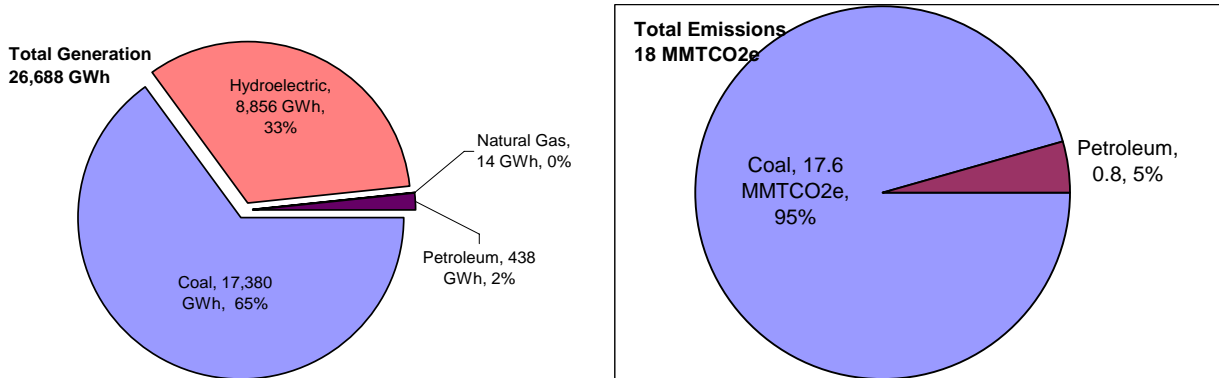
For comparison, Montana’s average annual growth rates by sector are also included in Table A3, for both 1990 to 2005 and also for the more recent time period, 2002 to 2005. Although industrial sector electricity sales have declined on average in the last fifteen years, both Table A3 and the previous Figure A2 show that much of that decrease occurred between 2000 and 2002. The projected growth rates for electric sales in this sector are similar to the more recent trends.

## Electricity Generation – Montana’s Power Plants

As mentioned above and displayed in Figure A3, coal figures prominently in electricity generation and accounts for almost all the GHG emissions from power plants in Montana. Table A3 reports the emissions from the four largest plants in Montana. The largest plant, Colstrip, accounts for 82% of Montana’s GHG emissions. Colstrip is a large facility with 4 generator units built between 1976 and 1984, having a combined capacity of over 2,100 MW. It runs primarily on coal but also consumes propane, distillate oil, and petroleum coke. Ownership of the plant is shared by PPL Montana (36%), Puget Sound Energy (33%), Portland General Electric (14%), Avista (10%) and PacifiCorp West (7%).<sup>9</sup> PPL Montana is a subsidiary of PPL Corporation (Pennsylvania Power and Light) and the company is based in Billings. However, the other companies owning shares of Colstrip, and most of their customers, are based outside of Montana.

<sup>9</sup> EPA’s Emission & Generation Resource Integrated database (EGRID), <http://www.epa.gov/cleanenergy/egrid/index.htm>.

**Figure A3. Electricity Generation and CO<sub>2</sub> Emissions from Montana Power Plants, 2004**



**Table A3. CO<sub>2</sub> Emissions from Individual Montana Power Plants, 1995-2004**

(Million Metric Tons CO <sub>2</sub> e)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
<i>Colstrip</i>	13.8	11.4	15.3	16.9	16.9	15.0	16.8	14.8	15.9	16.0
<i>Glendive Generating Statik</i>	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.01	0.04
<i>J E Corette</i>	1.2	1.1	0.8	0.7	1.1	1.3	1.1	1.2	1.4	1.4
<i>Lewis &amp; Clark</i>	0.4	0.3	0.3	0.4	0.3	0.5	0.5	0.4	0.5	0.5
<i>Other units</i>	1	1	0	0	0.0	0	0.0	0.0	0	1
<b>Total</b>	<b>17</b>	<b>14</b>	<b>16</b>	<b>18</b>	<b>18</b>	<b>17</b>	<b>18</b>	<b>16</b>	<b>18</b>	<b>18</b>

