Appendix B
Inventory and Forecast Details

Introduction

This appendix summarizes the data sources and general methods that were used to develop the community and municipal greenhouse gas (GHG) inventory and forecast updates for the unincorporated Marin County Climate Action Plan 2014 Update (CAP Update). This will be referred to as the "inventory" in this appendix.

This appendix describes the general methods for developing the community and municipal GHG emissions for each emissions sector. It also provides the approach used to develop the "business as usual" (BAU) forecast for 2020 for both community and municipal emissions.

GHG Inventory Structure and Definitions

Community Inventory. The Community Inventory includes GHG emissions associated with community activities occurring within the geographic or jurisdictional boundaries of the county and generally consist of sources of emissions that the County's community can influence or control. It is an activity-based inventory (as opposed to a consumption-based inventory). The boundaries of the community inventory are geographic; emissions included, or activities that result in emissions, must occur inside of the jurisdictional boundary of the county. Marin's cities/towns are separately responsible for calculating the emissions from their own jurisdictions.

Municipal Inventory. The Municipal Inventory includes GHG emissions associated with municipal activities and Marin County (County) government operations as it provides services to the public. It is an activity-based inventory (as opposed to a consumption-based inventory). This inventory includes emissions associated with municipal facilities and municipal activities. The boundaries of the municipal inventory are organizational; emissions included, or activities associated with emissions, must be under the control of the County.

Direct/Indirect Emissions. For direct emissions (such as natural gas combustion in buildings), if the County can have a substantial effect on those emissions by influencing energy use (such as through green building codes), then the direct emissions are included in the inventory. For indirect emissions (such as solid waste disposed outside of the county), if the County can have a substantial effect on those indirect emissions by influencing demand (such as waste minimization and diversion programs), then they are included in the inventory. By including emissions that are controlled by or subject to the influence of the County, the inventory can form the basis for local climate action planning.

GHG Emission Sectors. Community emissions are divided into the following ten sectors: building energy use, on-road transportation, off-road vehicles and equipment, water conveyance, wastewater generation, waste generation, stationary sources, agriculture, forestry, and carbon stock. Municipal emissions are divided into the following nine sectors: building energy use, vehicle fleet, employee commute, off-road vehicles and equipment, water conveyance, wastewater generation, solid waste generation, stationary sources, and refrigerants. The following table maps the community and municipal sectors:

Community Sector	Municipal Sector
Building Energy Use	Building Energy Use
	Streetlights and Traffic Signals
On-Road Transportation	Vehicle Fleet
	Employee Commute
Off-Road Vehicles and Equipment	Off-Road Vehicles and Equipment
Solid Waste Generation	Solid Waste Generation
Water Conveyance	Water Conveyance
Wastewater Generation	Wastewater Generation
Stationary Sources	Stationary Sources
Agriculture	N/A
Forestry	N/A
Rangeland Soil Carbon Stock	N/A
Aboveground Carbon Stock	N/A
N/A	Refrigerants

As noted above, the inventories are activity-based inventories, not consumption-based inventories. Consumption-based inventories include the global emissions associated with satisfying the purchase and use of products and services. These include fuels that are used in buildings and transportation as well as the production of food, other goods, and services. It is a lifecycle emissions approach that estimates total supply chain emissions. Typically, this method is applied at the household level, not at the community or municipal level. The ICLEI—Local Governments for Sustainability (ICLEI) *U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions* (2012) and the *Local Government Operations Protocol for the Quantification and Reporting of Greenhouse Gas Emissions Inventories* (LGOP) (2010) (used here) are both activity-based inventory protocols which do not require the preparation of lifecycle inventories for community or municipal inventories.[1] Consumption-based inventory protocols are currently under development. For these reasons, the community and municipal inventories for Marin County are activity-based inventories.

Municipal emissions are largely, but not exclusively, a subset of community emissions. For example, emissions related to natural gas and electricity consumption in municipal buildings are contained within the community building energy use sector, because this energy use was included in the utility data for the community. Because the municipal inventory uses an operational boundary as opposed to a geographic boundary, it may sometimes include emissions outside or not completely aligned with the community's boundary. For example, emissions from County vehicles (such as police cars or fire trucks) traveling outside of county boundaries (such as within an incorporated city) would be included in the municipal inventory. As another example, vehicle emissions from employees commuting from outside the county to work at a municipal office within the county would also be included in the municipal inventory. Caution should be taken when examining the two inventories as they are related but the municipal inventory is not always a complete subset, and should therefore never be added to or subtracted from community emissions.

[1] The ICLEI U.S. Community Protocol (2012) states the following: "Consumption‐based accounting of greenhouse gas emissions at the community scale is a relatively young field. Methods are still being tested, evaluated and compared and "best practices" have not yet been identified. Additional new methods and variations on those methods may still be developed."

Previous Inventories

Marin County assessed community and municipal GHG emissions for a number of years as part of its 2006 GHG Reduction Plan. Emissions were estimated for the years 1990, 1995, 2000, and 2005. Community emissions included emissions for the entire county, including both the cities and the unincorporated areas. The municipal emissions included activities associated with local government operations. These inventories used slightly different methods and data sources from those used in the inventory for this CAP Update, as data sources have expanded and improved, and methods for calculating emissions have grown more robust.

