Getting Real about Dynamic Greenhouse Gas Monitoring for Buildings: Long-Term Implications for Managing a Large Commercial Portfolio

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ABSTRACT

Federal building operators are moving toward reporting buildings' greenhouse gas (GHG) emissions, driven by policy requirements setting a goal to manage facility energy use to achieve 100% 24/7 carbon pollution-free electricity (CFE) by 2035. Real-time emissions monitoring can provide better data and insights to help achieve this Federal sustainability goal, but established Scope 1 and Scope 2 GHG emissions reporting is based on applying carbon dioxide equivalent (CO2e) conversion factors to annual consumption data.

Annual CO2e conversion factors meet a need for simplicity, but do not account for the time-varying Scope 2 emissions of a grid served by an increasingly diverse generation mix. As such, current reporting norms are disconnected from emerging goals targeting 24/7 CFE. While grid emissions data is available at an hourly resolution, and can be monitored in real time, the organizational impacts of doing so are not well defined. Having access to reliable grid emissions data would better enable organizations to manage loads and use battery and energy storage systems as demand growth increases due to electrification efforts.

In this paper, we describe efforts to understand the implications of using hourly Scope 2 GHG emissions monitoring across a large building portfolio. We address questions around data availability and consistency, impacts on internal reporting, placement of real-time Scope 2 monitoring within the full range of GHG reporting needs, and potential benefits for asset upgrade planning. The paper also describes planning efforts on demonstrations of two GHG monitoring software platforms. Future insights from this work will benefit building owners' long-term planning in conjunction with efforts to decarbonize electricity generation.

Introduction

Historically, sustainability goals for commercial buildings have focused on energy reductions, For example the U.S. Department of Energy's Better Buildings Challenge invites organizations to commit voluntarily to reducing energy use throughout their portfolios by at least 20% over a 10-year period (U.S. DOE 2024). Increasingly, such sustainability targets in the government and corporate realm have expanded to include goals for reducing operational greenhouse gas (GHG) emissions. Until relatively recently, GHG reduction goals (similar to energy reduction goals) were set relative to a historical baseline, such as California's target to reduce GHG emissions to 40 percent below 1990 levels (State of California 2015). There are multiple ways organizations are setting GHG goals, including absolute targets, intensity targets, or net-zero targets, such as achieving net-zero emissions by 2050 in alignment with the United Nations' "Paris Agreement" (United Nations 2015).

GHG emissions for buildings' energy consumption consist of Scope 1 and Scope 2 emissions. Scope 1 emissions relate to on-site fuel use, where each unit of fuel consumption is converted to emissions at a fixed ratio, regardless of time or location of consumption. Conversely, Scope 2 emissions relate to electricity consumption, whereby emissions per unit of consumption vary by time and location, depending on the grid generation mix (*e.g.*, emissions per kilowatt-hour of electricity consumption will be lower during a period where a utility's photovoltaic generation capacity is high). Thus, the concept of 24/7 CFE has recently emerged, which takes into account the variation in the generation mix of electricity throughout the day and year and by location. Google LLC was one of the first major companies to announce a specific target for achieving 24/7 CFE (Google 2022). More recently, the Biden-Harris administration has set the goal of an net-zero carbon operations across all federal buildings by 2045, sourcing 100% CFE on a net annual basis by 2030, including 50% 24/7 CFE, and 100% 24/7 CFE by 2035 (Executive Office of the President 2021).

While the concept of CFE aligns with the reality of an electric grid with time-varying GHG emissions, established GHG reporting norms rely on the use of average annual emissions, such as the GHG Protocol Corporate Accounting and Reporting Standard (World Resources Institute 2004), ASHRAE Standard 240P (ASHRAE 2024) and the Global Real Estate Sustainability Benchmark (GRESB 2024). This is also the approach required by the U.S. Department of Energy's voluntary Better Climate Challenge (U.S. DOE 2024). In the U.S., eGRID (U.S. EPA 2024) is a commonly used data source for average annual Scope 2 GHG emission data in connection with organizational or regulatory reporting. eGRID provides emission conversion factors (*i.e.*, kg emissions per unit of electricity consumed at the building level) based on region. Other data sources provide time-varying emission factors (Table 1), though these are not currently in use for organizational or regulatory reporting. As a departure from current GHG calculation methods, a recently initiated effort, sponsored by the New York State Energy Research and Development Authority, is targeted at demonstrating the benefits of time-varying GHG emission factors for regulatory reporting (JB&B n.d.).

