Tracking Greenhouse Gas Emissions –
a Move Towards Real-Time Emissions Data

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If you're reading this post you deserve credit -- comparisons of accounting methodologies rarely qualify as "clickbait". However, given the increasing importance of accurately tracking and reducing greenhouse gas (GHG) emissions to prevent the worse effects of climate change, this topic is highly relevant.

Singularity Pilot

When considering focus areas for our Student Sustainability Associates Project, we wanted one that would help Harvard meet the goals outlined in its **Sustainability Plan**. We were fortunate to have the opportunity to meet with Singularity, an award-winning Harvard spinoff that offers an AI-powered energy management platform incorporating real-time CO2 signals from the grid into the optimization of energy resources. Singularity and HBS are planning to pilot a battery storage deployment at Batten Hall which will enable HBS to optimize not only for electricity costs (i.e. choosing when to charge and discharge the battery based on electricity prices) but also for greenhouse gas reductions (i.e. charge / discharge based on the GHG emissions associated with the electricity). The Singularity and HBS teams wanted to better understand the standards being used today to account for GHG reductions -- information not only valuable for reporting this specific pilot's performance but more generally to inform overall emissions reporting, evaluation of energy projects and purchases, and compliance with state and federal policies.

Average Annual Emissions Factors vs Real-time Emissions Data

While researching the topic, an interesting debate emerged around using Average Annual Emissions Factors vs. Real-time Emissions Data. To date, Harvard and most organizations use the Average Annual Emissions Factors as found in the Greenhouse Gas Protocol to estimate GHG emissions. This approach estimates the amount of GHG emitted per unit of energy from the grid over the course of the year. This method is fairly easy to employ but can be less accurate if used to compare emissions reductions at different points in time since the emissions intensity (i.e. the emissions associated with a unit of energy) of power grids can vary significantly over the course of the year and even from hour to hour. For example, during a day when the sun is out and the wind is blowing, renewable energy sources such as wind and solar represent a higher percentage of supply and hence the grid has a lower emissions intensity. The average annual emissions approach considers only a change in the total amount of energy consumed, regardless of when this energy is deferred, stored, or consumed.

Figure 1 Average Annual vs. Real-time Emissions Factor example calculations

Emissions using Average Annual emissions intensity:

$$CO2 = energy * intensity$$

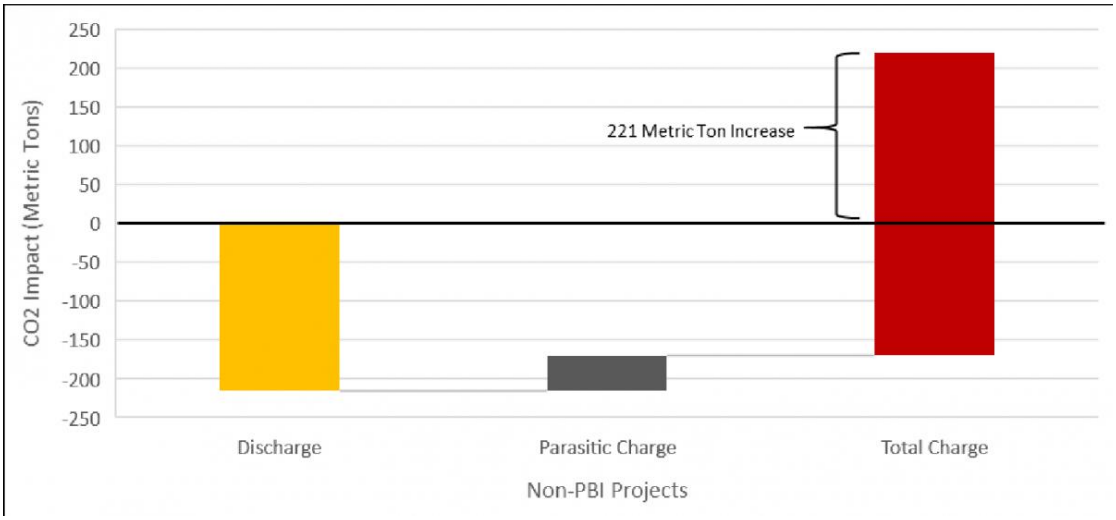
Emissions using Real-time emissions intensity:

