White Paper

Understanding CO_2 Emissions Accounting

Bloomenergy™

Executive Summary

Today's electricity grid is a marvel of 19th and 20th century technology: it powers modern life. Yet conventional electricity generation, much of which is dirty and inefficient, contributes to global warming. As society responds swiftly to the threat of climate change through changing consumer preferences and direct economic regulation, electricity consumers face financial risks from failing to actively manage this problem.

Today, many forward-thinking organizations seek to reduce their absolute CO_2 footprint, and to position themselves as leaders in corporate sustainability. Many have set quantitative goals for substantial greenhouse gas reductions to be achieved as their businesses continue to grow. Yet how should they properly account for the CO_2 reduction offered by clean onsite energy projects that displace grid electricity?

This white paper explains CO_2 accounting for onsite power generation. It demonstrates that, for every kilowatt-hour, Bloom Energy systems running on natural gas will reduce CO_2 emissions by 34% compared to the California grid, and by 37% compared to the U.S. grid as a whole. When running on renewable biogas, Bloom Energy systems offer reliable energy generation and a 100% CO_2 reduction.

Why is CO_2 Accounting Important?

CO_2 emissions will soon be regulated. On September 27, 2006, California Governor Schwarzenegger signed AB 32, the Global Warming Solutions Act. This legislation represented the first enforceable state-wide program in the U.S. to cap all greenhouse gas (GHG) emissions—and chiefly CO_2—from major industries that includes penalties for non-compliance.

AB 32 set broad, aggressive reduction goals: cap California's greenhouse gas emissions at 1990 levels by 2020, and reduce them 80% by 2050. Yet it did not specify precisely how to achieve these emissions reductions. Accordingly, there's a tremendous opportunity for companies to get smart today about CO_2 accounting, and understand how the tectonic effects of this legislation will impact their business.

Leading companies are acting now. They know that other states are not far behind California, and that federal regulation of CO_2 is imminent. They also know that customers rank climate change as an urgent environmental concern, and that investors increasingly seek to mitigate legal exposure from ignoring this problem.

So what can companies do? The highest leverage opportunity is often to reduce their CO_2 emissions from their ever-growing electricity consumption. Many are looking to clean on-site power generation technologies to achieve these reductions.

How to Account for Reducing Your CO_2 Footprint

Let's take the example of a Fortune 500 company. This company's CEO commits the company to reducing its *absolute* annual CO_2 emissions over the next 5 years. Yet the business is set to grow, that growth implies increased electricity consumption.

So the company must ask: how do we reduce our CO_2 emissions from every kilowatt-hour that we do consume? Clean onsite power generation is likely a key part of any comprehensive CO_2 reduction strategy.

The company then must ask: how do we quantify the reduction in our CO_2 emissions from using clean onsite power instead of continuing to get that power from the grid? This savings becomes their net CO_2 reduction, which applies to their absolute CO_2 emissions. The following procedure explains how to compute this quantity:

STEP 1: Determine Emissions from the Onsite Generator

Calculating the emissions from the onsite electricity generator is straightforward. Three factors apply:

1. **the fuel's carbon content.** Fuels with a higher ratio of hydrogen to carbon (e.g. natural gas) produce less carbon dioxide when consumed.

2. **the generator's electrical efficiency.** This dictates how much fuel is required to produce a unit of electrical energy (kWh).

3. **the generator's availability.** This metric reveals how frequently the generator can produce power at its rated power output (kW) throughout a month, quarter, or year.

The convention is to measure CO_2 emissions in terms of pounds emitted for each megawatt-hour (MWh = 1,000 kWh) of electricity generated.

When running on natural gas, Bloom Energy systems emit an average of 773 lbs. CO_2 per MWh. When running on a renewable fuel, Bloom Energy systems emit no net CO_2 emissions for all the energy they generate.[1]

STEP 2: Determine Emissions from the Grid
Determining the correct baseline of grid emissions requires a bit more investigation. Let's say this example company is located in Silicon Valley and buys conventional grid electricity from PG&E.

The EPA's eGRID database[2] provides the most easily accessible figure for the grid emissions. For the year 2005, eGRID tells us that PG&E's blend of power had a *weighted average* CO_2 footprint of 724 lbs CO_2/MWh.

