

Greenhouse Gas Emission Inventories and Forecasts for Nine Western States

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ABSTRACT

This paper presents a summary of the greenhouse gas (GHG) inventories and forecasts developed by the Center for Climate Strategies (CCS) in collaboration with the Western Regional Air Partnership (WRAP) for the following states: Alaska, Colorado, Idaho, Montana, Nevada, South Dakota, Utah, Washington, and Wyoming. These inventories and forecasts cover the period from 1990 to 2020. Emissions of each of the six gases recognized by the Intergovernmental Panel on Climate Change (IPCC) are included and presented in terms of their carbon dioxide equivalents (CO₂e). In addition, emissions of black carbon, an aerosol species known to have positive climate forcing potential, were included. Both sources and sinks of carbon dioxide are included. Summaries of the state-level results for each of the source sectors are described. These source sectors are as follows: energy supply (electricity generation, fossil fuel industry); residential/commercial/industrial (fossil fuel use, industrial processes), transportation, agriculture, forestry, and waste management. These inventories and forecasts are serving as the starting points in several state-level climate change mitigation plan development projects.

To provide a more complete picture of GHG contributions across the western region, emissions data from California, Oregon, New Mexico, and Arizona have also been included. The data for California and Oregon were taken from inventory and forecast work conducted in those states, while the data for Arizona and New Mexico were taken from previous work performed by CCS.

INTRODUCTION

Under an agreement with the Western Regional Air Partnership (WRAP), the Center for Climate Strategies (CCS) prepared greenhouse gas (GHG) inventories and forecasts for nine western states: Alaska, Colorado, Idaho, Montana, Nevada, South Dakota, Utah, Washington, and Wyoming. These inventories and forecasts cover the period from 1990 to 2020. Emissions of each of the six gases recognized by the Intergovernmental Panel on Climate Change (IPCC) are included and presented in terms of their carbon dioxide equivalents (CO₂e). In addition, emissions of black carbon, an aerosol species known to have positive climate forcing potential, were included. Both sources and sinks of carbon dioxide are included. Summaries of the state-level results for each of the source sectors are described. These source sectors are as follows: energy supply (electricity generation, fossil fuel industry); residential/commercial/industrial (fossil fuel use, industrial processes), transportation, agriculture, forestry, and waste management. These inventories and forecasts are serving as the starting points in several state-level climate change mitigation plan development projects.

To provide a more complete picture of GHG contributions across the western region, emissions data from California,¹ Oregon,² New Mexico, and Arizona have also been included. The data for California and Oregon were taken from inventory and forecast work conducted in those states, while the data for Arizona and New Mexico were taken from previous work performed by CCS.

A discussion of the overall inventory and forecast and approach is followed by an overview of GHG emissions at the state-level across all western states. The state-level overview is followed by comparisons of emissions for each of the major GHG subsectors.

GHG INVENTORY AND FORECAST PROJECT APPROACH

The primary purpose of State GHG inventory and reference case projections is to provide the State and stakeholders with an initial comprehensive understanding of current and possible future GHG emissions and variables that significantly affect emissions change over time, thereby informing analysis and design of GHG mitigation strategies. The analyses provide key information on:

- Current levels of GHG emissions and contribution of different activities (typically as close to present as possible, e.g. 2005);
- How the emissions are estimated to change in the future (typically through 2020), in total and by activity; and
- How emissions have changed in the past (typically from 1990 to present).

This information helps provide focus on particular activities for the mitigation strategies and provides some information on the impacts of past policies and programs on GHG emissions. As mitigation strategies are developed and implemented, the inventory and projections are used to estimate the impacts of these strategies. This information also assists states in the development of ongoing statewide inventory and reporting systems to measure progress against state goals and programs. It also provides a macro-economic framework to support development of micro-scale inventory, reporting and registry systems.

Since the state GHG inventories and projections are voluntary and have no current regulatory implication at the federal level, each state can define their own scope and approach. CCS seeks to maintain the following principles in developing our state-level inventories and projections:

- **Transparency:** We report data sources, methods, and key assumptions to allow open review and opportunities for additional revisions later based on input from others. In addition, we report key uncertainties where they exist.
- **Consistency:** To the extent possible, the inventory and projections are designed to be externally consistent with current or likely future systems for state and national GHG emissions reporting. As a signatory to the United Nations Framework Convention on Climate Change, the U.S. is required to produce a national GHG inventory, and many states have completed their own GHG inventories. Seeing the value in having harmonized approaches to these inventories, the U.S. EPA developed a set of guidelines for states developing GHG inventories, as part of the Emission Inventory Improvement Program (EIIP). The EIIP guidelines³ have been adapted from Volumes 1-3 of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories⁴ and the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003.⁵ EPA is currently in the process of updating the EIIP guidelines. EPA's state-level GHG inventory tool based on these EIIP methods is called the State Guidance and Inventory Tool or SGIT.

The CCS state inventories use the EIIP guidelines and software tools but have been supplemented with local or more up-to-date data where available and with slight variations in the approach when deemed preferable to capture local conditions. For example, the software tools were released in August 2004, while the inventories discussed in this paper were developed in 2005. CCS modified the EPA software tool to include more recent and updated data on energy consumption, animal stock, and agriculture. For some smaller emission categories, such as industrial processes, the EPA

tool also provided rough estimates of state emissions using the state's share of population or industrial production to estimate the state's share of national emissions. By contacting industrial experts in each state (such as semi-conductor producers), CCS was able to improve the emission estimates with direct data. We also make all efforts to check and correct for internal consistency among the variety of data sources.

- **Comprehensive Coverage.** Reference case projections are estimates of future emissions based on actions that are currently in place or reasonably expected over the time period of analysis and growth in source activity. Few states have developed reference case projections, and the EPA does not prepare GHG emission projections or provide guidelines for state projections. Our approach relied on compiling various existing, documented sources for projections of electricity generation, fuel use, and other GHG emitting activities, along with a set of simple, transparent assumptions often based on population or economic growth forecasts.

All sectors. Emissions are generally reported under the following sector categories to support policy analysis and formulation:

- Energy Use
 - Electricity supply
 - Residential, commercial and industrial fuel use
 - Transportation fuel use
- Non-Energy Use
 - Industrial processes
 - Agriculture
 - Solid waste and wastewater
- Forestry and Land Use

Functionally this information is provided to technical workgroups that typically are organized as follows:

- Energy Supply
- Residential, Commercial and Industrial
- Transportation and Land Use
- Agriculture, Forestry and Waste Management
- Cross Cutting Issues (inventories, reporting, registries and education)

These categories and sub-categories may differ between states to reflect different relative importance of activities. For example, the fossil fuel production industry is a large source of emissions in New Mexico and is reported under a separate category. In Arizona, this industry is relatively small and the emissions are reported as part of the industrial sector and non-energy sectors. Additional issues on coverage include:

- *All six greenhouse gases covered by U.S. and other national inventories-* Carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). We aggregate six gas results into CO₂ equivalence (CO₂e) using IPCC 100-year global warming potentials, consistent with EPA methods. In Arizona, we have also constructed an inventory of black carbon (BC) emissions (described further below).
- *Emissions from 1990 onward-* We start the inventory with 1990, and include available subsequent years up to the most recently available data (2002, 2003 or 2004), with projections to 2010 and 2020.
- *Emissions at the statewide level, with local detail as needed and practical.* In general, we report emissions at the state-level at a minimum. Reporting of emissions from individual entities is limited to publicly-available data – in general only for historical emissions from large emitters.
- *Report both total gross emissions and total net emissions-* Gross emissions estimates do not include the effects of carbon sinks, i.e., the net carbon sequestered in, or released from, soils and vegetation. Our estimates of emissions

from carbon sinks are based on U.S. Forest Service estimates that have been collected between 1982 and 2002. Refined estimates of forest carbon stock change may result in significant changes to current estimates and should, in some cases, be the focus of further analysis. We report net GHG emissions – which include the above net forest carbon stock change estimates – separately from the gross GHG emissions.

- **Use of Consumption-Based Emissions Estimates:** To the extent possible, we estimated emissions that are caused by activities that occur in each state. For example, we reported emissions associated with the electricity consumed in each state. The rationale for this method of reporting is that it can more accurately reflect the impact of State-based policy strategies such as energy efficiency on overall GHG emissions, and it resolves double counting and exclusion problems with multi-emissions issues. This approach can differ from how inventories are compiled, for example, on an in-state production basis, in particular for electricity.
- **Priority of Existing State and Local Data Sources:** In gathering data and in cases where data sources may conflict, we place highest priority on using local and state data and analyses, followed by regional sources with national data used as defaults where necessary.
- **Presentation of Additional Metrics and Units for Better Understanding:** SGIT provides emission estimates (tons of CO₂e emissions), but not the underlying activity data (energy use, land use, cement production estimates, etc.). For additional analysis, as well as for stakeholder understanding, we provide the activity data in energy units (BTU, GWh, etc.), land use (acres), agricultural units (e.g., head of livestock), and other relevant units that are the basis for emission estimates. This information is often important to policy development.

STATE-LEVEL INVENTORY & FORECAST RESULTS

Figure 1a shows the overall results of this inventory and forecast project for each of the nine states included in the project as well as the four additional states (AZ, CA, NM and OR). This chart shows the historical, current and projected gross emission estimates in million metric tons of carbon dioxide equivalent (MMtCO₂e). Figure 1b provides a regional view of the gross emissions by sector. Table 1 provides the state-level gross estimates as well as the net emission estimates for each state (includes anthropogenic sinks in the forestry and agricultural sectors). For the 13 state region, total gross emissions were estimated to be 1,032 MMtCO₂e in 1990 rising to 1,645 MMtCO₂e in 2020 (a 60% increase) under business as usual conditions.