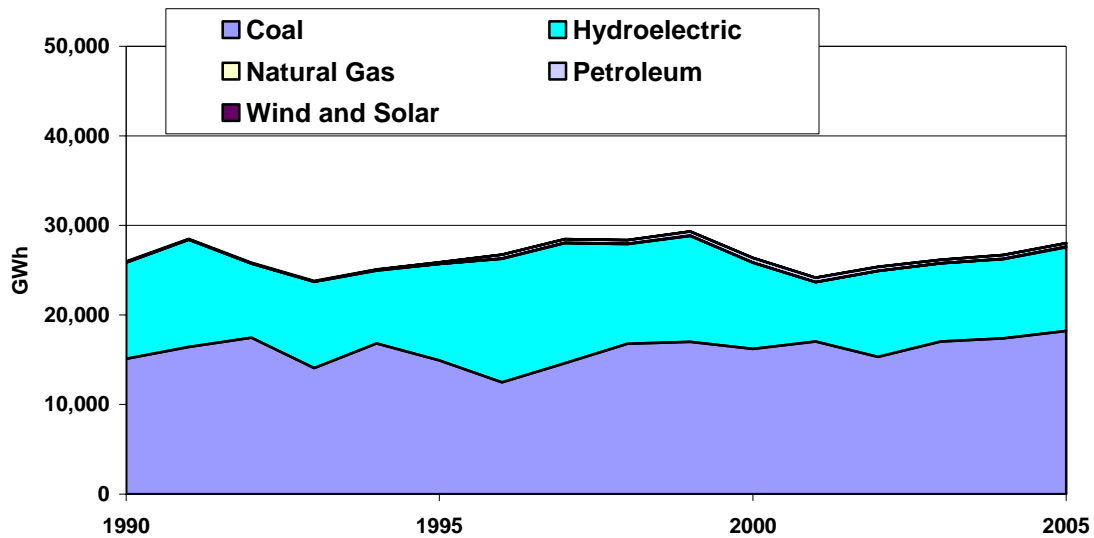
Source: U.S. EPA Clean Air Markets database for named plants (<http://cfpub.epa.gov/index.cfm>). Total emissions calculated from fuel use data provided by U.S. DOE EIA.

Figure A4 shows historical sources of electricity generation in the state by fuel source from 1990 through 2004. Table A4 shows the growth in generation by fuel type between 1990 and 2004. Overall generation grew by 3 percent between these two years, but as shown in Figure A4, generation levels vary greatly year to year. Coal generation shows the greatest increase in absolute terms over the 14-year period. Petroleum grew by the greatest percentage due to the use of petroleum coke at the BGI power plant starting in 1995, but started at an extremely low level.

**Table A4. Growth in Electricity Generation in Montana 1990-2004.**

	Generation (GWh)		Growth
	1990	2004	
Coal	15,120	17,380	15%
Hydroelectric	10,717	8,856	-17%
Natural Gas	41	14	-67%
Biomass and waste	75	0	-100%
Petroleum	27	438	1500%
<b>Total</b>	<b>25,980</b>	<b>26,688</b>	<b>3%</b>

**Figure A4. Electricity Generation in Montana 1990 - 2005**



Source: EIA data, note that natural gas, wind and solar generation are less than 100 GWh in most years and are not visible in the figure.

### *Future Generation and Emissions*

Estimating future generation and GHG emissions from Montana power plants requires estimation of new power plant additions and production levels from new and existing power plants. There are, of course, large uncertainties, especially related to the timing and nature of new power plant construction.

The future mix of plants in Montana remains uncertain as the trends in type of new builds are influenced by many factors. The most recent fossil-fuel plants have been natural gas-fired; however, there are concerns that natural gas prices may increase over the next decade, which could cause a trend towards a more coal-dominated mix. Recent announcements by several utilities indicate that coal will dominate new builds; Hardin Power Plant is the first coal-fired power plant to be built in the State in the last 20 years. Montana has also recently announced a renewable portfolio standard (RPS), requiring investor-owned utilities to generate (or purchase) a minimum amount of electricity from renewable sources. The RPS will likely spur additional new wind projects in the state. Table A5 presents data on new and proposed plants in Montana.

