Measuring Greenhouse Gas Emissions at Big Sky Mountain Inn

Introduction

Big Sky Mountain Inn is a hotel located in Big Sky Resort, the largest ski resort in the state of Montana. Known for the quality of its snow, 5,800 acres of terrain, and a 4,350 vertical drop, Big Sky Resort is a world-class ski resort. With its close proximity to Yellowstone National Park, the resort also attracts summer visitors. Summer activities include hiking, mountain biking, golf, horseback riding and easy access to Yellowstone. Like many resorts, Big Sky wants to provide an outstanding outdoor recreation experience for its guests, while taking steps to protect the environment. In fact, the resort has put many environmental practices in place and continues to find new ways to operate in a sustainable and environmentally friendly manner.

Because of its direct connection to the resort area, Big Sky Mountain Inn wants to do its part to help the environment, and to present an eco-friendly image to guests. As part of this effort, the Inn is interested in measuring its greenhouse gas emissions. The hope is that continuing efforts to reduce emissions will be measurable and, over time, the Inn will be able to promote its emissions reductions as part of its sustainable image.

About the Hotel

Big Sky Mountain Inn has 153 guest rooms, a restaurant and bar, and several meeting rooms. Occupancy in the hotel is seasonal. The busy seasons are ski season, December through March, and summer, June through August. The hotel remains open in the spring and fall but occupancy declines dramatically during those months.

Many guests arrive at the hotel using their own car. For those guests arriving by plane, the Inn maintains three small buses for bringing guests from the nearest airport, located about 55 miles away. Although the hotel has lawnmowers and a truck with a snowplow, almost all of the gasoline use is related to the buses traveling back and forth to and from the airport.

Because of its restaurant and bar the hotel has commercial refrigerators, which use ozone-depleting refrigerants (HFC-134a). The hotel also has air conditioning available in its rooms, but because of its altitude, they are used infrequently (which use R410A refrigerants). The hotel does not keep track of its inventory of refrigerants, but it did

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purchase refrigerants for its existing refrigeration equipment during the year, due to leakage. No other data on refrigerants is available.

As part of its effort to measure emissions the Inn has begun gathering data for use as part of its calculations. General information about the hotel for the most recent year is provided in Table 1. Additional information for use in the emissions calculations is provided in Table 2.

What Are Greenhouse Gas Emissions

The Earth's atmosphere is a complex and dynamic system, containing many types of gases and other airborne particulates. The most abundant gases in the atmosphere are nitrogen (N_2) and oxygen (O_2). The atmosphere also contains relatively inert gases such as argon, dust particles such as pollen, plant fibers and other organic matter, ash, sand, minerals, etc., and a variety of other gases, including air pollutants such as greenhouse gases.

Greenhouse gases are gases that allow sunlight to reach the earth's surface unimpeded, but absorb energy reradiated from the earth's surface in the form of infrared energy (heat). The result is that these gases trap heat in the lower atmosphere. The four primary greenhouse gases are water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). All of these gases occur naturally in the atmosphere, and continue to be released into the air by natural processes. The levels of carbon dioxide, methane, and nitrous oxide in the atmosphere, however, have increased dramatically over the past two centuries. In addition to the four primary GHG gases there is another group of GHG gases, called fluorinated gases that are man-made and include hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride.

Anthropogenic emissions occur when human actions release elements and compounds into the atmosphere. Carbon dioxide, for instance, comes from human activities such as fossil fuel combustion, deforestation, and industrial processes such as making steel or cement. Methane comes from human activities such as mining, transporting, and burning fossil fuels, burning other fuels such as cornstalks or wood, livestock, rice cultivation, and landfills. Nitrous oxide comes from human activities such as using fertilizers that contain nitrogen, and burning fossil fuels and wood. Finally, manmade hydrofluorocarbons are used as refrigerants, aerosol propellants, solvents, and fire retardants. Perfluorocarbons are a byproduct of various industrial processes associated with aluminum production and manufacturing of semiconductors, sulfur hexafluoride is used in electrical transmission equipment, and nitrogen trifluoride is used in the production of liquid-crystal displays and silicon-based thin-film solar cells.

Measuring GHG emissions requires that the impact of each type of gas on the environment is converted into a standard unit. This allows emissions of all types of GHG emissions to be quantified using a single measuring unit. To create this standardization, greenhouse gas emissions are measured using the "carbon dioxide equivalency" for each type of greenhouse gas. This is the amount of carbon dioxide that would have the same global warming potential (GWP), over time, as the actual greenhouse gas being measured. Thus, when greenhouse gas emissions are reported, they are reported in metric tonnes of carbon dioxide equivalents (CO_2e). Since carbon dioxide is the reference gas its GWP is set equal to one. The higher the GWP value, the more infrared radiation the gas will tend to absorb over its lifetime in the atmosphere, leading to more warming.

GWPs calculated by the Intergovernmental Panel on Climate Change (IPCC) are commonly used to convert emissions to carbon dioxide equivalents. The IPCC has recently updated its global warming potentials in its Fifth Assessment. Examples of GWPs for different gases are presented in Table 3. As can be seen from the table some types of gases, especially manmade gases have a dramatic impact on global warming. As an example of calculating the carbon dioxide equivalency, it can be seen from the table that the global warming potential of methane in the IPCC Fifth Assessment Report is 28. Thus, the carbon dioxide equivalency of the emission of 1,000 tonnes of methane would be 28,000 (28 x 1,000) tonnes of carbon dioxide.