Figure 2 shows the estimated western region emissions compared to other worldwide estimates of GHG emissions. The comparison emission estimates are taken from the World Resources Institute.⁶ As shown in this figure, the western region would rank sixth in the world among top emitting countries (excluding the top-emitting U.S. as a whole). Results are presented in greater detail below by emissions sector.

Figures 3 through 5 show comparisons of growth in some of the key emissions drivers across the western region: population, employment, and vehicle-miles traveled (VMT). Figure 6 provides a comparison of gross GHG emissions per capita for each state. States with low population and strong fossil fuel industries (WY and AK) or large agricultural emissions (SD) show the largest GHG emissions on a per capita basis.

Electric Sector

The electric sector includes GHG emissions (carbon dioxide, nitrous oxide, and methane) from fossil fuel combustion at electricity-only and combined-heat-and-power (CHP) plants within the NAICS (North American Industry Classification System) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. This sector was estimated to contribute 27% of the western region's gross GHG emissions in 2005 (see Figure 1b). GHG emissions from the electric sector are projected to grow by 29% from 2005 to 2020. Figure 7 shows the state-level totals for the sector,

using the consumption-based approach. The historic values (1990-2004) show the impact of low water years in the region (1993/4 and in 2001) which led to lower generation from hydro-electric plants and increased generation from fossil fuel-fired power plants. Economic conditions in 2001 also contributed to increased generation from fossil-fueled generation.

Figure 8 reports the electric sector GHG emissions from each state in 2005, showing GHG emissions under both consumption-based and production-based accounting methods. As described above, the consumption-based approach is used to report emissions associated with electricity consumption in a state, while the production-based approach reflects GHG emissions from electricity production in that state. For states with large electricity exports, such as Wyoming and Montana, production-based emissions are much higher than consumption-based emissions. The opposite is true for states with significant electricity imports, such as California and Oregon. Production-based emissions can be directly calculated using reported energy consumption by power plants in each state. Consumption-based emissions require additional data or assumptions on electricity trade. The consumption-based emissions for this report were calculated using a simplified approach. For each state we calculated net exported or imported electricity in each year. We then assumed that the mix of resources used to generate net exported electricity was the same as the average mix of electric generation resources in the state. For net imported electricity, the approach uses the average GHG emission rate of states in the surrounding region. This simplified approach provides general information on the importance of electricity imports and exports, but further refinement – for instance, based on data from utility contracts and trades – is recommended.

Residential, Commercial, Industrial (RCI) Fuel Use

Figure 9 provides the state-level inventory and forecast for RCI fuel use. Emissions include CO₂, CH₄, and N₂O from the combustion of fossil fuels and biomass (for biomass, CO₂ emissions are excluded). Emissions for all transportation fuels are included in the transportation sector (see discussion below). The figure shows a downturn in GHG emissions in the period immediately after 2001 (related to energy reductions in the period after 9-11). Emissions of nearly 250 MMtCO₂e in 1990 are expected to grow to well over 300 MMtCO₂e by 2020.

Figure 10 provides the state-level RCI subsector detail (residential, commercial, and industrial subsectors). Note that fossil fuel combustion in the fossil fuels industry sector is included in the industry subsector of Figure 10.

Figure 11 shows GHG emissions in the RCI sector by fuel type. Consumption of natural gas and oil contribute the most to RCI GHG emissions in the western region. Again, biomass combustion includes N₂O and CH₄ emissions only.

Fossil Fuel Industry

The fossil fuel industry includes the GHG emissions that are released during the production, processing, transmission, and distribution of fossil fuels. Known as fugitive emissions, these are methane and carbon dioxide emissions 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 greenhouse gas emissions in 2004.⁷ For the western region, this sector accounted for about 3.9% of total gross GHG emissions in 2005 (see Figure 1b).

Figure 12 displays state-level GHG emission totals released during the production, transport and processing of fossil fuels between 1990 and 2005, with projections to 2020. Generally, historical emissions are calculated by multiplying emissions-related activity levels (e.g. miles of pipeline, number of compressor stations) by aggregate industry-average emission factors. Based on projected activity, emissions from the fossil fuel industry are expected to increase by about 12% from 2005 through 2020 in the Western States.

For each state, Figure 13 reports 2005 GHG emissions by fossil fuel industry subsector: coal mining, natural gas, and oil. With the exception of Alaska, where most produced natural gas is reinjected, emissions from natural gas systems typically exceed emissions from oil systems within each state. In New Mexico and Wyoming, some produced gas contains relatively high levels of entrained carbon dioxide which must be separated in processing facilities, resulting in increased natural gas

system emissions for these States as reflected in Figure 13 (data on entrained CO₂ were not available in the other states). Key coal mining states - Colorado, Wyoming, and Utah - have the highest reported coal mining methane emissions of the Western States.

Other Industrial Processes

Figure 14 shows the western region GHG emissions for the Industrial Processes sector. These emissions include non-combustion emissions associated with a variety of industrial processes and both CO₂ as well as other GHGs [e.g. hydrofluorocarbons (HFC), perfluorocarbons (PFC), nitrous oxide (N₂O), and sulfur hexafluoride (SF₆)]. Figure 15 provides 2005 state-level emissions by pollutant.

Transportation

The transportation sector includes GHG emissions from fossil fuel combustion from onroad vehicles, aircraft, commercial marine vessels, and rail. Figure 16 shows the state-level totals for the sector. This sector was estimated to contribute 61% of the western region's 2005 gross GHG emissions (see Figure 1b). Emissions include carbon dioxide, nitrous oxide, and methane from fuel combustion. By 2020, the contribution is expected to decline slightly to 59%. It is important to note that for the business as usual forecasts prepared by CCS, the effects of new onroad vehicle standards (for States that adopted California's Pavley Standards) were not incorporated. California's projection appears to include the effects of these standards.

Figure 17 shows the subsector detail for 2005. The onroad sector is shown to dominate in the more populated states, while sectors such as aviation and commercial marine vessels make notable contributions in AK and WA. For aviation, emissions include those associated with the sale of all aviation fuels in the state (even though the fuels might not have been consumed within the State's airspace). For commercial marine, emissions include those from in-port fuel consumption as well as underway emissions within 200 miles from shore (the State's Exclusive Economic Zone).

Agriculture

The emissions discussed in this appendix refer to non-energy CH₄ and N₂O emissions from enteric fermentation, manure management, and agricultural soils. Emissions and sinks of carbon in agricultural soils are also covered. Figure 18 provides a summary of western region agriculture sector emissions. 1990 emissions of just over 90 MMtCO₂e are expected to grow to over 125 MMtCO₂e by 2020.

Figure 19 shows the sector-level detail for gross agriculture GHG emissions (i.e. carbon sequestration in agricultural soils is not included). Agricultural soils N₂O emissions are shown to be the largest contributor to the sector's emissions across all states.

Forestry and Agricultural Soils Carbon Flux

For the inventories prepared by CCS, the forestry flux estimates have been based on information from the U.S. Forest Service (USFS) on forest carbon pools based on the agency's FORCARB model. The FORCARB model in turn relies on forest inventory data from USFS' Forest Inventory & Analysis (FIA) database. From the carbon pools data, flux is calculated from inter-annual changes for the following carbon pools: standing live trees; standing dead trees; down dead trees (coarse woody debris); understory; forest floor; and soil carbon. This includes the effects of land cover change or the change of forests to nonforest uses through FIA data. Through compilations of data covering the latest 15 – 20 years, annual changes in carbon stocks can be calculated for each pool and an overall estimate of flux (typically sequestration) is made. A final carbon pool incorporates carbon removed from the forests in the form of durable wood products or landfilled waste.

Alaska's estimates only cover the coastal maritime forests of the state (the boreal forest is largely unmanaged). The data differ from all other states in that they are based on University of AK, Fairbanks modeling, not USFS data.

Agricultural soils can also be sources or sinks of carbon dioxide emissions. Our data come from EPA's national inventory, and the latest data were available for 1997. Figure 20 provides estimates for each of the State inventories developed by CCS. Of note, ID shows up as the only state with a positive flux from forested areas, presumably associated with land conversion.

Waste Management Sector

This sector incorporates emissions (primarily methane) from both municipal solid waste landfills and wastewater treatment (both industrial and municipal). Emissions from solid waste combustion (carbon dioxide, nitrous oxide, and methane) are also included. Of these sources, methane emissions from landfills tend to be the most important from both a CO₂e perspective, as well as an energy capture opportunity. Figure 21 provides State-level emission estimates for the waste management sector. For many states, emissions were fairly static over time; however UT, CO, and NV were estimated to experience significant growth by 2020. Figure 22 provides a break-out of solid waste management versus liquid waste management for the estimates prepared by CCS.

Black Carbon

Black carbon (BC) is recognized by the IPCC as having positive climate forcing potential (i.e. that it can warm the atmosphere like GHGs do). However, the IPCC does not currently have a global warming potential assigned to BC. Details of the BC inventories are presented in an appendix to the GHG inventory report prepared for each State. Briefly, 2002 BC mass emissions were estimated through chemical speciation of particulate matter emissions for each State. To present these mass emission estimates of BC as CO₂e, CCS applied climate response factors based on recent global climate modeling studies.

The results included a range (both low and high estimates) of CO₂e associated with BC emissions. Organic material (OM), another component of particulate matter emissions, also needed to be factored in to the CO₂e estimates. OM is generally recognized as having a negative climate forcing potential (net cooling effect). [OM represents organic carbon plus the associated hydrogen, oxygen, nitrogen, and other atoms]. Based on the modeling results mentioned above, CCS selected a cut-off ratio of 4:1 (OM:BC) to include in our CO₂e estimates for BC. Above this ratio, it was assumed that the particulate matter emitted did not have a positive climate forcing potential.