**Table A5. New and Proposed Power Plants in Montana**

	Plant Name	Fuel	Status	Capacity	Expected Annual	Notes		
				MW	generation GWh	Emissions MMTCO <sub>2</sub> e		
Wind Plants	Judith Gap	wind	On-line 2006		135	355	The project will generate about 150 megawatts of power from 90 turbines.	
	McCormick Ranch	wind	Proposed		120	315	0	
	Valley County Wind Energy Project	wind	Proposed	50 MW by 2008 100 MW by 2010 150 MW by 2013 200 MW by 2016	130 GWh 2008 260 GWh 2010 390 GWh 2013 520 GWh 2016		0	Proposal by Wind Hunter LLC for a project in north-central Valley County.
New plants	Rocky Mountain Hardin	coal	On-line 2006		109	812		Initially proposed as a coal gasification plant; 3-year contract to sell 100% of electricity to British Columbia.
	Tiber Dam	water	On-line 2004		7	39	0.00	
	Basin Creek	Natural gas	under-construction 2006		55	434		Offsets purchased so that power plant will meet the Oregon Standard for CO <sub>2</sub> emissions
Proposed plants	Highwood Generating Plant, Great Falls, MT	lignite coal	An air quality permit application accepted.		250	1,862		
	Silver Bow	Natural gas	Permitted		500	3942		Permit application Jan-2001. Major permits secured Mar-2002.
	Roundup Bull Mountain, Broadview, MT	lignite coal IGCC	Proposed		300			Proposed coal to liquids plant permitting proposed to be supplemental to MT DEQ air permits issued Feb 2003 for previously proposed steam-electric plant.

Given the many factors impacting electricity related emissions and a diversity of assumptions by stakeholders within the electricity sector, developing a “reference case” projection for the most likely development of Montana’s electricity sector is particularly challenging. The principal uncertainty of interest is on the high side, given the many plans and initiatives to increase coal utilization locally and nationally. As a result, we explore two cases of future electric sector development – the reference case and the high fossil fuel production scenario (these two cases were also developed for the fossil fuel production sector). For each case, simple assumptions were made to develop projections for electric generation, relying to the extent possible on existing proposals for future changes to Montana’s transmission infrastructure.

The reference case projections assume:

- Existing transmission lines are upgraded in Montana but no new lines are built. These upgrades will allow an additional 500 MW of additional capacity to be built in the State, over the period 2008 - 2020.
- New fossil fuel plants will be coal plants, which are assumed to be pulverized coal with heatrates at on average 9000 BTU/kWh.

The high fossil fuel production case projections assume:

- Additional new transmission lines will be built to export power from Montana. The total additional transmission lines in this case would have a capacity of 2,500 additional MW over the reference case addition of 500 MW, or 3,000 total additional MW capacity, relative to current levels. This scenario assumes the following transmission lines are available, or lines of similar capacity:

- A transmission line capable of carrying 300 MW of power from Montana to Alberta-British Columbia is approved and functioning by 2009. An example of such a project is the Montana Alberta Tie Line.<sup>10</sup> This is a privately funded transmission line proposed between Alberta and Montana capable of transferring 300 MW of power South North (and 300 MW of power North South, with capability of transfer to California).<sup>11</sup>
- A transmission line capable of carrying 2,200 MW of power from Montana to Las Vegas (or that general area) will be approved and functioning by 2012. The proposed Northern Lights transmission line, to be operated by Transcanada, is an example of such a project.<sup>12</sup> According to MT DEQ staff, it is very possible that such a line would initially carry up to 1,500 MW and eventually enough generation could be built in Montana to fill the 3,000 MW line.<sup>13</sup> An estimate of 2, 200 MW is an approximate mid-point between these potential capacity levels.
- The High Fossil Fuel Scenario assumes that new power plants will be built in Montana to use the full capacity of these two assumed lines by 2020. The new plants are assumed to be a mix of 65% fluidized bed coal and 35% wind. These new power plants are in addition to the new plants described in the reference case.