The previous community inventories included emissions for building energy (residential, commercial, and industrial), transportation, waste, and agriculture. The previous municipal inventories included emissions for buildings, streetlights, vehicle fleet, employee commute, and waste. The new inventories contained in this CAP Update include additional emissions sectors to encompass more sources of emissions and provide a more comprehensive picture of emissions associated with the county.

Inventory Update Year – 2012

The inventory update year for the GHG inventory is 2012. The year 2012 was chosen because complete or nearly complete activity data was available for the year 2012 for all sectors to support inventory preparation. Socioeconomic data for 2012 (including population, employment, and housing) was derived from a combination of data from the Association of Bay Area Governments (ABAG) and the U.S. Census. For sectors where 2012 data is not available, appropriate scaling methodologies were developed to project activity data to the year 2012. Any measures or programs (such as those designed to reduce emissions) implemented prior to the base year (2012) are accounted for in the inventory.

2020 Business as Usual Forecast

The inventory also supports development of the 2020 BAU Community Forecast, which is a prediction of how community emissions may change in the future, in absence of State and local actions to reduce GHG emissions. A BAU projection is an estimate of future emissions; it does not include the effects of *any* new federal, State, or local measures. The CAP Update 2020 BAU Community Forecast is similar to a BAU projection but differs slightly because 1) the data used to forecast 2020 emissions include General Plan socioeconomic assumptions and 2) the transportation emissions forecast accounts for future planned highway and transit network improvements (including the launch of SMART). Local actions and all other State regulations (e.g., AB 32) are not included in the forecast.

The BAU forecasts for 2020 used socioeconomic metrics, which scaled the base-year data. A unified set of socioeconomic data (population, jobs, and households) was developed through coordination with ABAG and the Metropolitan Transportation Commission (MTC).

Additional methods of forecasting 2012 activity and emissions data to 2020 were used depending on the sector and availability of data. For example, some water consumption projections were already available in Urban Water Management Plans (UWMPs) for the County's water suppliers.

Updated Community GHG Emissions for 1990

To facilitate comparison to 2012 and 2020 emissions, and to provide a more accurate GHG reduction target for community emissions, a revised GHG emissions inventory for the year 1990 was conducted for the community (1990 municipal emissions were not updated as part of this effort). The data sources used for 1990 are consistent with the data sources used for 2012. The revised 1990 community emissions inventory is consistent with the latest GHG protocols and the 2012 Community GHG inventory and 2020 Community BAU forecast. This is important because the 2020 GHG reduction target is based on 1990 emissions, so consistent GHG accounting across all years of analysis is necessary.

The 1990 municipal emissions are not completely consistent with the 2012 emissions in terms of sectors, data, and methods. There were some significant data gaps in the 1990 Municipal Inventory, which makes comparisons between years difficult. These data gaps include missing utility data for certain buildings (including some fire stations and the fairgrounds), missing electricity consumption data for some streetlights and traffic signals, over-reported solid waste diversion, fuel sold to other agencies not controlled by the County in the vehicle fleet sector, and a lack of data for water use, wastewater treatment, stationary sources, and refrigerants. Because of these data gaps, comparing municipal emissions in 1990 with emissions in 2012 (or 2020) should be done with care.

Inventory Protocol

The ICLEI - Local Governments for Sustainability (ICLEI) *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions* (October 2012) was used to quantify community emissions for 2012 wherever applicable and appropriate. For some sectors, like land use sequestration, the ICLEI 2012 Community Protocol provides no guidance and alternative protocols were consulted including the Association of Environmental Professionals white paper on baseline community inventories and IPCC methodologies. The California Air Resources Board's *Local Governments Operations Protocol* (LGOP) was used to develop the municipal inventory for 2012 (California Air Resources Board et. al. 2010).

Emission Sectors

The following section includes detailed methods and supporting information for the inventory. This section is organized by sector. For each sector, the following information is provided:

- Overview: a brief description of the emission calculation(s).
- Methods Used in Previous Inventory: a brief description of the methods used in the County's 2005 GHG inventory (Marin County Community Development Agency 2007).
- Data and Models: a list of data and models that were used to calculate emissions.

- Inventory Methods: the detailed methodology for calculating emissions for both the community and municipal inventories for 2012.
- Forecast Methods: the detailed methodology for forecasting emissions for the community and municipal inventories to 2020.

Building Energy (Community and Municipal) and Streetlights and Traffic Signals (Municipal)

Overview

This sector includes GHG emissions from electricity and natural gas consumption for residential, commercial, industrial, institutional, and municipal buildings in the county.

Methods Used in Previous Inventory

The County's previous inventory for 2005 included four building energy sectors: two community sectors (Residential and Commercial/Industrial) and two municipal sectors (Street lighting/traffic signals and buildings). Residential, commercial, and industrial building energy emissions were determined using ICLEI's Cities for Climate Protection (CCP) software, which incorporates energy consumption data (electricity and natural gas) from Pacific Gas and Electric (PG&E) and electricity GHG emission factors based on California's fuel mix. Similarly, municipal building energy emissions from 20 County-owned buildings were determined using PG&E data and the California energy generation emission factors. Emissions from municipal street lighting and traffic signals were determined using the same methods as described above. 1990 emissions only included traffic signals and not streetlights.