Similar estimates were also developed based on 2018 particulate matter emissions for the significant contributing source sectors. Across all states, the most significant sectors were onroad and nonroad diesel engines. Results of the analysis are shown in Figure 23 below. Substantial reductions in BC are expected by 2018 as a result of new Federal engine and fuel standards that will control particulate matter emissions in the onroad and nonroad diesel engine sectors.

CONCLUSIONS

As a result of these state-level GHG inventory and forecast projects, states are gaining an understanding of important contributing source sectors. For states that have begun climate change mitigation planning, the inventories and forecasts are important inputs to inform the types of policies and the stringency needed to meet reduction goals. Currently, the following states have used these data in their climate change mitigation planning: AZ, NM, MT, CO, UT and WA. Collectively, these States produce a significant contribution to worldwide GHG emissions and State to regional mitigation planning is underway throughout much of the western U.S.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support of the Western Regional Air Partnership and each State's environmental agency in the development of the CCS inventories and forecasts: Alaska Department of Environmental Conservation, Arizona Department of Environmental Quality, Colorado Department of Public Health and Environment, Idaho Department of Environmental Quality, Montana Department of Environmental Quality, Nevada Division of Environmental Protection, New Mexico Environment Department, South Dakota Department of Environment and Natural Resources, Utah Department of Environmental Quality, Washington Department of Ecology, and Wyoming Department of Environmental Quality.

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REFERENCES

1. G. Bemis, California Energy Commission, personal communication and datasets provided to CCS, February 2007.
2. *Oregon Strategy for Greenhouse Gas Reductions*, Governor's Advisory Group on Global Warming, State of Oregon, December 2004.
3. *Volume VIII: Estimating Greenhouse Gas Emissions of the Emission Inventory Improvement Program (EIP) Document Series*, ICF Consulting, Washington, DC, 2003.
4. *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, IPCC, 1997, <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>.
5. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*, U.S. Environmental Protection Agency, Washington, DC, 2005, <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html>.
6. Climate Analysis Indicators Tool (CAIT), version 4.0, all gases and sources, except land use change, The World Resources Institute, http://www.wri.org/climate/project_description2.cfm?pid=93.
7. *The US Inventory of Greenhouse Gas Emissions and Sinks*, U.S. EPA, 2005.

KEY WORDS

Climate Change
 Greenhouse Gases
 Aerosols
 State Action
 Carbon Dioxide
 Emissions Inventory
 Emissions Forecast

Table 1. State-level gross and net GHG emissions, 1990-2020.

	1990	1995	2000	2005	2010	2015	2020
State	Annual Emissions (MMtCO₂e)						
AK							
<i>Gross</i>	43	49	49	52	55	58	61
<i>Net</i>	43	48	47	51	54	57	60
AZ							
<i>Gross</i>	66	72	89	100	116	137	161
<i>Net</i>	59	65	82	93	110	130	155
CA							
<i>Gross</i>	428	419	476	509	546	570	598
<i>Net</i>	411	404	461	502	527	555	583
CO							
<i>Gross</i>	87	96	111	118	132	144	157
<i>Net</i>	53	62	77	84	98	110	124
ID							
<i>Gross</i>	28	32	36	37	39	41	43
<i>Net</i>	27	30	35	36	38	40	42
MT							
<i>Gross</i>	32	37	36	37	39	40	42
<i>Net</i>	-6	-2	-2	-2	0	2	4
NM							
<i>Gross</i>	57	66	71	73	79	85	92
<i>Net</i>	36	45	50	53	58	65	71
NV							
<i>Gross</i>	30	37	45	50	54	63	72
<i>Net</i>	22	29	38	42	46	55	64
OR							
<i>Gross</i>	60	64	69	74	79	85	90
<i>Net</i>	59	63	68	73	78	84	89
SD							
<i>Gross</i>	27	29	33	36	39	43	47
<i>Net</i>	26	28	32	35	38	41	45
UT							
<i>Gross</i>	49	58	66	69	76	85	96
<i>Net</i>	11	18	27	30	37	47	58
WA							
<i>Gross</i>	81	88	97	89	95	102	108
<i>Net</i>	44	50	60	52	57	65	70
WY							
<i>Gross</i>	44	50	52	56	60	65	69
<i>Net</i>	3	9	11	15	19	24	28
Total							
<i>Gross</i>	1,570	1,693	1,905	1,997	2,191	2,381	2,587

Figure 1a. State-level gross GHG emissions, 1990-2020.

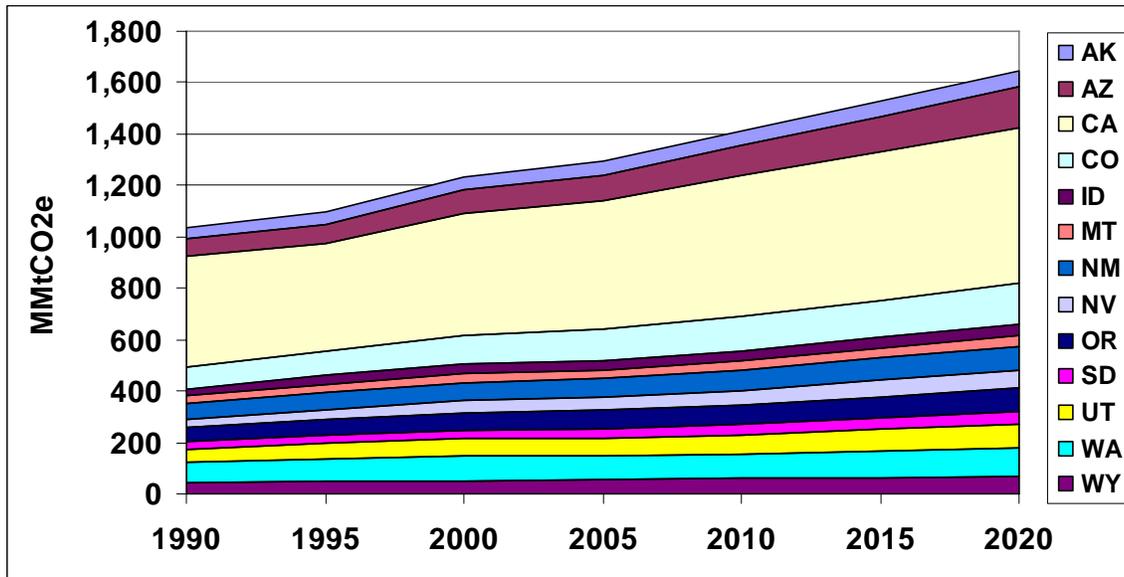


Figure 1b. Region-wide gross GHG emissions by sector, 1990-2020.

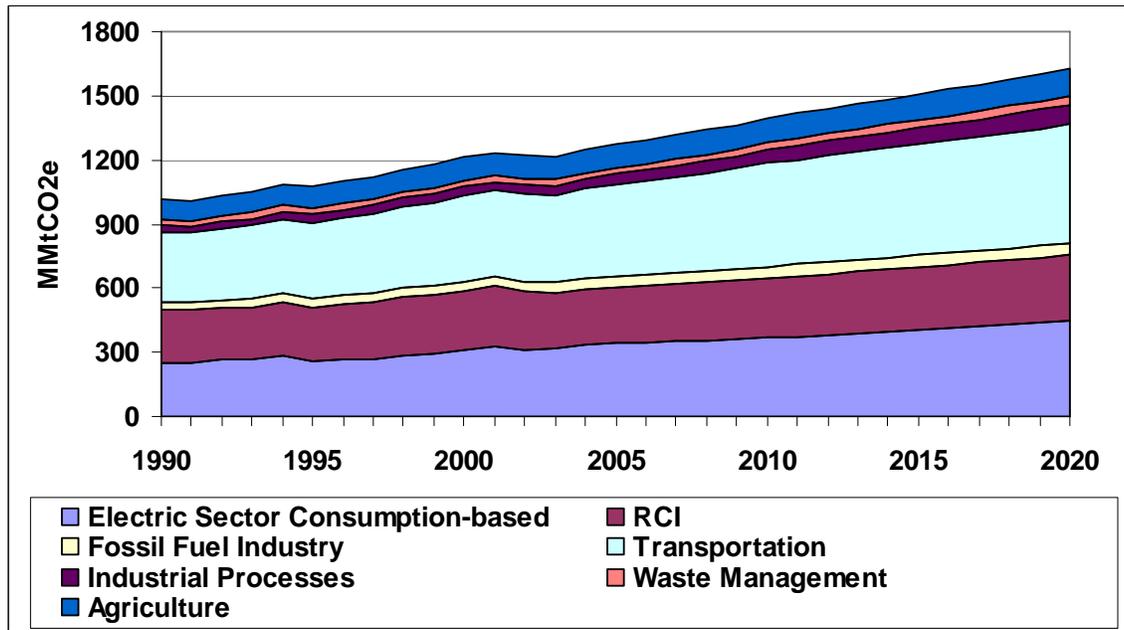


Figure 2. 2000 GHG emissions comparison of western region to top emitting countries.