Both cases assume:

- Generation from existing non-hydro plants is based on 2004 levels. Generation from existing hydro-electric plants is assumed to be 10,356 GWh per year, the average generation from the last ten years (EIA electric power annual data, 1995-2004). New plants and changes to existing plants due to plant renovations and overhauls that result in higher capacity factors are counted as new generation.
- The Renewable Portfolio Standard requirements are assumed to be met by in-state wind generation. Renewable generation must meet a minimum of 10 percent of sales from investor-owned utilities in 2010 and 15 percent in 2015 and every year thereafter.
- Electricity sales grow at 1.2 percent per year from 2006-2010 and 0.9 percent per year from 2011-2020, as described previously.

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<sup>10</sup> <http://www.matl.ca/>

<sup>11</sup> ABB Engineering. 2006. System Feasibility Report: Montana Alberta Tie Line (MATL) project. Executive summary. [http://www.matl.ca/documents/ABB\\_Executive.pdf](http://www.matl.ca/documents/ABB_Executive.pdf)

<sup>12</sup> [http://www.transcanada.com/pdf/company/projects/NorthernLights\\_LR.pdf](http://www.transcanada.com/pdf/company/projects/NorthernLights_LR.pdf)

<sup>13</sup> Email from Jeff Blend, MT DEQ to Alison Bailie, CCS, November 13, 2006.

## Electricity Trade and Allocation of GHG Emissions

Montana is part of the interconnected Western Electricity Coordinating Council (WECC) region - a vast and diverse area covering 1.8 million square miles and extending from Canada through Mexico, including all or portions of 14 western states. The inter-connected region allows electricity generators and consumers to buy and sell electricity across regions, taking advantage of the range of resources and markets. Electricity generated by any single plant enters the interconnected grid and may contribute to meeting demand throughout much of the region, depending on sufficient transmission capacity. Thus, it is challenging to define which emissions should be allocated to Montana, and secondly in estimating these emissions both historically and into the future. Some utilities track and report electricity sales to meet consumer demand by fuel source and plant type; however, tracing sales to individual power plants may not be possible.

In 2004, electricity consumption in Montana was 13 terawatt-hours (TWh), while electricity generation was 27 TWh. Also as mentioned above, Montana utilities own less than half of the largest generating plant in the state. Thus, a significant portion of the electricity generated and economic benefits may serve consumers and investors in other states.

Since almost all states are part of regional trading grids, many states that have developed GHG inventories have grappled with the problem of how to account for emissions. Several approaches have been developed to allocate GHG emissions from the electricity sector to individual states for inventories.

In many ways the simplest approach is *production-based* – emissions from power plants within the State are included in the state’s inventory. The data for this estimate are publicly available and unambiguous. However, this approach is problematic for states that import or export significant amounts of electricity. Because of the State’s small imports and the uncertainty of the magnitude of future net imports, the question of consumption- versus production-based emissions may not be as important in Montana as in other states with greater percentages of net imports or exports. Under a production-based approach, characteristics of Montana electricity consumption would not be captured since only emissions from in-state generation would be considered.

An alternative is to estimate *consumption-based* or *load-based* GHG emissions, corresponding to the emissions associated with electricity consumed in the State. The load-based approach is currently being considered by states that import significant amounts of electricity, such as California, Oregon, and Washington.<sup>14</sup> By accounting for emissions from imported electricity, states can account for increases or decreases in fossil fuel consumed in power plants outside of the State, due to demand growth, efficiency programs, and other actions in the State. The difficulty with this approach is properly accounting for the emissions from imports and exports.