Note: this method factors in the timing of the power generated (the delta t variable)

$$CO2(t) = power(t) * intensity(t) * \Delta t$$

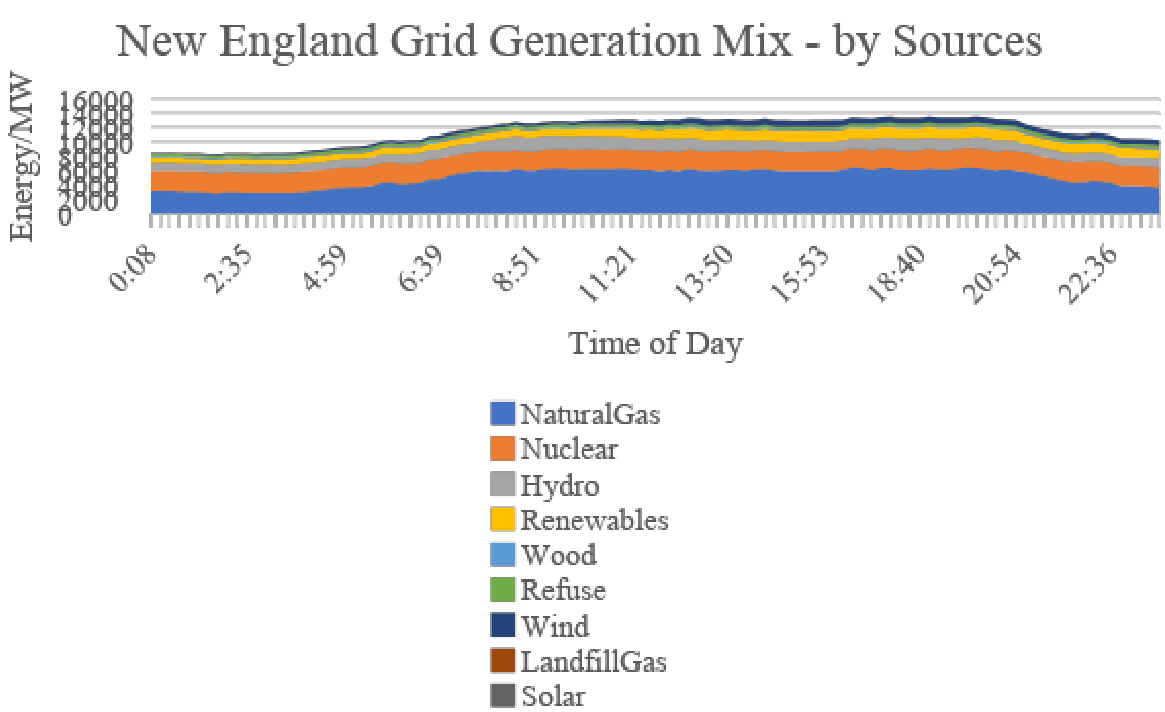
Real-time Emissions data are increasingly important for evaluating GHGs impacts. A 2017 **study** on the California Self Generation Incentive Program (SGIP), for example, highlighted the need for real-time emissions data to use as signals for battery charging. The incentive program, designed to motivate deployments of battery storage to reduce GHGs, was shown to have actually increased emissions in its first couple years because batteries were charging and discharging during times that were not in line with periods of lower grid emissions intensity. The batteries were responding to electricity price signals but the price of electricity was not directly coordinated with the emissions intensity (i.e. higher electricity costs did not correspond to higher grid intensity). California is now focused on adjusting its rates to better align monetary and GHG costs using real-time emissions data. Examples of companies that are utilizing real-time emissions data include **Google** managing its data centers and **eMotorWerks** optimizing their electric vehicle chargers. Google visualized its data center annual energy usage as percentage of carbon-free energy used. (Figure 4)

Figure 2 The relative size of the yellow negative bar (emissions due to charge / discharge timing) compared to the black ("parasitic" charge from round-trip efficiency losses) shows the importance of having and responding to real-time emissions data.