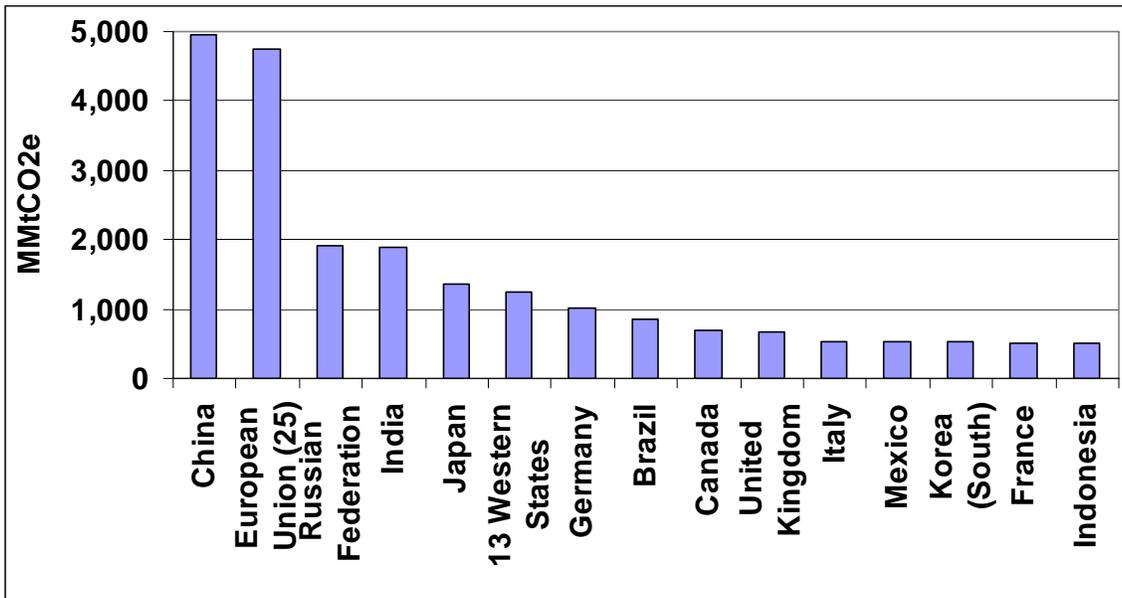


Figure 3. Historic and forecast western region population growth.

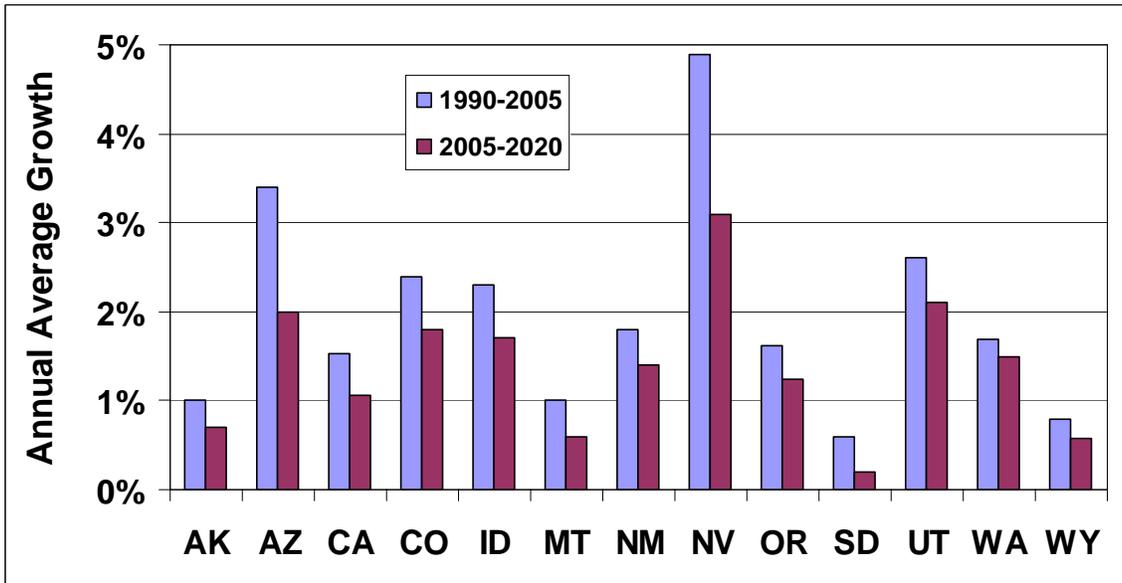


Figure 4. Historic and forecast western region employment growth.

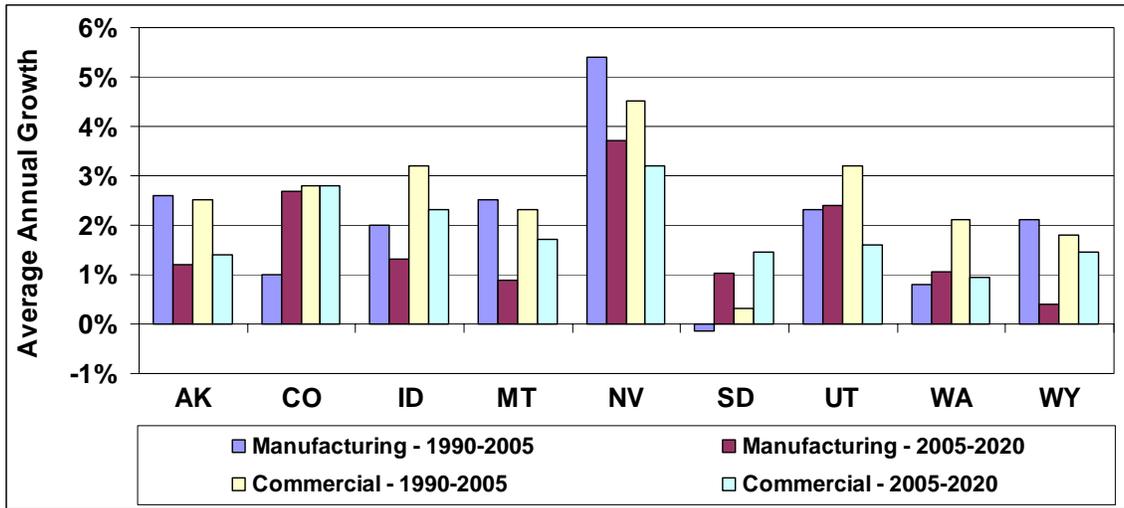


Figure 5. Historic and forecast western region VMT growth.

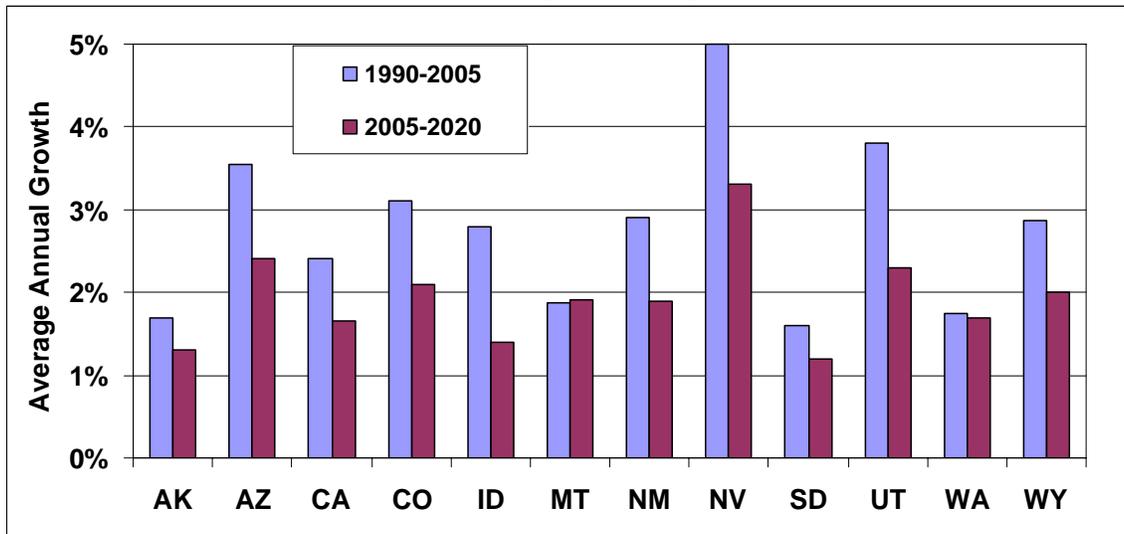


Figure 6. Gross GHG emissions per capita.