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<sup>14</sup> See for example, the reports of the Puget Sound Climate Protection Advisory Committee (<http://www.pscleanair.org/specprog/globclim/>), the Oregon Governor’s Advisory Group On Global Warming (<http://egov.oregon.gov/ENERGY/GBLWRM/Strategy.shtml>), and the California Climate Change Advisory Committee, Policy Options for Reducing Greenhouse Gas Emissions From Power Imports - Draft Consultant Report (<http://www.energy.ca.gov/2005publications/CEC-600-2005-010/CEC-600-2005-010-D.PDF>).

Since the electricity flowing into or out of Montana is a mix of all plants generating on the interconnected grid, it is impossible to physically track the electrons.

The approach taken in this initial inventory is a simplification of the consumption-based approach. This approach, which one could term “*Net-Consumption-based*,” estimates consumption-based emissions as in-state (production-based) emissions times the ratio of total in-state electricity consumption to in-state generation (net of losses).

This method does not account for differences in the type of electricity that is imported or exported from the State, and as such, it provides a simple method for reflecting the emissions impacts of electricity consumption in the State. More sophisticated methods – e.g., based on individual utility information on resources used to meet loads – can be considered for further improvements to this approach.

## **Summary of Assumptions and Reference Case Projections**

As noted, projecting generation sources, sales, and emissions for the electric sector out to 2020 requires a number of key assumptions, including economic and demographic activity, changes in electricity-using technologies, regional markets for electricity (and competitiveness of various technologies and locations), access to transmission and distribution, the retirement of existing generation plants, the response to changing fuel prices, and the fuel/technology mix of new generation plants. The key assumptions described above are summarized in Table A6.

**Table A6. Key Assumptions and Methods for Electricity Projections for Montana**

**Assumptions for Both Scenarios**

<b>Electricity sales</b>	Average annual growth of 1.2% from 2006 to 2010 and 0.9% per year from 2010 to 2020, based on growth rates from Northwestern Energy and MDU.
<b>Transmission and Distribution losses</b>	10% losses are assumed, based on average statewide losses, 1994-2000, (data from the US EPA Emission & Generation Resource Integrated Database <sup>15</sup> )
<b>Renewable Portfolio Standard</b>	Montana’s Renewable Portfolio Standard will be met by Northwestern Energy and MDU, 10% of State sales met by renewable generation by 2010, 15% by 2015 and in subsequent years. New renewables are assumed to be wind.
<b>Heat Rates</b>	The assumed heat rates for new gas and coal generation are 7000 Btu/kWh and 9000 Btu/kWh, respectively, based on estimates used in similar analyses. <sup>16</sup>
<b>Operation of Existing Facilities</b>	Existing facilities are assumed to continue to operate as they were in 2004. Improvements in existing facilities that lead to higher capacity factor and more generation are captured under the new non-renewable generation sources.

**Assumptions for Reference Case**

<b>New Electric Transmission Capacity</b>	Transmission lines capable of carrying an additional 500 MW of new capacity will be on-line by 2020
<b>New Generation Sources</b>	All of the new generation capacity will be fluidized bet coal plants.

**Assumptions for High Fossil Fuel Scenario**

<b>New Electric Transmission Capacity</b>	Transmission lines capable of carrying an additional 3,000 MW of new capacity will be on-line by 2020
<b>New Generation Sources</b>	65% of new generation capacity will be fluidized bet coal plants, with wind generation accounting for the remaining 35%.

**Results – Reference Case**

Figure A5 shows historical sources of electricity generation in the state by fuel source, along with projections to the year 2020 based on the assumptions described above for the reference

<sup>15</sup> <http://www.epa.gov/cleanenergy/egrid/index.htm>.

<sup>16</sup> See, for instance, the Oregon Governor’s Advisory Group On Global Warming <http://egov.oregon.gov/ENERGY/GBLWRM/Strategy.shtml>.

case. Based on the above assumptions for new generation, total generation increases by an average rate of 1.5 percent from 2005 to 2020 and coal continues to dominate new generation.