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Table 1: Examples of time-varying GHG data sources and a description of their data

Tool / data source	Description
AVoided Emissions and geneRation Tool (AVERT)	AVERT data contains approximations of marginal emission rates for 14 AVERT regions and for a national weighted average. AVERT uses a peer-reviewed methodology to analyze electric power sector impacts on an hour-by-hour basis, but it can also produce annual emission rates for each AVERT region and for the Nation. The AVERT method uses historical hourly emission rates, with the most recent release being 2022.
Cambium	Cambium data contains long-run marginal emission rate estimates for the contiguous United States. Cambium data contains modeled hourly emission, cost and operational data for a range of possible futures of the U.S. electricity sector through 2050, with metrics designed to be useful for forward-looking analysis and decision support. The most recent release is 2021.
WattTime(fee-based)	WattTime data contains real-time, short-term forecast, and historical marginal emissions data for electric grids around the world. The marginal emissions rate provided is a Marginal Operating Emissions Rate in units of pounds of emissions per megawatt-hour (*e.g.*, CO2 lbs/MWh).
Singularity	Singularity data contains carbon intensity of consumed electricity within a region, accounting for imports and exports from neighboring regions.

In theory, the use of time-varying GHG emissions factors provides a more accurate representation of a building's GHG emissions impact and improvement over time. This enables GHG emissions reduction efforts at the building level (e.g., HVAC control strategies, battery and energy storage systems, electric vehicle charging) to be prioritized for those times of day and year where emissions intensity is greater. It is also well matched to emerging analytical methods for assessing the electricity savings impact of projects using interval data from smart meters, known as "Advanced Measurement and Verification" (Franconi 2017). Real-time monitoring of interval electric consumption data and corresponding emission factors can also be facilitated by energy management and information systems (EMIS), a class of analytical tool that has been growing in adoption over the past decade (Kramer 2020).

In this paper we document the current practices for GHG emissions reporting for the U.S. General Services Administration (GSA) and consider the feasibility and implications of integrating time-varying energy monitoring and GHG emissions factors.

U.S. General Services Administration's Organizational Approach to GHG Reporting

Figure 1 provides a high-level overview of the key steps involved in GSA's current GHG reporting and analysis. Often these steps are conducted using a combination of data streams, spreadsheets and semi-automated tools and requires addressing the gaps in the information, where necessary, to enable consistent tracking of GHG emissions and decision making.

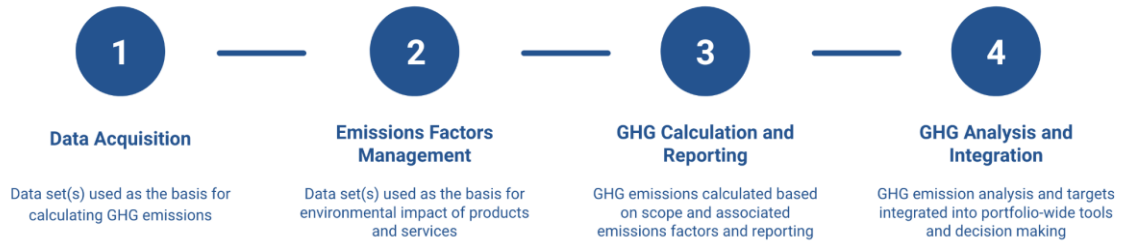

Figure 1. U.S. General Services Administration GHG reporting steps

To understand the processes, data, tools, and decision making that underlies GSA's GHG reporting and analysis, GSA's Applied Innovation Learning Lab conducted in-depth focus group interviews with a cross section of stakeholders across GSA, including the Facility Technology and Innovation Division, the Advanced Metering program, the Climate and Sustainability Division, the Energy Division, the Energy Savings Performance Contracting program, and the Carbon Pollution-Free Electricity Division. These interviews helped put into perspective each group's efforts to accelerate the collective GHG reduction efforts across the Federal Government.

The Facility Technology and Innovation Division, which includes the Advanced Metering program, leads the management of building energy use data, including the development and implementation of the infrastructure to collect the data (through advanced metering), the curation and the analysis of the data. The scope of the data collection includes energy metering at the building and regional levels and building data consolidation tools to provide consistent and reliable access to the data. It is important to highlight that this data is foundational to all of GSA's energy- and carbon-related priorities.

The Carbon Pollution-Free Electricity Division leads the procurement of CFE and monitors utility regulatory actions throughout the country. The scope of this division covers both vertically integrated and retail choice energy markets to develop and implement effective and efficient energy procurement strategies to achieve the goal of 100% 24/7 CFE for the Federal Government by 2035 to help decarbonize the grid.

The Climate and Sustainability Division is responsible for tracking data to calculate GSA's Scope 1 and 2 operational greenhouse gas (GHG) emissions and reporting in accordance with the GHG Compliance Tracking System requirements. This reporting also helps set targets for emissions reductions on an annual basis for the entire portfolio, which enables goal setting and prioritization of related efforts, such as regional-level energy projects and strategic Regional Sustainability Implementation Plans.