Categorizing Greenhouse Gas Emissions

GHG emissions come from a variety of sources. To account for GHG emissions it is first necessary to divide emissions into different categories, or *scopes*, based on their source. Direct GHG emissions, or **Scope 1** emissions, occur from sources that are owned or controlled by the company. Direct GHG emissions include, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc. They also include emissions from chemical production in owned or controlled process equipment. **Scope 2** accounts for GHG indirect emissions from the generation of purchased electricity, heat, or steam consumed by the company. Scope 2 emissions physically occur at the facility where the electricity, heat, or steam is generated. **Scope 3** is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company.

Scope 3 emissions result from a wide variety of activities, including:

- Purchased goods and services
- Transportation and distribution of products purchased in vehicles not owned by the organization
- Transportation and distribution of products sold in vehicles not owned by the organization
- Business related travel in vehicles operated by third parties
- Emissions from the use of goods sold by the organization

Identifying Emissions Sources and Measuring Emissions

To create a greenhouse gas inventory it is necessary to identify the various sources of emissions from the organization's operations. While some emissions sources should be easy to identify such as electricity use, natural gas use, use of company owned vehicles, etc., other sources may be more difficult to identify. Many industry associations provide information on sources of emissions for companies within their particular industry. This is a good place to start. For instance, the World Travel & Tourism Council, in conjunction with leading hotel companies and the International Tourism Partnership provides guidance on measuring hotel emissions.[i] The ultimate goal is to create an inventory of all significant emissions sources, by scope.

There are a variety of methods for measuring greenhouse gases. The aim is to use the most accurate calculation method available, while taking into account the cost of the system. Continuous emissions monitoring systems (CEMS) are used to measure various industrial sources of air pollutants, and are required under some EPA regulations. These systems are used to continuously monitor emissions from exhaust stacks and ducts. In most other situations, the calculation of emissions is accomplished through the application of documented emission factors. These factors are calculated using ratios relating GHG emissions to a proxy measure of activity at an emissions source. For instance, vehicle emissions can be calculated using gallons of gas as a proxy measure, along with a factor that converts gallons of gasoline to GHG emissions. The GHG Protocol website has calculation tools available for computing emissions for a variety of emissions sources and in many different industry sectors. They also provide a list of third party databases that have tools for calculating emissions.

Because of the scientific expertise required, measuring Greenhouse gas emissions can, at first glance, seem like a daunting task, perhaps best left to environmental engineers with strong science backgrounds. Fortunately, however, most of the technical calculations have been done and straightforward tools exist for completing the calculations. For this case study, the calculation tools are available at the GHG Protocol website (www.ghgprotocol.org). Specific calculation tools that may be helpful for calculations for Big Sky Mountain Inn include:

- GHG Emissions from Purchased Electricity
- GHG Emissions from Stationary Combustion
- GHG Emissions from Transport and Mobil Sources
- Refrigeration and Air-Conditioning Equipment

Required

You have been asked to prepare a greenhouse gas inventory for Big Sky Mountain Inn. Specifically, the Inn would like to know the following:

1. Level of Scope 1 greenhouse gas emissions, with a list of sources (in tonnes of CO_2e)
2. Level of Scope 2 greenhouse gas emissions, with a list of sources (in tonnes of CO_2e)
3. Total combined Scope 1 and Scope 2 greenhouse gas emissions per occupied room on a daily basis (in kilograms of CO_2e). First, convert tonnes of emissions to

kilograms. Then determine what part of the total emissions relate guest rooms. Divide this amount by annual occupied room-days.
4. Have all material Scope 1 and Scope 2 greenhouse gas emissions been captured? Are any of the emissions measured so immaterial that tracking can be eliminated in the future?
5. A list of the types of Scope 3 greenhouse gas emissions that are likely to be most material.
6. A list of steps you believe the Inn can take to reduce its greenhouse gas emissions.

Prepare a report for the Big Sky Mountain Inn that thoroughly and concisely answers each of their questions. The report should be typed using a 12-point font, and double-spaced. Pages should be numbered. Format, punctuation, spelling, clarity, and presentation will be graded.

Table 1. General Hotel Information	
Annual revenue:	$6,743,000
Facility square footage:	
Guest rooms and corridors	68,850
Meeting facilities	12,450
Lobby, restaurant, bar	17,550
Back of house	9,780
Total square feet	108,630
Guest rooms:	
Number of rooms	153
Occupancy %	64%

Table 2. Data Gathered for GHG Emissions Calculations	
Electricity used (kWh)*	2,200,968
Natural Gas used (mmBTUs)	11,830
Miles Driven in vehicles	200,000
Gasoline used in vehicles (US gallons)	16,700
Refrigerants purchased – R410A (kg.)**	15

*Big Sky Mountain Inn is located in the Northwest Power Pool area, which is one of the four sub-regions of the Western Electricity Coordinating Council (WECC) and is comprised of all or major portions of the states of Washington, Oregon, Idaho, Wyoming, Montana, Nevada, and Utah, a small portion of Northern California, and the Canadian provinces of British Columbia and Alberta.

**This is refrigerant used to service existing equipment.

Table 3. Examples of Global Warming Potentials		
Common Name	**GWP Values for 100-Year Time Horizon**	
	IPCC Fourth Assessment Report	**IPCC Fifth Assessment report**
Carbon Dioxide	1	1
Methane	25	28
Nitrous Oxide	298	265
Hydrofluorocarbons (HFCs)*	124 to 14,800	4 to 12,400
Perfluorocarbons (PFCs)*	7,390 to 12,200	6,630 to 11,100
Sulfur Hexafluoride	22,800	23,500

Table 3: Examples of Global Warming Potentials (GWPs) for different greenhouse gases. For gases marked with an asterisk (*) the specific compound must be identified to determine the GWP.

[i] World Travel and Tourism Council. (2013, June). Retrieved from World Travel and Tourism Council: wttc.org.