**Figure A5. Electricity Generated by Montana Power Plants, 1990-2020, Reference Case**

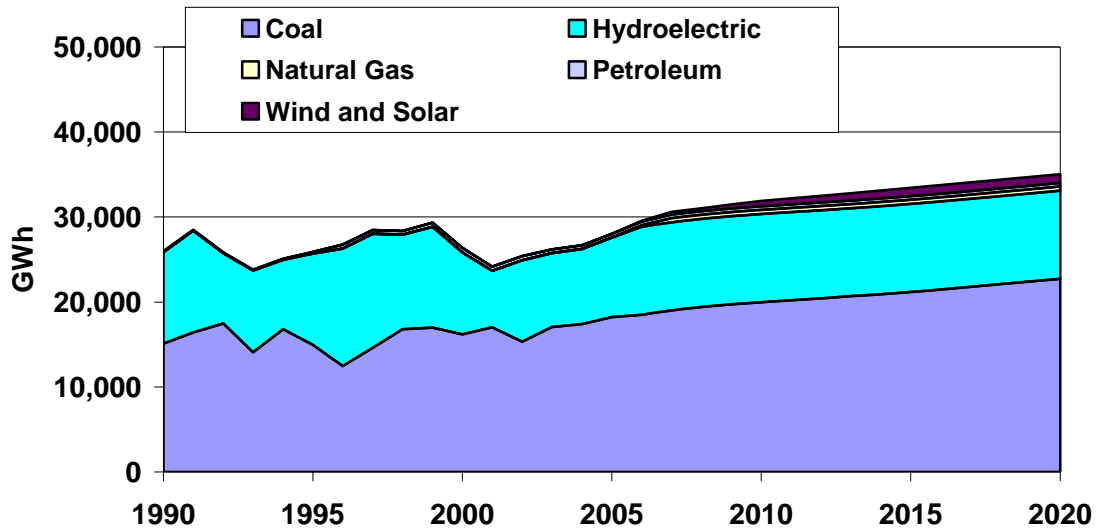


Figure A6 illustrates the GHG emissions associated with the mix of electricity generation shown in Figure A5. From 2005 to 2020, the emissions from Montana electricity generation are projected to grow at 1.3 percent per year, similar to the growth in electricity generation. The emission intensity (emissions per MWh) of Montana electricity is projected to decrease slightly, by about 2.4 percent (from 0.69 MtCO<sub>2</sub>/MWh in 2005 to 0.67 MtCO<sub>2</sub>/MWh in 2020).

**Figure A6. Montana GHG Emissions Associated with Electricity Production (Production-Basis), includes Exports, Reference Case**