Data and Models

- Electricity consumption (kWh) provided by PG&E for residential, commercial, industrial, institutional, and municipal buildings and by Marin Clean Energy (MCE) for customers they serve (Armanino pers. comm.; Kudo pers. comm.).
- Natural Gas consumption (therms) provided by PG&E for residential, commercial, industrial, institutional, and municipal buildings (Armanino pers. comm.).
- Utility specific electricity GHG emission factors for PG&E (year 2012 data) and regional average emission factors from the U.S. Environmental Protection Agency (USEPA) for methane (CH_4) and nitrous oxide (N_2O) (year 2010 data) (Pacific Gas and Electric 2014; USEPA 2014). Marin Clean Energy emission factor for 2012 (Kudo pers. comm.).
- GHG emission factors for natural gas for 2012 (Pacific Gas and Electric 2013).
- Socioeconomic data for 2012 and 2020, including population, square footage of commercial and industrial establishments, employment by sector, and number of households (Wong pers. comm.).
- Municipal building construction information.
- Municipal employment data and projections for 2012 and 2020.

Inventory Methods

Community and Municipal: The County estimated CO_2 emissions from electricity provided by PG&E by multiplying electricity use by the utility-specific CO_2 emission factor for PG&E-delivered electricity for 2012. The 2012 emission factor (445 pounds of carbon dioxide equivalent per megawatt hour) represents all emissions related to electricity deliveries in 2012, including owned and purchased power. Methane (CH_4) and nitrous oxide (N_2O) emissions for both utilities were calculated using USEPA eGRID year 2010 emission factors for the CAMX/WECC region (this region represents electricity primarily generated in California; 2010 is the latest year available). Similarly, emissions associated with power provided by MCE were estimated using emissions factors. The inventory update includes community emissions for residential, commercial, and industrial buildings and municipal emissions for municipal buildings and street lighting/traffic signals. Water-related energy use was subtracted from the building energy sector to avoid double counting.

Transmission and distribution (T&D) electricity losses, which occur between the points of generation and the points of consumption, were also included in the building energy sector. The T&D loss value used in the inventory was 6.84% (USEPA 2014). The CAMX/WECC emission factors cited above were used to estimate GHG emissions for this electricity.

GHG emissions from natural gas consumption were calculated by multiplying the natural gas consumption statistics by emission factors from PG&E and ICLEI (Armanino pers. comm.; ICLEI – Local Governments for Sustainability USA 2012).

Forecast Method

Community: 2020 BAU building energy consumption was estimated by projecting 2012 data using the socioeconomic forecasts. Residential energy use was forecasted using the projected number of single-family and multi-family homes in 2020 and commercial and industrial energy use was forecasted using employment projections. The State's renewable portfolio standard will impact electricity emissions in future years, however, the impact of the State's goals is quantified under the reduction measures and is not counted toward BAU estimates.

A future PG&E emission factor was calculated by taking a running average of emission factors for the past five years (2008–2012) to partially neutralize the large annual variability in utility emission factors. PG&E has published future emissions factors out to 2020 but those take into account Renewable Portfolio Standard (RPS) advancement, whereas the BAU forecast will not take into account future activities. For MCE power, usage was held constant; increases in MCE participation is part of the CAP strategies to reduce GHG emissions.

Municipal – Building energy emissions resulting from energy consumption in County-owned facilities and equipment in 2020 was estimated by projecting the 2012 municipal building energy emissions using building expansion/construction projections provided by the County.

On-Road Transportation (Community); Vehicle Fleet and Employee Commute (Municipal)

Overview

This sector includes GHG emissions from fuel combusted by on-road vehicles. For the municipal inventory, this includes County vehicle fleet emissions and employee commutes.

Methods Used in Previous Inventory

Community: The County's previous GHG inventory estimated transportation emissions by using county vehicle miles traveled (VMT) data from the Caltrans Highway Inventory and Performance Branch database (HPMS Database), the Caltrans Motor Vehicle Stock, Travel, and Fuel Forecast (MVSTAFF) reports for 2005, and transportation GHG- emission factors embedded in the ICLEI Cities for Climate Protection (CCP) software.

Municipal: The County's municipal on-road transportation emissions, which includes employee commute and vehicle fleet emissions, were determined using employee commute survey data from the Employee Transportation Survey and vehicle fleet fuel consumption data from the Department of Public Works' fleet accounting software. Emissions were likely estimated using the ICLEI CCP software, but the County's Inventory Report does not specify.

Data and Models

- Traffic model results provided by MTC for 2012 and 2020. The MTC model was run for the years 2010 and 2020. 2012 VMT values were interpolated using methods from MTC. The MTC outputs will include VMT for the county aggregated by origin/destination (inbound, outbound, or intra-city) and speed increments ("speed bins") of 5 miles per hour from 0 to 65 mph) (Brazil pers. comm.).
- EMFAC2011 model emission factors.
- Employee commute survey data for 2012.
- Fuel consumption for County-owned vehicles for 2012.
- Municipal employment data and projections for 2012 and 2020.

Inventory Methods

Community: Quantification of on-road transportation emissions followed the 2012 ICLEI Community Protocol. Community VMT data was provided by MTC for 2012 (interpolated using an MTC-derived interpolation factor). The MTC model uses the latest Association of Bay Area Governments (ABAG) (Plan Bay Area) forecasts.