The Energy Division focuses on improving energy efficiency across GSA's portfolio and makes operational and mission driven decisions to achieve energy reduction goals through energy use benchmarking, reporting and analysis efforts, such as building audits (*e.g.*, Building Energy Analysis Manager or BEAM and ASHRAE Level II [ASHRAE 2011]), dashboards and Energy Savings Performance Contracts. The Climate Smart Building Initiative sets targets and

tracks carbon emission reduction accomplished through Energy Savings Performance Contracts. Reducing energy consumption across the GSA portfolio is instrumental to achieving GSA's net-zero operational carbon emissions goals.

The Office of the Chief Sustainability Officer coordinates agency-wide sustainability goals, the annual climate and sustainability plans, and monitoring of agency progress in meeting those goals. This office is responsible for reviewing all greenhouse gas submissions.

Current GHG Monitoring Practices in Non-Federal Market Segments

Outside of the Federal buildings sector, there is diversity in methods for calculating and tracking organizational GHG emissions. For example, commercial partners in the Better Climate Challenge commonly use spreadsheets to track emissions, with a minority electing to use custom software applications. Whichever tool or method is used, Scope 2 emissions are generally calculated using eGRID annual average emission factors. The Framework for Greenhouse Gas Emissions Reduction Planning: Building Portfolios (developed through the Better Climate Challenge) recommends using energy management and information systems to support GHG emissions reduction efforts (Kramer 2023). While such tools lend themselves to hourly energy consumption monitoring, the application of such capabilities to GHG monitoring is beyond current practices for the majority of building owners. Shifting from annual to monthly tracking of GHG emissions would be considered a significant step forward, even though it has been recommended to use hourly emission factors when there are large variations in the hourly generation mix and building load profiles (NREL 2022).

Energy Management and Information Systems and GHG Reporting Software

The marketplace of software tools to support GHG emissions monitoring and reporting is growing, with a variety of platforms focused on building energy-related emissions or broader accounting, including, for example, Scope 3 emissions and transportation. As part of its fiscal year 2024 Applied Innovation Learning Lab (AILL) program, GSA selected two GHG emissions accounting software products for assessment. These ongoing technology evaluations are focusing on two main capabilities:

- GHG emissions monitoring to benchmark, track progress toward goals and prioritize operational management improvement opportunities and
- Data-driven identification of retrofit opportunities based on GHG emissions reduction potential.

In developing an assessment approach for these ongoing technology evaluations, GSA conducted internal interviews to assess the potential organizational benefits and implications of using higher resolution (hourly or even monthly) GHG monitoring software. Following are the key findings and recommendations based on the discussions with the focus group participants.

1. **A centralized data platform can improve data quality and access, streamline analysis and deliver critical insights to multiple stakeholders.** GSA's transition toward consolidating energy data sets into one platform and streamlining data collection

will make it more accessible for energy use analysis and carbon emissions tracking. Additionally, improving data access and transparency can help accelerate alignment and facilitate collective effort to drive GSA's GHG reduction strategy.

2. **Real-time grid emissions data are important for timely accounting of Scope 2 emissions and making decisions about energy use to decrease overall carbon emissions.** Currently, the most commonly used GHG emissions factors, which are critical data for Scope 2 emissions calculations, are based on static data that is released with a one to two year time lag (in the case of eGRID). This means that the emissions factor will not reflect recent changes, such as changes in fuel sources at the utility level or energy optimization measures such as demand response and load shifting strategies that depend on real-time emissions. Real-time emissions data can enable more rapid response and problem solving for building optimization, and can be used for predictive analysis of carbon reduction strategies.

3. **Scaling advanced metering across the GSA portfolio can yield significant benefits to improve energy efficiency and identify highest impact measures for carbon emission reduction.** While monthly utility data is helpful for big-picture analysis and trend analysis over time, interval data provides a more detailed look at opportunities that can have the greatest impact on reducing overall carbon emissions; however, interval data meters are not installed on all buildings. Tracking interval data and identifying the associated real-time opportunities to reduce carbon emissions is in contrast to the often generic recommendations for energy reduction and optimization that are based on monthly data. Interval data also overcomes the challenges of data quality and lag that are associated with monthly data, providing a more near-real-time understanding of building energy use patterns and potential opportunities for improvement. Building energy audit technologies and standards, such as BEAM and ASHRAE Level II, can benefit from these granular data sets in addition to having a streamlined method of accessing all the relevant information for prioritization.