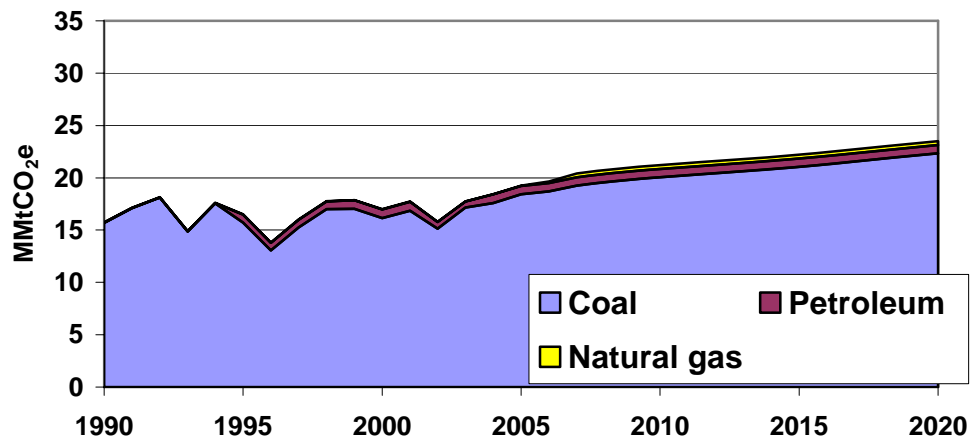
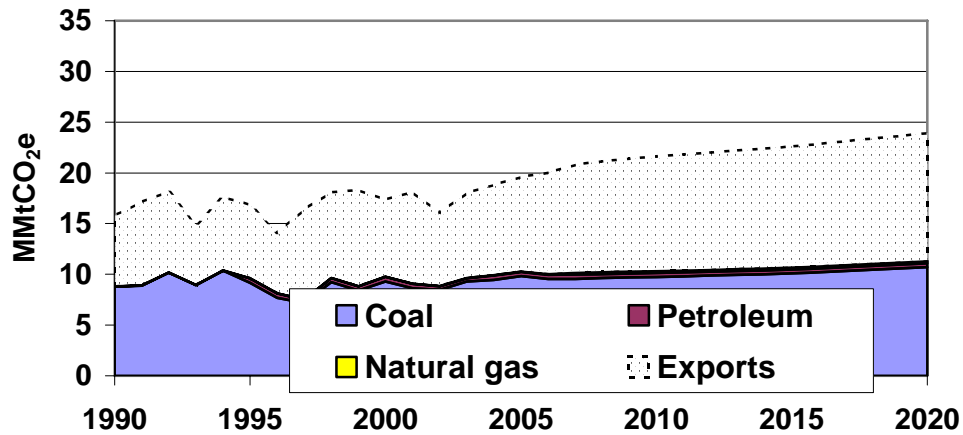


Figure A7 shows the “net-consumption-basis” emissions from 1990 to 2020. Total emissions match those shown in the previous “production-basis” chart; here, however, a significant fraction is attributed to net electricity exports as shown in the top area. Net-consumption based emissions grow at an average 0.6 percent per year from 2005 to 2020. This growth is lower than the average growth in total electricity sales for this period (1.0 percent per year) as the State RPS causes renewable generation to meet a larger fraction of in-state electricity sales.

**Figure A7. Montana GHG Emissions Associated with Electricity Use (Consumption-Basis) and Exports**



## Results – High Fossil Fuel Scenario

Figure A8 shows historical sources of electricity generation in the state by fuel source, along with projections to the year 2020 based on the assumptions described above for the high fossil fuel scenario. Based on the above assumptions for new generation, coal continues to dominate new generation throughout the forecast period but wind generation also grows strongly. Total generation increases by 3.9 percent per year from 2005 to 2020.