To determine passenger VMT for the county, MTC apportioned one-half of the trip distance for any trip with an origin or destination within the county. This eliminates apportioning through-trips on freeways or major arterials to the county, while adding regional traffic burden to land uses generating trips on a 50/50 split. This is the current recommended approach of the State's Regional Targets Advisory Committee (RTAC) and provides a better accounting of VMT associated with land use jurisdiction than approaches that apportion VMT on a pro-rata share or on the basis of VMT that occurs within the boundaries of a jurisdiction. This approach can also help to reveal potential differences in VMT generation that can be useful during future land use and GHG reduction planning. VMT by speed bin and the corresponding speeds were used as inputs into the EMFAC2011[2] model to determine emission factors that were used to quantify the GHG emissions for passenger vehicles.

[2] The Emissions Factor (EMFAC) model is a transportation model issued by the California Air Resources Board. It includes a set of emission factors that represent the local vehicle fleet, speeds, and environmental conditions that can be useful in performing project-level air quality modeling.

VMT and GHG emissions for commercial and other vehicles was supplied at the countywide level and apportioned to the unincorporated county using apportionment factors developed by MTC.

Municipal: Municipal GHG emissions include employee commute and vehicle fleet emissions. Employee commute emissions were estimated using the most recent employee commute survey data from the County. Employee commute VMT were then multiplied by the appropriate emission factors from the EMFAC model.

Vehicle fleet emissions were estimated using the County's most recent fuel consumption data, mileage data, and other vehicle fleet data, provided by the County. Fuel consumption data was multiplied by the appropriate emission factors from the Climate Registry (Climate Registry 2014).

Forecast Methods

Community: VMT data was provided by MTC for 2020. Similar to the inventory methods, the forecast methods used the 2020 VMT data and corresponding emission factors from the EMFAC model to determine community on-road GHG emissions in 2020.

Municipal: The County's 2020 employee commute emissions were projected using the 2012 employee commute emissions and municipal employment projections provided by the County. Municipal vehicle fleet emissions were projected using municipal employment projections provided by the County.

Off-Road Vehicles and Equipment (Community and Municipal)

Overview

This sector includes GHG emissions from small off-road equipment (e.g., recreational, harbor craft, rail yard, private airport, lawn and garden, agricultural, commercial, and industrial equipment), and County-owned off-road equipment.

Methods Used in Previous Inventory

Off-road vehicles and equipment emissions were not included in the County's previous GHG inventory.

Data and Models

- The California Air Resources Board (CARB) OFFROAD model.
- CARB's Diesel Off-road On-line Reporting System.
- Socioeconomic data for 2012 and 2020, including population, employment by sector, and number of households (Wong pers. comm.).
- Municipal employment data and projections for 2012 and 2020.

Inventory Methods

Community: For quantification of off-road emissions, The County used the 2012 ICLEI Community Protocol as a guide. The 2012 ICLEI Community Protocol recommends using the USEPA's NONROAD model, but this analysis will use CARB's OFFROAD model because it is more specific to California communities than the NONROAD model.

CARB's OFFROAD model provides estimates for emissions at the county level for a variety of off-road equipment types, including construction equipment, lawn and garden equipment, airport ground support equipment, and recreational equipment. The County obtained county-level data from the OFFROAD model or CARB's Diesel Off-road On-line Reporting System (DOORS). This analysis was based on the model's default assumption of annual hours of operation for all equipment in the county.

Emissions resulting from the use of agricultural equipment were included under this sector.

Municipal: A list of County-owned off-road equipment and fuel consumption data for 2012 was used. The fuel consumption data and fuel-GHG emissions factors from the Climate Registry were used to estimate emissions from the County-owned equipment (Climate Registry 2014).

Forecast Methods

Community - 2020 BAU off-road emissions were estimated using 2012 off-road emissions and socioeconomic forecast data (population, housing and jobs). The type of socioeconomic data that was used depends on the off-road equipment type (e.g. landscaping equipment was projected using housing forecast projections for 2020; industrial equipment was projected using employment projections for 2020).

Municipal – Off-road emissions resulting from County-owned equipment in 2020 were estimated by projecting the 2012 municipal off-road emissions using municipal employment projections provided by the County.

Solid Waste Generation (Community and Municipal)

Overview

This sector includes GHG emissions associated with the decomposition of waste generated by the County.

Methods Used in Previous Inventory

Community: The County's previous community GHG inventory used waste disposal data from the California Integrated Waste Management Board (CalRecycle) and ICLEI's Cities for Climate Protection software.

Municipal: The County's previous municipal GHG inventory used data provided by the Department of Public Works and the ICLEI software.

Data and Models

- Tons of waste sent to landfills in 2012 from the California Department of Resources Recycling and Recovery (CalRecycle) (CalRecycle 2013).
- Landfill characteristics for the Redwood Landfill (Waste Management 2014).
- Waste emission factors from the 2012 ICLEI Community Protocol (ICLEI – Local Governments for Sustainability USA 2012).
- Municipal employment data and projections for 2012 and 2020.

- Socioeconomic data for 2012 and 2020, including population, and employment by sector (Wong pers. comm.).
- Municipal waste generation from the County's Department of Public Works.