4. **Decisions made upstream, such as the purchase of clean energy, can be improved by having more visibility into downstream load demand at the building and portfolio levels. This will help to identify areas where grid-level supply can be improved and carbon emissions impact can be reduced.** Currently, grid-level supply-focused procurement decisions are not informed by the variable demand profiles of buildings across the portfolio. By providing this visibility and information exchange, the portfolio demand side can better signal the opportunities for prioritizing the phasing out of carbon-intensive generation resources and accelerating the deployment of utility-scale clean energy sources. Similarly, the supply side can enable better coordination of technologies and solutions that can reduce energy storage investment needs.

In addition to GSA's ongoing efforts to improve GHG reporting and data management, it is also funding ongoing emerging and sustainable technology evaluation projects through the Agency's Green Proving Ground (GPG) and Applied Innovation Learning Lab (AILL) programs (GSA 2024). The GPG and AILL programs leverage GSA's real estate portfolio to evaluate innovative building technologies (31 ongoing evaluations and 54 published evaluation reports to date). Past and ongoing GPG projects have focused on the building envelope, energy management, heating, ventilation and air conditioning systems, lighting, onsite power and renewables, water, and other facility operation and management areas.

GHG Monitoring Software Demonstration Projects

Two of the current ongoing AILL projects feature GHG monitoring software products, one focused on interval data input and the other on monthly data. These products are intended to be used for portfolio-level GHG benchmarking and long-term planning, ongoing monitoring/analytics and retrofit identification based on GHG reduction potential. The evaluation measurement and verification plan is designed to assess:

- Alignment of software-driven retrofit identification with alternative assessment methods (e.g., energy audits and other open-source tools);
- User response to ongoing GHG monitoring capabilities and retrofit recommendations;
- Ease of data acquisition and ingestion and time to get software configured and retrofits identified; and
- Return on investment potential, based on development of reliable retrofit recommendations at lower cost than alternatives and, if practical, the associated value of developing portfolio-level GHG reduction plans in a rapid time frame.

Progress to date on these two technology demonstration projects has been focused on selecting suitable buildings and obtaining the necessary data security clearance to allow for input of GSA energy consumption data into the software. Under the demonstration, energy consumption data from up to 100 buildings will be ingested into the software tools for the purpose of assessing the emissions profiling/benchmarking capabilities, and up to 20 of those sites will be selected for deeper study of software retrofit recommendations (comparing the emission reduction measures recommended by the software remotely, to an onsite assessment). Results of the demonstrations are expected in late 2024, for publication in 2025.

Conclusions

Monitoring of Scope 2 emissions using region-specific time-varying hourly emission factors provides a more representative accounting of the impacts of GHG emissions. This enables more holistic consideration of the steps that can be taken at the building level to more rapidly decarbonize electricity generation (*e.g.*, by shifting more building consumption to time periods where zero-emission generation resources are available). Hourly GHG emission factors are available from several sources, and a growing array of EMIS and other monitoring platforms have the technical capability to monitor and report hourly emissions for buildings. The barriers to shifting toward hourly accounting of Scope 2 emissions for portfolio owners are more organizational in nature:

- While electric interval data is becoming more available, a national portfolio owner cannot be assured of being able to get hourly resolution electric data for all buildings, and using different data and methods for different buildings presents significant challenges when assessing overall portfolio performance;
- Established GHG reporting norms for commercial buildings are based on annual accounting; separately using hourly GHG data for ongoing monitoring creates a disconnect since the cumulative hourly GHG emissions will not match the official regulatory reporting based on annual average emission factors; and
- Overall organizational accounting of GHG is broad and complex, and data management practices are still being refined. In this context, there is limited appetite for adding further complexity to Scope 2 emissions monitoring portfolio-wide.

Aside from the rare case where a building owner has set binding 24/7 CFE targets, there currently is no regulatory, structural or programmatic driver for owners to employ hourly Scope 2 GHG emission factors. In the absence of tools and management processes for quantifying time-varying GHG intensity, there is a risk that energy efficiency investments are not matched to the time periods of greatest need (*i.e.*, time periods of high GHG intensity). To that end, GSA's AILL program will be evaluating the ease of implementation and benefits of GHG monitoring software.

Policy-driven requirements to monitor Scope 2 emissions at an hourly level may be unfeasible to implement at scale due to regulatory variations across different states and grid regions. However, market-based mechanisms and programs that can monetize Scope 2 emissions at an hourly level could potentially encourage building owners to take a more granular approach to tracking GHG emissions; for example, virtual power plants (VPPs) are a structure for incentivizing time-sensitive variations in energy consumption, and similar mechanisms may worthy of consideration with respect to hourly GHG emissions.

Acknowledgements

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Office, U.S. Department of Energy, under Contract No. DE-AC02-05CH11231.

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