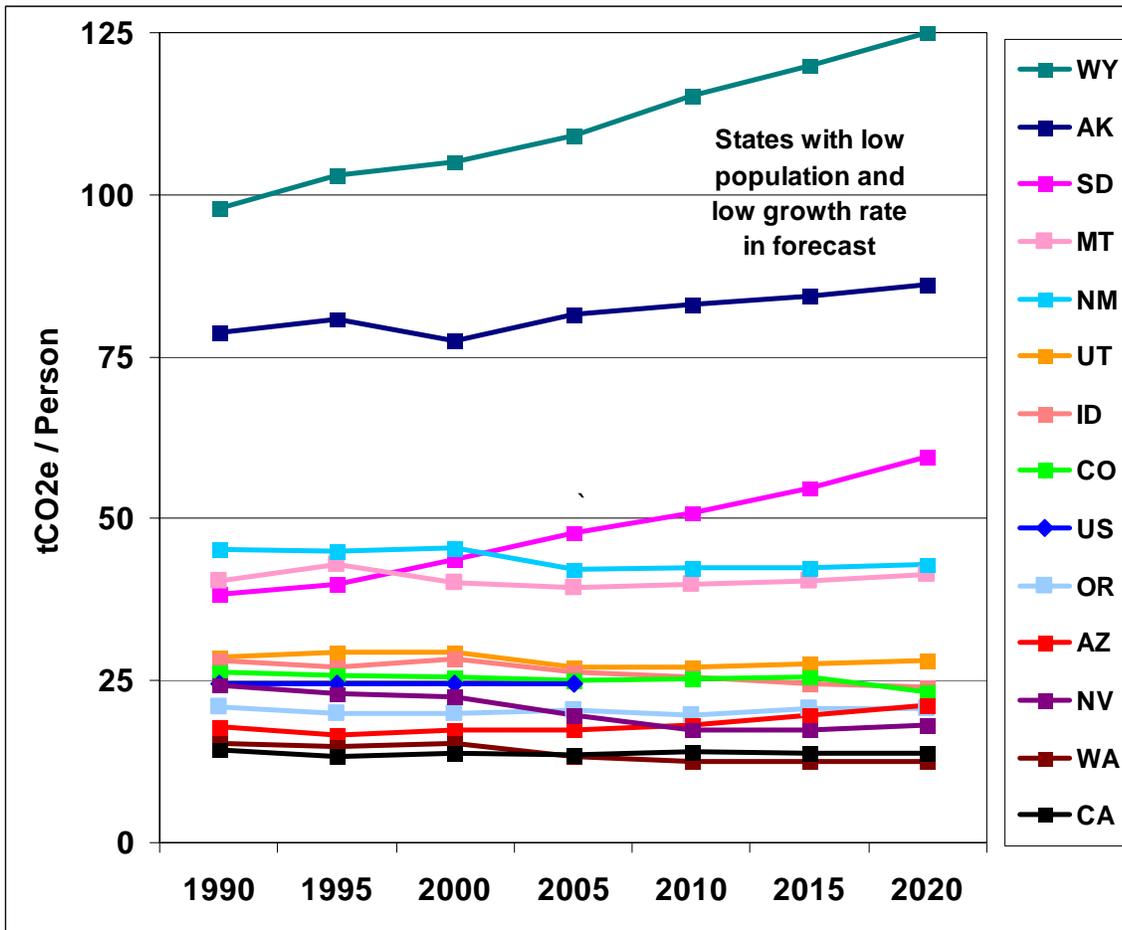


Figure 7. Consumption-based GHG emissions for electricity supply.

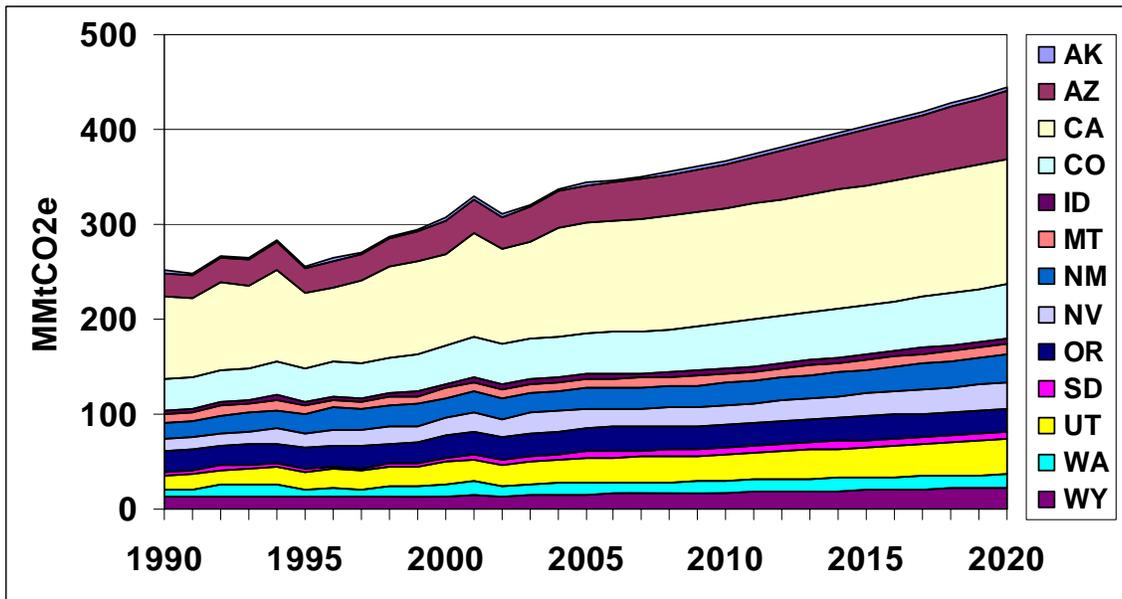


Figure 8. 2005 consumption-versus production-based GHG emissions for electricity supply.

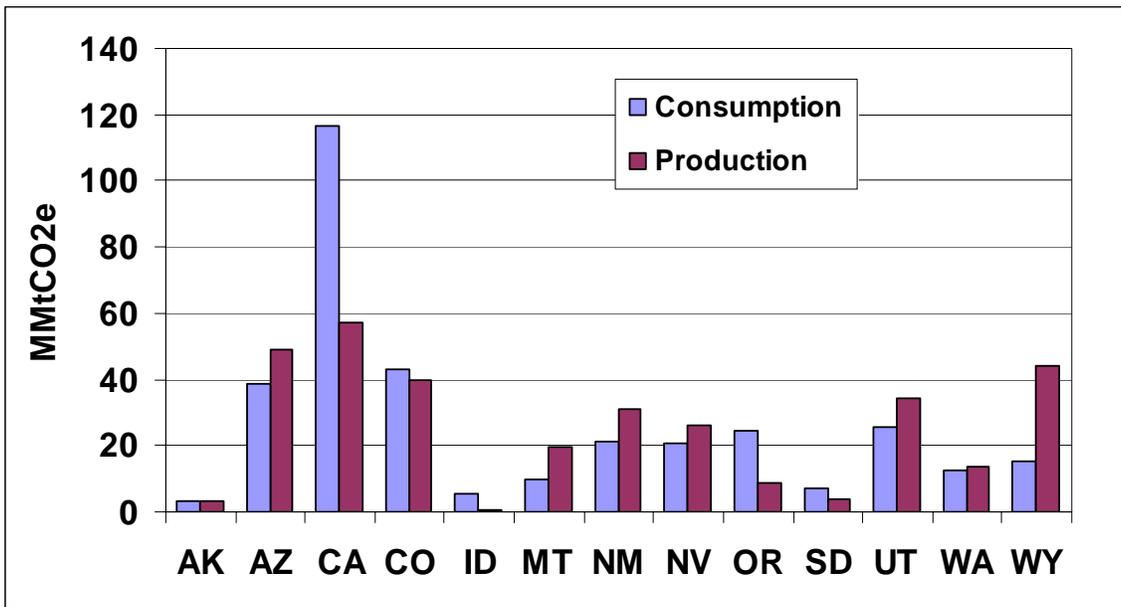


Figure 9. RCI fuel consumption GHG emissions.

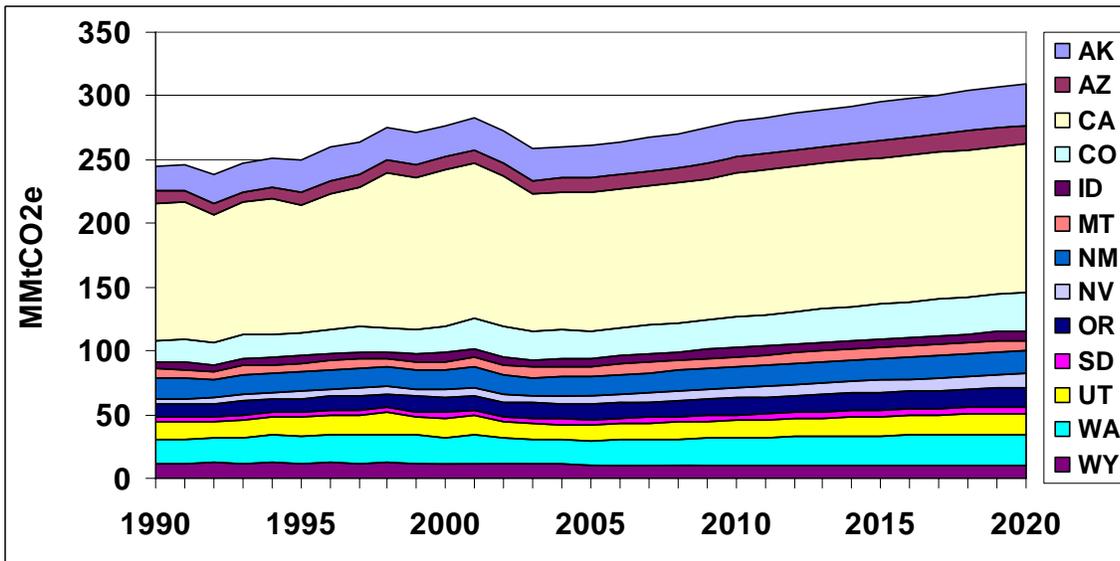


Figure 10. 2005 RCI fuel consumption GHG emissions by subsector.