Inventory Methods

Community: Consistent with the 2012 ICLEI Community Protocol solid waste emissions calculation methods, the County evaluated emissions from solid waste management by considering future indirect emissions resulting from solid waste deposited in the inventory year, as reported by CalRecycle,[3] regardless of where that waste is disposed.

Per the 2012 ICLEI Community Protocol for indirect future emissions from community-generated waste during the inventory year, total tons of waste (residential and commercial) sent to landfills in 2012 and waste profile data was combined with equations from ICLEI. Redwood Landfill accepts county waste and has a 90% methane collection rate, which is higher than the industry standard 75% rate (Waste Management 2014). This capture rate was used in place of the default ICLEI capture value to calculate emissions for the county. The ICLEI emission factors for waste cover a variety of waste types (glass, plastic, wood, etc.). These emission factors were multiplied by the corresponding waste amounts (by waste type) generated in the county in 2012 to calculate future indirect emissions. The generation-based estimates can help identify opportunities for waste reduction measures through source reduction, recycling, or composting. As such, the generation-based emissions method was used in the inventory.

Total site-based emissions from the Redwood Landfill (which are associated with *all* waste deposited in the landfill, not just the waste deposited by unincorporated Marin County) were not included because these emissions would be double-counted with the generation-based emissions that were included. Emissions from composting and combustion of solid waste were not included in the inventory due to data availability issues, as CalRecycle does not provide this data. These sources are likely minor emissions sources. Emissions from waste hauling (trucks) are not included in this sector. These emissions are included in the On-Road Transportation sector for trucks (waste trucks are part of the aggregate countywide VMT data provided by MTC).

Municipal: The County's municipal waste emissions were estimated using waste generation data from County facilities provided by the Department of Public Works and the ICLEI equations described above for the Community inventory (Marin County Civil Grand Jury 2014). The County does not own and operate any landfills, so direct site-based landfill emissions were not included.

Forecast Methods

Community: 2020 community solid waste emissions were estimated by projecting 2012 waste generation using population and employment forecast data for residential and commercial waste, respectively.

Municipal: Solid waste emissions resulting from municipal operations in 2020 were estimated by projecting 2012 municipal waste generation using municipal employment projections provided by the County.

[3] CalRecycle is California's leading authority on recycling, waste reduction, and product reuse. Officially known as the Department of Resources Recycling and Recovery, CalRecycle plays an important role in the stewardship of California's vast resources and promotes innovation in technology to encourage economic and environmental sustainability.

Water Conveyance (Community and Municipal)

Water consumption-related emissions originate from energy used to transport, treat, and pump water to the county, including water consumed at County-owned facilities. Emissions from water conveyance were estimated for the following sources: 1) the energy associated with water usage *inside* the county (such as local pumps distributing water within the county) and 2) energy associated with water transport from *outside* the county (such as regional pumps delivering water from the Russian River in Sonoma County to the county's borders). Electricity used to treat and distribute water locally is captured within the building energy sector; all attempts were made to avoid any double counting of this energy use and resulting emissions.

Overview

This sector includes GHG emissions associated with water consumption in the county.

Methods Used in Previous Inventory

Water consumption emissions were not included in the County's previous GHG inventory.

Data and Models

- Water consumption (gallons) in (2012) provided by MMWD, NMWD and Stinson Beach County Water District (Armanino pers. comm.).
- Electricity and natural gas use for water treatment and pumping in 2012 provided by MMWD, NMWD and Stinson Beach County Water District (Armanino pers. comm.).
- Water consumption at County-owned facilities in 2012 provided by MMWD and NMWD (Armanino pers. comm.).
- Water supply sources for the county.
- Utility specific electricity GHG emission factors for PG&E (year 2012 data) and regional average emission factors from the U.S. EPA for methane (CH_4) and nitrous oxide (N_2O) (year 2010 data) (USEPA 2014). Marin Clean Energy emission factor for 2012 (Kudo pers. comm.).
- GHG emission factors for natural gas for 2012 (Pacific Gas and Electric 2013).
- Socioeconomic data for 2012 and 2020, including population and jobs (Wong pers. comm.).
- Municipal employment data and projections for 2012 and 2020.

Inventory Methods

Community: Water is provided to the county by the Marin Municipal Water District (MMWD), the North Marin Water District (NMWD), and the Stinson Beach County Water District (SBWD). Actual electricity and natural gas use for water treatment and pumping in the county (provided by MMWD, NMWD, and SBWD) was used to develop emissions. Countywide energy use was apportioned to the unincorporated county using service population figures. Water-related energy use was subtracted from the building energy sector to avoid double counting. T&D losses associated with water-related electricity were also included in this sector (details provided in the building energy sector section). Emissions calculations were based on electricity emission factors as described in the building energy sector.

Municipal: Municipal water consumption was provided by the water districts. Total gallons of water were multiplied by energy intensity factors derived from the community-level data provided by the water districts, as listed above (on a per gallon basis). T&D losses associated with water-related electricity were also included in this sector (details provided in the building energy sector section). Emissions calculations were based on electricity emission factors as described in the building energy sector.

Forecast Methods

Community: 2020 BAU water consumption estimates were developed using population growth.

Municipal: 2020 BAU municipal water consumption emissions were projected from 2012 municipal water consumption emissions using municipal employment projections provided by the County.