**Figure A8. Electricity Generated by Montana Power Plants, 1990-2020, High Fossil Fuel Scenario**

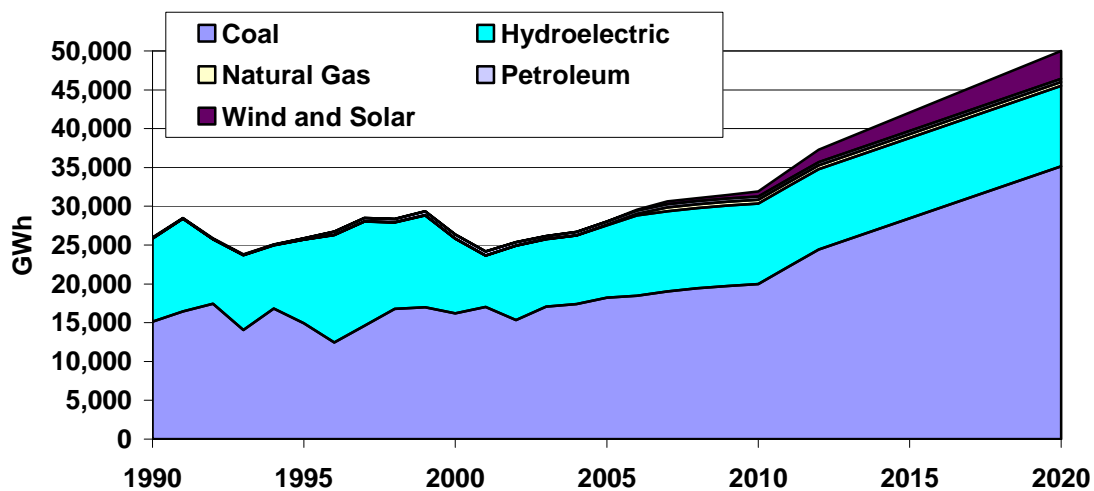
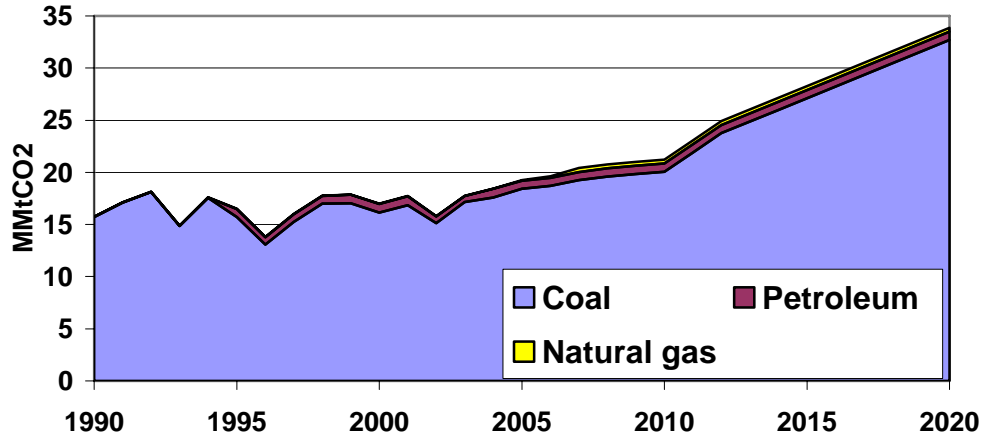


Figure A9 illustrates the GHG emissions associated with the mix of electricity generation shown in Figure A8. From 2005 to 2020, the emissions from Montana electricity generation are projected to grow at 3.8 percent per year, similar to the growth in electricity generation. The emission intensity (emissions per MWh) of Montana electricity is projected to decrease slightly, by about 2 percent (from 0.69 MtCO<sub>2</sub>/MWh in 2005 to 0.68 MtCO<sub>2</sub>/MWh in 2020). Although wind generation accounts for 35 percent of new electricity capacity, wind has lower capacity factors than coal generation and no new hydro-electric plants are assumed to be built so coal continues to dominate electricity production.

**Figure A9. Montana CO<sub>2</sub> Emissions Associated with Electricity Production (Production-Basis), includes Exports, High Fossil Fuel Scenario**



The “net-consumption-basis” emissions for the high fossil fuel case are the same as for the reference case because the additional generation that is built under the high fossil fuel scenario is assumed to be used for export to other states.

Table A7 presents a summary of GHG emissions from the electric sector in Montana on a production basis for both the reference case and the high fossil fuel scenario and on a consumption basis, which has the same estimated emissions for each case. Though the GHG emissions are significantly different from each other, each set of estimates is valid depending on circumstances. The difference between the emissions in the reference case and the high fossil fuel scenario estimates reflect the uncertainty in future energy development in Montana. The consumption-based emissions represent a focus on the emissions associated with electricity consumption in Montana – this focus is important when evaluating the effects of actions directed at in-state electricity conservation.

**Table A7. Summary GHG Emissions for Montana Electric Sector**

(Million Metric Tons CO <sub>2</sub> e)	1990	2000	2005	2010	2020
<b>Production-based</b>					
Reference case	15.8	17.1	19.3	21.3	23.6
High Fossil Fuel Scenario	15.8	17.1	19.3	21.3	34.0
<b>Consumption-based</b>	8.8	9.8	10.3	10.3	11.3

Note: Consumption-based emissions are the same for both the reference case and the high fossil fuel scenario because electricity consumption in Montana is the same for both cases.