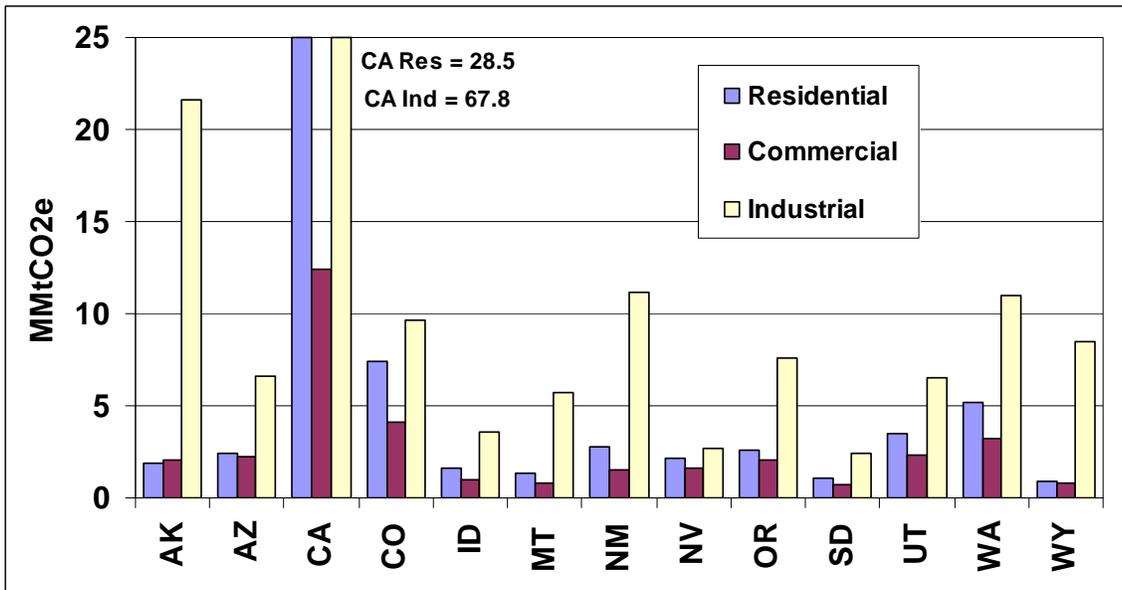


Figure 11. 2005 RCI fuel consumption GHG emissions by fuel type.

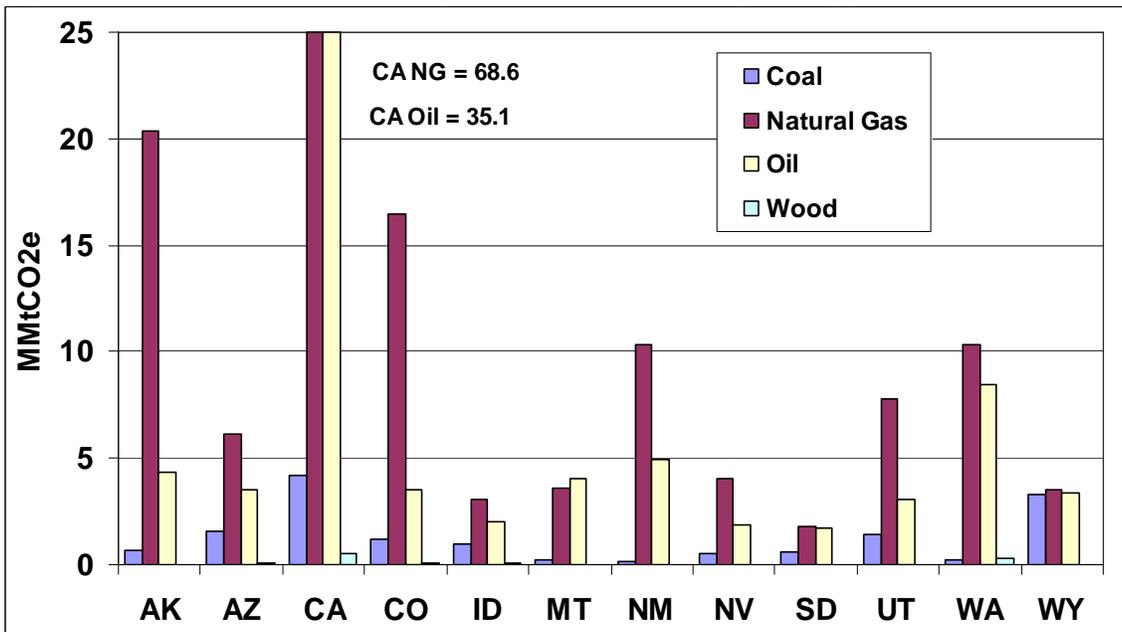


Figure 12. Fossil fuel industry GHG emissions.

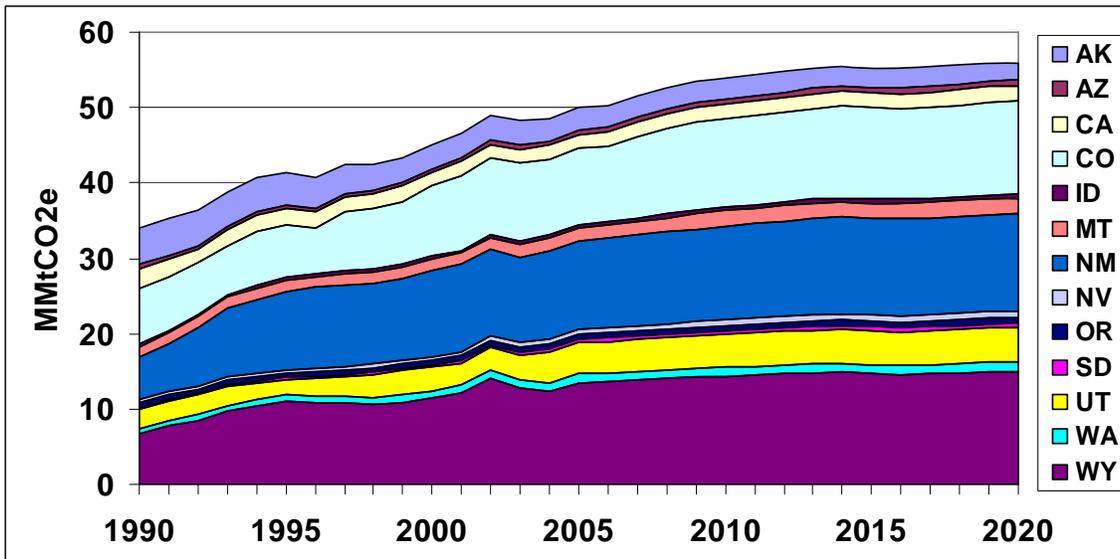


Figure 13. 2005 fossil fuel industry GHG emissions by subsector.

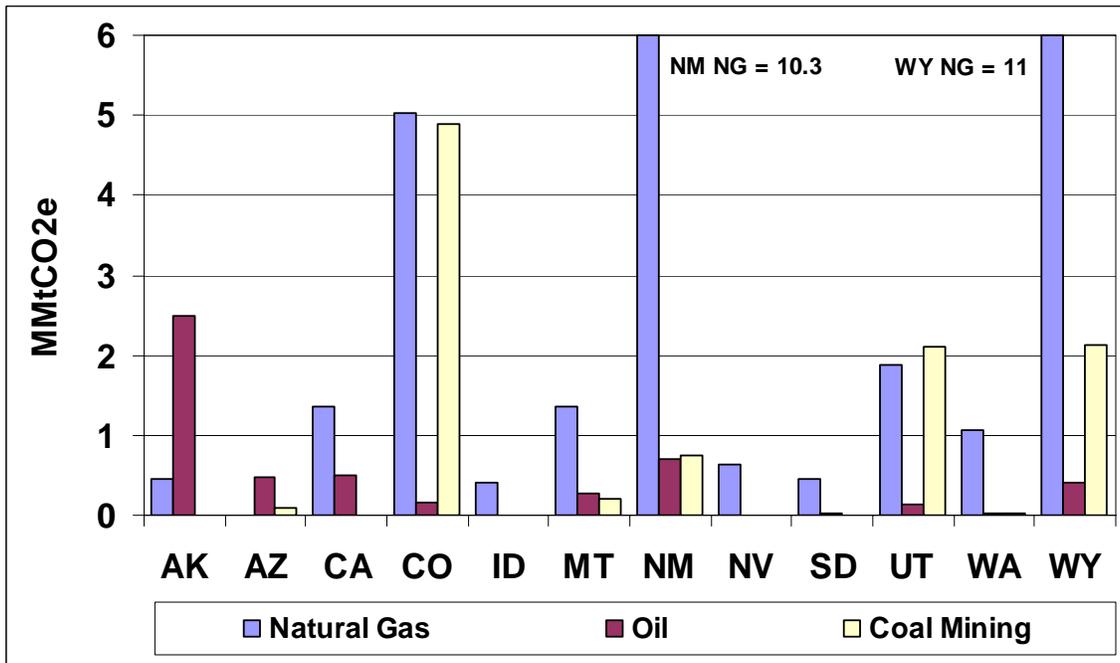


Figure 14. Industrial processes GHG emissions.

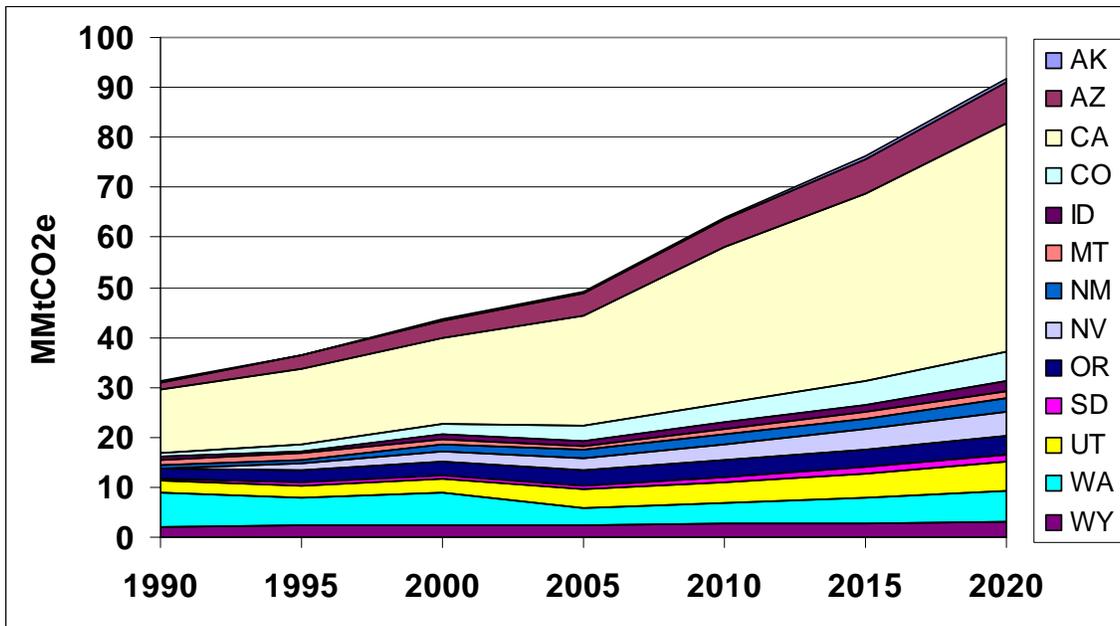


Figure 15. 2005 industrial processes GHG emissions by pollutant.