Wastewater Treatment (Community and Municipal)

Overview

This sector includes GHG emissions from the treatment of industrial, residential, commercial, and municipal wastewater produced within the county.

Methods Used in Previous Inventory

Wastewater treatment emissions were not included in the County's previous GHG inventory.

Data and Models

- 2012 ICLEI Community Protocol equations for emissions calculations (ICLEI – Local Governments for Sustainability USA 2012).
- Wastewater treatment data from the sanitation districts who operate wastewater treatment plants (WWTPs) in the county (Armanino pers. comm.).
- Wastewater flow projections for 2020 from the sanitation districts (Armanino pers. comm.).
- Urban Water Management Plans for the county (MMWD 2010; NMWD 2010).
- Socioeconomic data for 2012 and 2020, including population and jobs (Wong pers. comm.).
- Municipal employment data and projections for 2012 and 2020.

Inventory Methods

Community: The county is served by the following wastewater treatment plants:

- Bolinas Community Public Utility District
- Central Marin Sanitary Agency
- Las Gallinas Valley Sanitary District
- North Marin Water District (provides treatment services to Dillon Beach area)
- Novato Sanitary District
- Sausalito-Marin City Sanitary District

- Sewerage Agency of Southern Marin
- Tomales Village Community Services District

The energy consumed to operate any WWTP that is located within the county's borders was included in the building energy sector. GHG emissions from electricity and natural gas consumption at wastewater treatment plants were calculated according to the 2012 ICLEI Community Protocol, as described above in the building energy sector.

Fugitive emissions from wastewater treatment were calculated following the 2012 ICLEI Community Protocol based on actual WWTP characteristics, provided by the wastewater treatment agencies. This information includes population served, cubic feet of digester gas produced and combusted per day, fraction of methane in digester gas, BOD5 load,[4] the fraction of BOD5 removed during treatment, gallons of wastewater treated per day, and information regarding any existing methane capture, combustion, or energy conversion programs. GHG emissions from septic systems were estimated and based on the County's inventory of septic tanks and general septic tank characteristics.

Municipal: To estimate wastewater emissions resulting from municipal operations, the 2012 ICLEI Community Protocol as described above was used to calculate emissions from wastewater generated by municipal facilities. This sector only includes emissions resulting from municipal wastewater generation.

Forecast Methods

Community: The 2020 BAU wastewater emissions were estimated by collecting wastewater projection estimates (including projected wastewater flows) from the WWTPs serving the county, where available. Where these data were not available, 2012 data were projected using population forecasts.

Municipal: The 2020 BAU municipal wastewater emissions were projected from 2012 municipal wastewater emissions using municipal employment projections provided by the County.

Stationary Sources (Community and Municipal)

Industrial/Commercial/Municipal

Overview

This sector includes GHG emissions from nonresidential stationary (typically industrial) combustion of fossil fuels of any type *except* natural gas (accounted for in the building energy use sector) and fugitive emissions from industrial processes in the county.

Methods Used in Previous Inventory

Stationary Sources emissions were not included in the County's previous GHG inventory.

[4] Biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period

Data and Models

- GHG emissions for fuel consumption from the Bay Area Air Quality Management District (BAAQMD) by facility.
- GHG emissions data from USEPA MRR database and CARB's online GHG Emissions Reporting Tool.
- Emission factors from the CalEEMod model (South Coast Air Quality Management District 2013).
- Emission factors from the USEPA, CARB, the 2012 ICLEI Community Protocol, and Climate Registry protocols.
- Fuel consumption in 2012 for all County-owned stationary sources from the County Department of Public Works (e.g. emergency generators) (Armanino pers. comm.).
- Socioeconomic data for 2012 and 2020, including square footage of commercial and industrial establishments, and employment by sector (Wong pers. comm.).
- Municipal employment data and projections for 2012 and 2020.

Inventory Methods

Community: The methods used to quantify GHG emission from stationary sources were consistent with the 2012 ICLEI Community Protocol. GHG emissions data for all facilities in Marin County under BAAQMD's jurisdiction was provided by the BAAQMD. This data was supplemented by emissions data from the USEPA MRR database and from CARB's online GHG Emissions Reporting Tool for large facilities, as necessary.

Municipal: Characteristics for all stationary sources owned by the County (such as Emergency Stand-By Generator, and diesel pumps), including horsepower, engine type, fuel type, and hours of operation were used to develop emissions. Emission factors from the CalEEMod model for the appropriate equipment type were used to calculate GHG emissions from municipal stationary source equipment (South Coast Air Quality Management District 2013).

Forecast Methods

Community: 2020 BAU stationary source emissions were estimated by projecting 2012 year data using total employment estimated in 2020.

Municipal: 2020 BAU municipal stationary source emissions were projected from 2012 municipal stationary source emissions using municipal employment projections provided by the County.

Residential (Community)

Overview

Calculation of GHG emissions from residential combustion of fossil fuels of any type *except* natural gas (accounted for in the building energy use sector). This includes fuel oil, propane, kerosene, and wood.