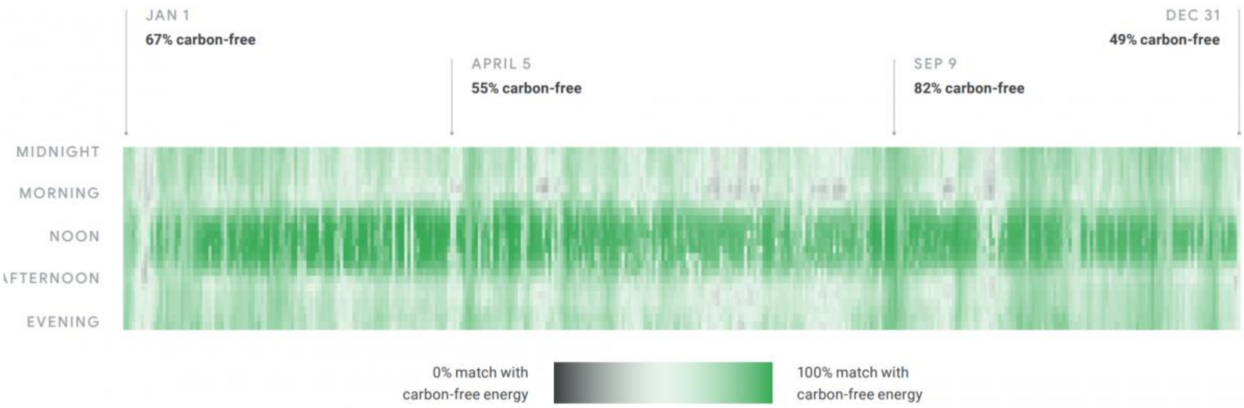
Source: *2017 SGIP ADVANCED ENERGY STORAGE IMPACT EVALUATION*. Itron, 2018, **www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/2017_SGIP_AES_Impact_Evaluation.pdf**

Figure 3 Example of variable grid generation mix. As the sources of energy change throughout the day, so too will the grid's GHG emissions intensity.



Source: Resource Mix. ISO New England, Resource Mix, **www.iso-ne.com/about/key-stats/resource-mix/**.

Figure 4 Google's emissions data charts.



Source: Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights. Google, 2018, Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights, storage.googleapis.com/gweb-sustainability.appspot.com/pdf/24x7-carbon-free-energy-data-centers.pdf.

In addition to the need for real-time data to inform the behavior of energy storage and consumption, the concept also applies to how GHG reductions should be accounted. The Greenhouse Gas Protocol, used by more than 1,000 companies and institutions worldwide, also outlines how **grid-connected electricity projects** (e.g. new power plants) can use real-time data to account for GHG reductions. The method includes an "Operating Margin Emissions Factor" comprised of the approximate marginal emissions of electricity production on an hourly basis.

A Shift Towards Real-time Data

Pros and cons exist for using real-time emissions data to make energy decisions and account for GHG reductions. The benefits include improved precision and accuracy of GHG reporting, more effective demand-response schemas, and more informed project decision-making. However, the annual average emissions factors used widely today require less monitoring of infrastructure (meters to obtain real-time data) and are easier to implement. Additionally, it's not always clear that the added precision and accuracy of real-time data is worth the effort required to establish emissions baselines with the more complicated approach, especially if the real-time GHG emissions data may not be 100% accurate itself due to the highly dynamic nature of the grid. One thing we believe for certain, HBS and Harvard University should continue to evaluate this tradeoff as it designs its GHG reporting and decision-making tools.

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