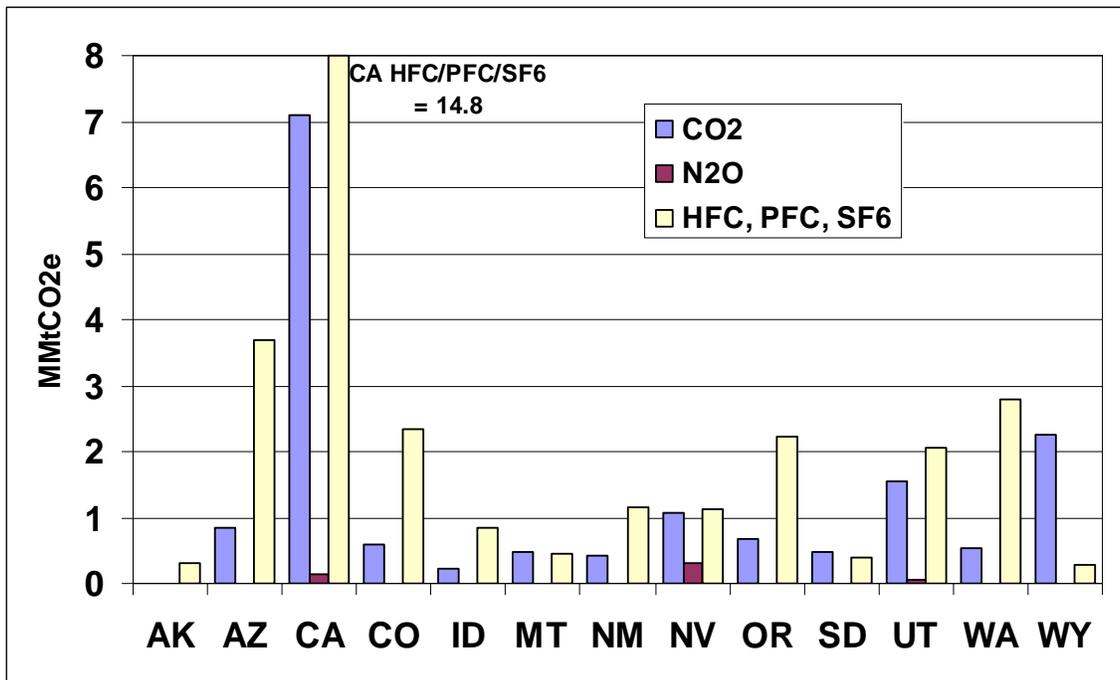


Figure 16. Transportation GHG emissions.

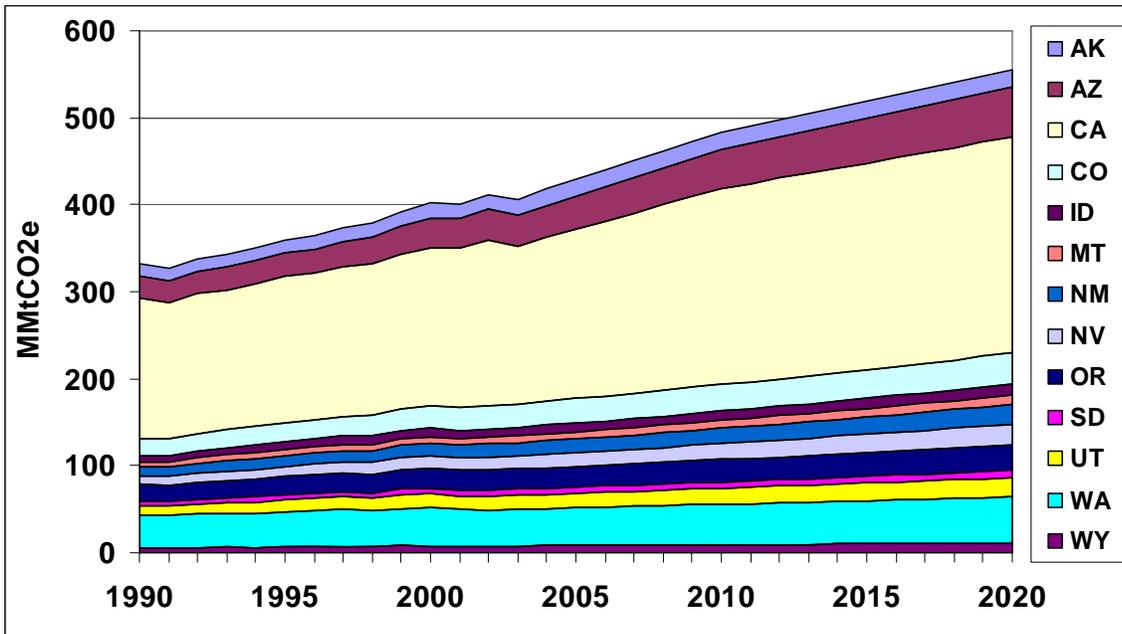


Figure 17. 2005 transportation GHG emissions by subsector.

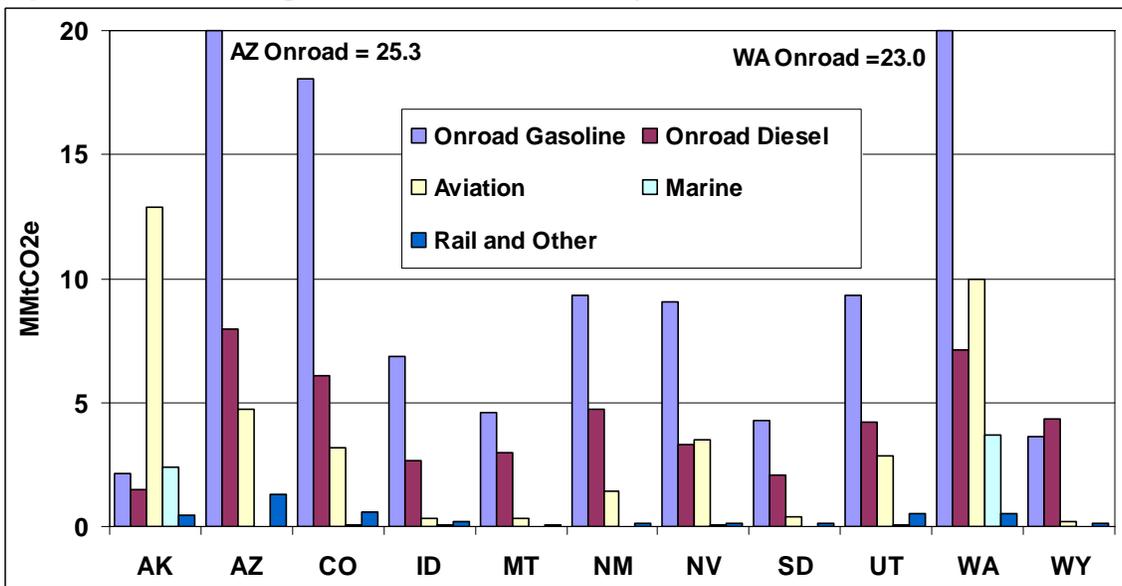


Figure 18. Agriculture GHG emissions.

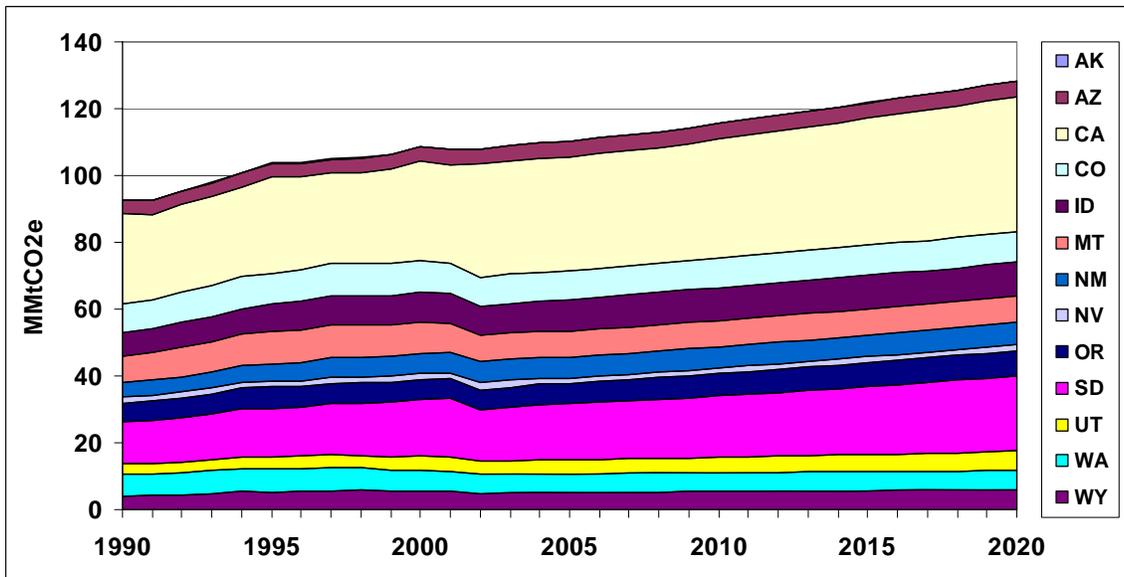


Figure 19. 2005 agriculture GHG emissions by subsector.