Data and Models

- U.S. Census data from the American Community Survey (ACS) (U.S. Census. 2012).
- Energy Information Administration's (EIA) Residential Energy Consumption Survey dataset (Energy Information Administration 2013a).
- EIA State Energy Data System (SEDS) (Energy Information Administration 2013b).
- Emission factors from the USEPA, CARB, the 2012 ICLEI Community Protocol, and Climate Registry protocols.
- Socioeconomic data for 2012 and 2020, including population, employment by sector, and number of households (Wong pers. comm.).

Inventory Methods

The County used quantification methods consistent with the 2012 ICLEI Community Protocol to quantify GHG emissions from residential fuel combustion. The number of households in the county that use each type of fuel was determined using information from the EIA and the ACS. Fuel consumption for each fuel type was calculated using state-level fuel use from the EIA SEDS. This fuel use was multiplied by emission factors from the USEPA, CARB, the 2012 ICLEI Community Protocol, and Climate Registry protocols (as appropriate) to determine emissions.

Forecast Methods

The 2020 BAU residential fuel use emissions were estimated by projecting 2012 data using housing forecasts.

Refrigerants (Municipal)

Overview

This sector includes GHG emissions from the leakage of refrigerants that contain or consist of HFC compounds that contribute to global warming. These chemicals are used in refrigeration, fire suppression equipment, air conditioners, and chillers. Through the installation, use, and disposal of these systems and products, leaks are likely to occur. Although the leaks are generally small, emissions may be significant because these chemicals typically have high GWPs.

Methods Used in Previous Inventory

Refrigerant emissions were not included in the County's previous GHG inventory.

Data and Models

- Refrigerant purchases and usage.
- GPWs from the LGOP and the IPCC (California Air Resources Board et. al. 2010; Intergovernmental Panel on Climate Change 2013).
- Municipal building construction information.

Inventory Methods

The 2012 ICLEI Community Protocol and the LGOP were used to quantify emissions from refrigerant use. Total refrigerant purchases by refrigerant type and by weight from 2011–2013 were used to estimate refrigerant emissions. Refrigerant replacement and leakage values were not available, so it was assumed that the purchases roughly equal the amount of refrigerant leakage. Three years of refrigerant purchase data was used to calculate an average annual refrigerant usage rate, which was assumed to be equal to the refrigerant leakage rate.

The County uses the following refrigerants: R-22, R-410A (GWP = 1,725), R-407C (GWP = 1,526), R-134a (GWP = 1,300), and R-404 (GWP = 3,620). R-22 is currently being phased out under the Montreal Protocol and is not classified as GHG under the Kyoto Protocol; as such, the LGOP recommends that R-22 should not be included in any emissions inventory and R-22 was therefore not included in the inventory for the county.

Total annual purchases of each refrigerant were multiplied by the corresponding GWPs to estimate emissions from refrigerants.

Forecast Methods

2020 BAU refrigerant emissions were projected using the growth in municipal building energy use (see building energy sector above). Building energy use represents a reasonable proxy for the amount of refrigerants used in buildings.

Agriculture (Community Only)

Overview

This sector includes GHG emissions from manure management (fugitive emissions of methane and nitrous oxide), enteric fermentation (fugitive emissions of methane and nitrous oxide), and fertilizer use (fugitive emissions of nitrous oxide). Other emission sources from agriculture were excluded because they are not covered in the ICLEI U.S. Community Protocol.

Data and Models

- Marin County Crop Report for 2012 (Marin County Department of Agriculture 2013)
- U.S. Department of Agriculture (USDA) Census of Agriculture (U.S. Department of Agriculture n.d.).
- Standard emissions factors from USEPA, CARB, and ICLEI (USEPA 2014; CARB 2011; ICLEI – Local Governments for Sustainability USA 2012).
- *A Low-Cost, High-Benefit Approach to Climate Change Mitigation* (Silver and Ryals 2009)
- CropScape GIS database from the National Agricultural Statistics Service (NASS) (U.S. Department of Agriculture 2013).

Methods Used in Previous Inventory

The County's previous inventory calculated livestock-related agricultural emissions using livestock population data from the U.S. Department of Agriculture's National Agriculture Statistics Service. Methane and N_2O emissions from livestock were calculated using the EPA's 1999 Emission Inventory Improvement Program handbook. Only livestock-related emissions were estimated for this sector.

Inventory Methods

Emissions from agricultural vehicles were based on countywide activity levels of these vehicles, based on the OFFROAD model outputs (these emissions were included in the Off-Road Transportation and Equipment sector). It should be noted that the 2012 ICLEI Community Protocol does not include agricultural vehicle-related emissions with other agricultural emissions.

Manure management emissions were calculated using livestock population numbers from the Agriculture Commissioner and the United States Department of Agriculture (USDA) agriculture census. Standard emissions factors from USEPA and CARB, and 2012 ICLEI Community Protocol equations specific to manure management were used. Similarly, emissions resulting from enteric fermentation were calculated using livestock population numbers from the Agriculture Commissioner or USDA's agriculture census, standard emissions factors from CARB and USEPA, and 2012 ICLEI Community Protocol equations specific to enteric fermentation.

Emissions resulting from fertilizer use were calculated using the number of acres treated with fertilizers from the USDA's agriculture census for the years 2000 through 2010 (U.S. Department of Agriculture n.d.). The following standard fertilizer use emission factors from CARB were used in estimating fertilizer emissions.

Crop Type	Fertilizer Application (lbs/acre)
Grapes (wine)	44
Miscellaneous Fruits and Nuts	94.68
Miscellaneous Veggies	191.76
Hay, Oat	64
Silage, Corn	78
Pasture, Irrigated	5
Rangeland	0

Forecast Methods

Manure management and enteric fermentation emissions were not forecast due to uncertainty regarding future change in land cover types and livestock numbers in the county.

Fertilizer emissions were forecast using an estimate of acres by crop type in 2020 by using historical trends from 2008 to 2012. Fertilizer rates from the 2009 USDA survey data were applied to the 2020 forecasted crop acreages.

Community Emissions Sectors for Informational Purposes Only

The following sectors are presented as informational items but were not added to the emissions total for the community inventory or forecast.

Forestry Carbon Sequestration

Overview

Calculation of annual carbon sequestration from outside the agricultural sector in forest, timberland, and urban forests.

Data and Models

- CropScape GIS database from NASS (U.S. Department of Agriculture 2013)
- Carbon sequestration rates from the California Energy Commission (CEC) (Brown et. al. 2004)

Methods Used in Previous Inventory

Forestry emissions were not included in the County's previous GHG inventory.

Inventory Methods

Urban forests and rural non-agricultural land covers (such as forests) can be long-term emissions sinks, depending on management since these natural areas actively sequester atmospheric carbon dioxide during their growth cycle. Rural lands that are not developed or used for agriculture can include conservation areas, state and national forests, private forests and timberland,[5] scrubland, grassland, wetlands, and other covers. "Urban forests" refers to trees planted within developed areas, including residential trees, urban city parks, median trees, etc.

Calculating sequestration from rural forest covers and urban forestry can be challenging due to lack of data and the inherent uncertainties associated with vegetation-based carbon accounting.

This inventory only quantified annual carbon sequestration from forest cover. Annual sequestration rates from the CEC for deciduous forest, mixed forest, and evergreen forest were used to calculate emission sinks (Brown et. al. 2004). Annual sequestration for other non-agricultural land covers (such as scrubland, grassland, wetlands, etc.) was not estimated due to data limitations.

Acreage data by land cover type for the unincorporated county was obtained from the National Agricultural Statistics Service (NASS), which has broad land cover data based on aerial photography for 2012; see Table B-1, below. Acres for each land type were multiplied by the sequestration values to determine GHG emission sinks in the forestry sector.

Table B-1. Acres by Land Type for Unincorporated Marin County for 2012

Land Type	2012 Acres
Deciduous Forest	3,617
Mixed Forest	23,081
Evergreen Forest	67,792
Total	*94,489*

[5] Timberland may or may not be a long-term sink, at least in terms of woody biomass. Depending on the harvesting schedule, timberland can be a source of net emissions (if there is a declining amount of biomass) or a net sink of emissions (if there is an increasing amount of biomass).

Forecast Methods

A forecast of forestry sequestration was not conducted due to uncertainty regarding future change in land cover types in the county.

Rangeland Soil Carbon Stock

Overview

Carbon storage in rangeland soils represents total storage and not sequestration or GHG flux. Units presented in the inventory and forecast are in metric tons of carbon, not carbon dioxide equivalent (note: carbon storage in non-rangeland soils was not included due to lack of data).

Data and Models

- *A Low-Cost, High-Benefit Approach to Climate Change Mitigation* (Silver and Ryals 2009)
- Acreage values from the Marin County 2012 Crop Report (Marin County Department of Agriculture 2013).

Methods Used in Previous Inventory

Rangeland soil carbon was not included in the County's previous GHG inventory.

Inventory Methods

Rangeland acreage for 2012 as defined in the Marin County Crop Report for 2012 was multiplied by Marin/Sonoma soil carbon values to determine the amount of carbon stored in county rangelands. The soil carbon value of 180 megagrams of carbon per hectare for a depth of 1 meter was obtained from the report *Soil Carbon Sequestration: A Low-Cost, High-Benefit Approach to Climate Change Mitigation* (Silver and Ryals 2009).

Forecast Methods

A forecast of soil carbon stock was not conducted due to uncertainty regarding future change in land cover types in the county.

Aboveground Carbon Stock

Overview

This sector represents carbon stock in aboveground biomass in the county. This is not a source or sink of GHG emissions; it represents the total amount of carbon storage in biomass in 2012. Units presented are in metric tons of carbon, not carbon dioxide equivalent.

Data and Models

- CropScape GIS database from NASS (U.S. Department of Agriculture 2013)
- Carbon stock values from the USEPA and the CEC (USEPA 2010; Brown et. al. 2004)

Methods Used in Previous Inventory

Aboveground carbon stock was not included in the County's previous GHG inventory.

Inventory Methods

Acreage data by land cover type for the unincorporated county in 2012 was obtained from NASS. Land cover types used in this analysis include coniferous forest, croplands (not vineyards or rangeland/pastureland), rangeland/pasture, oak woodlands/riparian woodlands, shrublands, and vineyards. Acres for each land type were multiplied by carbon stock factors from the USEPA and the CEC to determine total aboveground carbon stock (USEPA 2010; Brown et. al. 2004).

Forecast Methods

A forecast of aboveground carbon stock was not conducted due to uncertainty regarding future change in land cover types in the county.

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