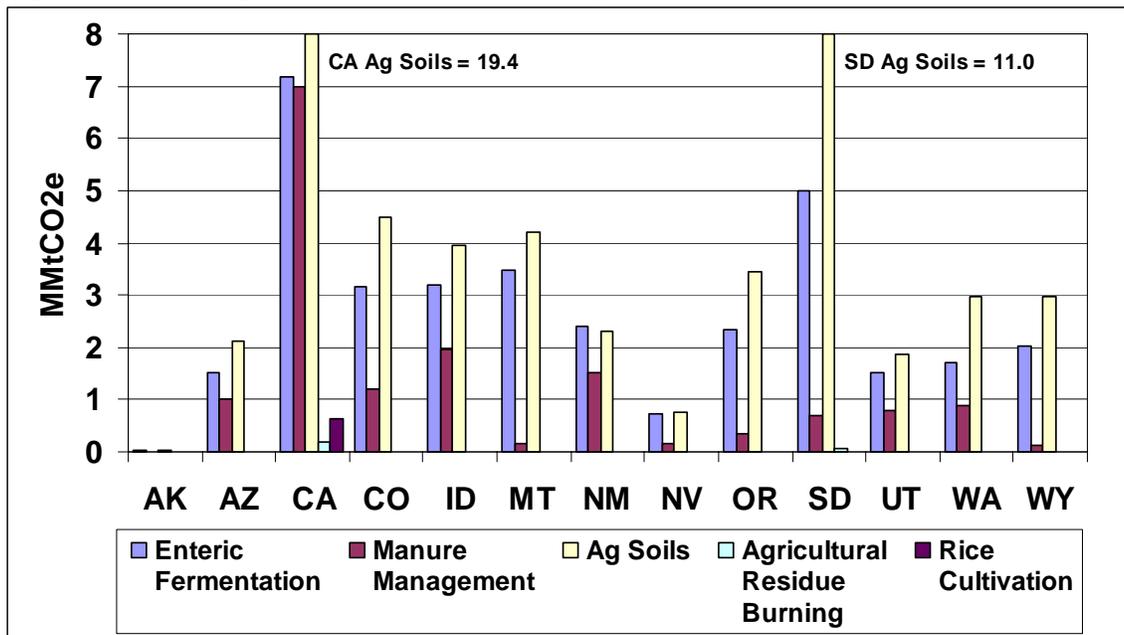


Figure 20. Forestry and agricultural soils GHG flux.

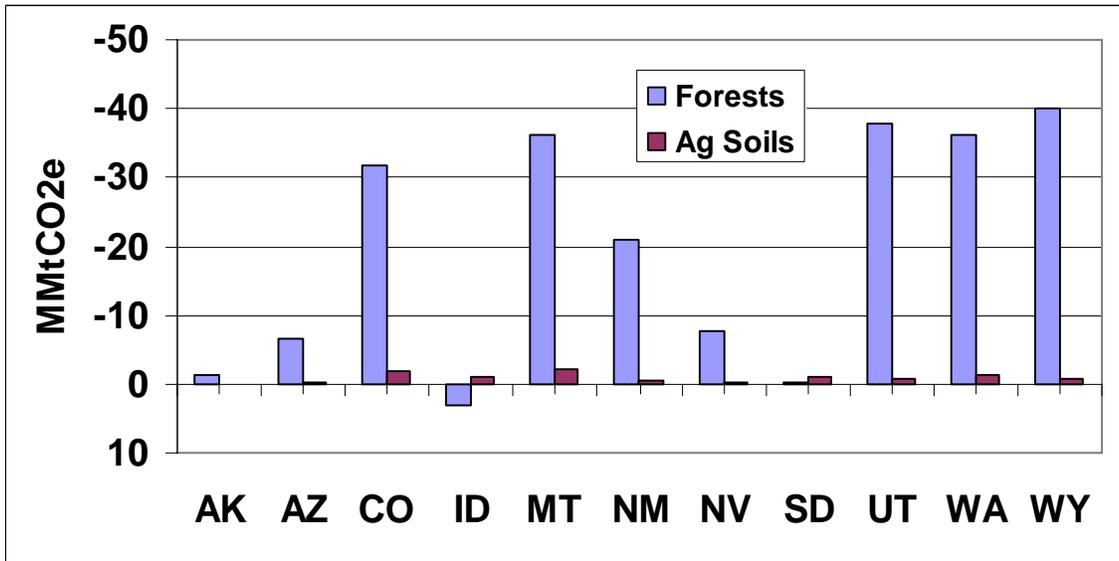


Figure 21. Waste management GHG emissions.

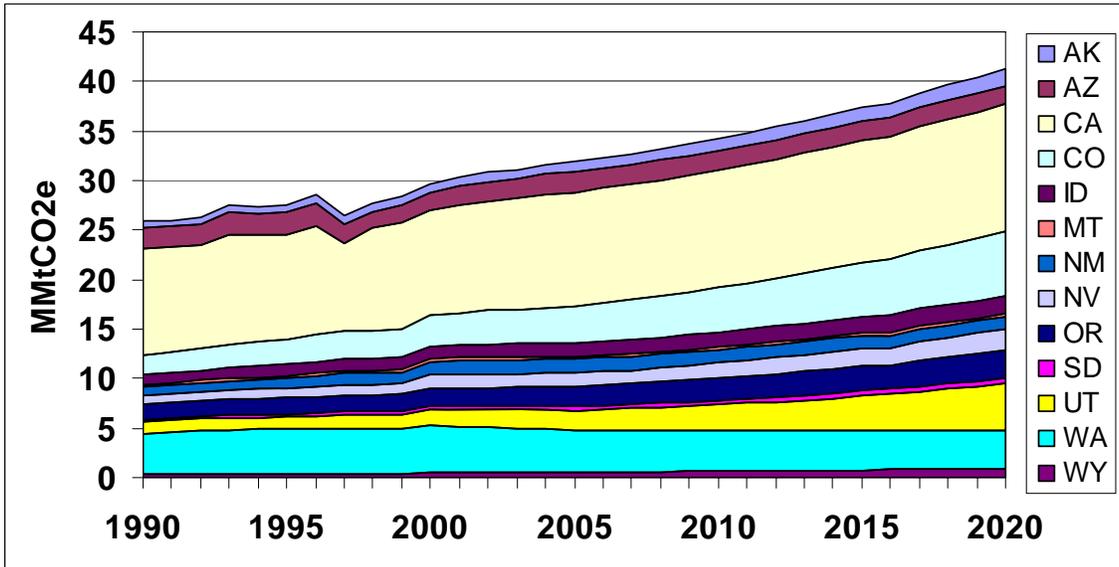


Figure 22. 2005 waste management GHG emissions by subsector.

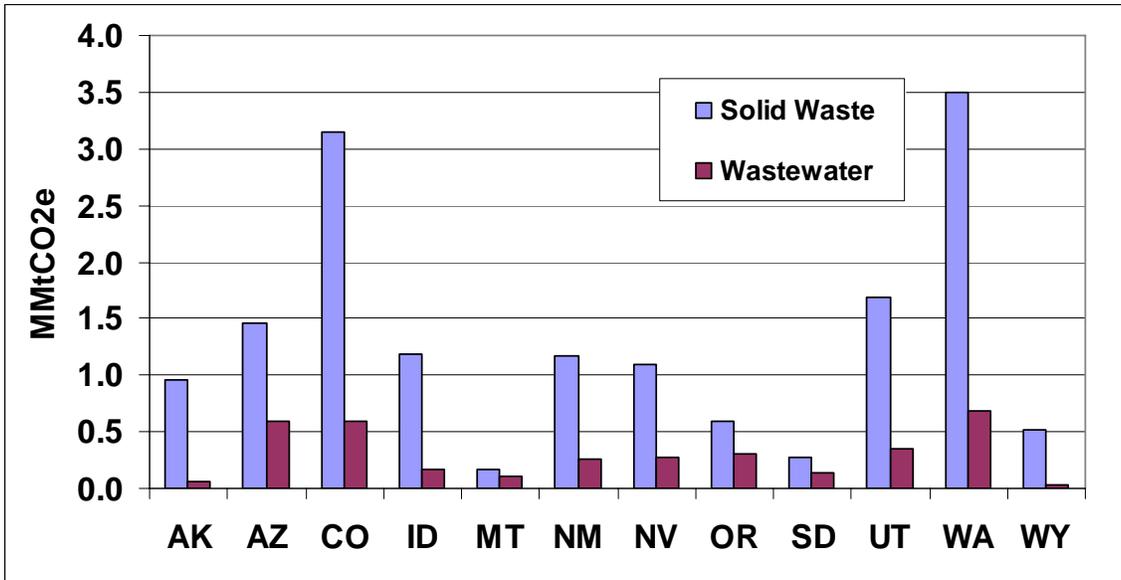


Figure 23. 2002 and 2018 black carbon emissions.