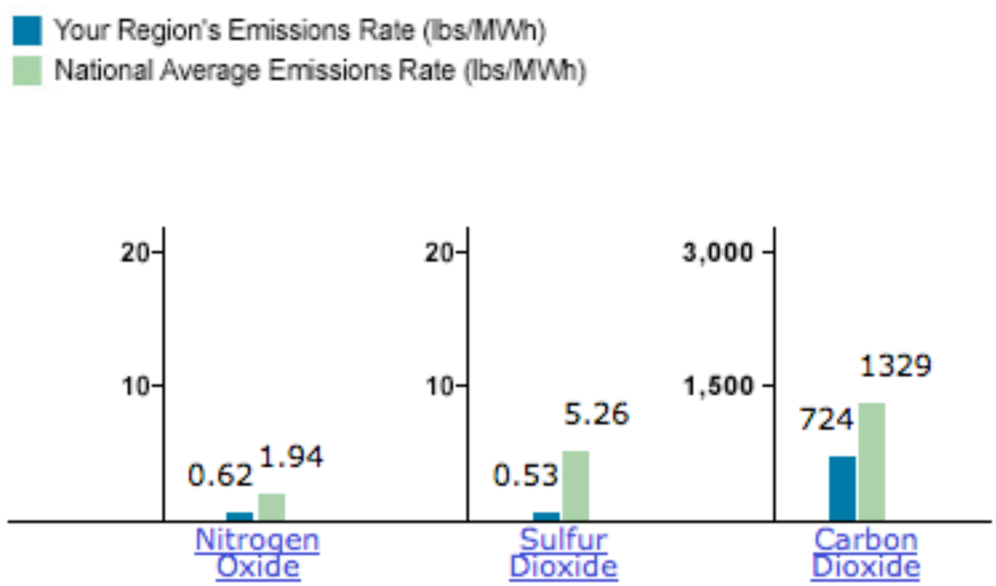

Figure 1: The year 2005 average emissions rates for PG&E vs. the National Average. Source: US EPA.

STEP 3: Compare Emissions from the Grid

It would be tempting — but incorrect — to use this average figure as the baseline to calculate the emissions reductions obtained from the onsite energy project. Why? 724 lbs CO_2/MWh provides the average emissions footprint of a *historical* unit of PG&E electricity. Yet the choice before us today concerns this company's *future* consumption, which occurs at the margin. That is to say that as this Fortune 500 company continues to grow, it will increase its demand for grid electricity, requiring PG&E to supply marginally more power to serve that load.

[1] This is referred to being "carbon neutral". For more information: http://www.wordspy.com/words/carbonneutral.asp
[2] Access the eGRID datbase via EPA's PowerProfiler web tool: http://www.epa.gov/cleanenergy/powerprofiler.htm

Accordingly, what we really want to know is the combined emissions footprint of that marginal unit of grid electricity.

Marginal Grid CO_2 Emissions in California

Why are the grid's average emissions different from its marginal emissions? Because the grid's past is distinct from its future. The average tells you what already happened. Yet in the future, it is highly unlikely that California will build any more large sources of CO_2-free power generation like large hydroelectric dams or nuclear power stations (together these make up 34% of the state's annual electricity production). Additionally, CA gets a significant fraction of power from other states, many of which rely on coal-based generation. So the question is, what future large electricity plants will not operate because of this Fortune 500 company's choice to utilize clean onsite power generation?

This set of future plants is called the "marginal build". It is the correct reference of grid emissions to use for onsite base load power systems. This marginal accounting methodology has been explicitly supported by the World Resources Institute (WRI), as well as by Energy & Environmental Economics, Inc. (E3) in their modeling for California's AB32 legislation enactment.

The marginal emissions are not calculated by state boundaries, but by the grid's "basin" of service, or "NERC region".[3] The World Resources Institute (WRI) laid out the methodology to compute the marginal build in the paper footnoted below.[4] Yet while WRI defined the marginal emissions accounting methodology, they stopped short of producing the grid's actual CO_2 emissions figures. They left that up to Green-e, an organization that creates standards for CO_2 accounting & offset certification, which subsequently crunched the numbers.[5] They produced the following guide:

[3] North American Electric Reliability Council (NERC) Region Map here: http://www.bydesign.com/fossilfuels/crisis/html/NERC_regions_map.html

[4] http://www.wri.org/publication/guidelines-quantifying-ghg-reductions-grid-connected-electricity-projects

[5] http://www.green-e.org/docs/Green-e_Climate_Protocol_for_RE.pdf. Green-e's set of numbers were generated for RECs, but they also apply to base load onsite generation.

Region	Operating margin[8] (lbs/MWh)	Build Margin (lbs/MWh)	Combined Margin (lbs/MWh)
Alaska Systems Coordinating Council (ASCC)	1,437	1,541	1,489
Electric Reliability Council of Texas (ERCOT)	1,335	1,306	1,320
Florida Reliability Coordinating Council (FRCC)	1,475	1,109	1,292
Hawaiian Islands Coordinating Council (HICC)	1,698	1,456	1,577
Midwest Reliability Organization (MRO)	2,192	1,433	1,813
Northeast Power Coordinating Council (NPCC)	1,539	1,142	1,341
ReliabilityFirst Corporation (RFC)	1,987	1,083	1,535
SERC Reliability Corporation (SERC)	1,842	1,306	1,574
Southwest Power Pool, Inc. (SPP)	1,659	1,034	1,346
Western Electricity Coordinating Council (WECC)	1,411	1,179	1,295

Note that the Build Margin applies to base load generators like Bloom Energy's systems, while the Combined Margin applies to intermittent, peaking distributed generation like solar photovoltaics. The Green-e paper explains the theory behind this distinction.

In summary, the marginal build grid emissions in the WECC, which includes California, is 1,179 lbs CO_2 per MWh.

Summary

In conclusion, we return to the Fortune 500 company's central question: How much CO_2 savings will they realize by choosing an onsite energy generator for their electricity production, as opposed to continuing to rely on the dirty grid? The following table provides the answer for each region:

CO_2 Reductions Offered by Onsite Baseload Generation				
	Grid Marginal Build	Bloom Energy (Natural Gas)	CO_2 Reduction Using Bloom Energy	
Region	lbs/MWh	lbs/MWh	lbs/MWh	%
California	1,179	773	406	**34%**
New England	1,142	773	369	**32%**
Midwest	1,433	773	660	**46%**
Alaska	1,541	773	768	**50%**
Hawaii	1,456	773	683	**47%**
National	1,232	773	459	**37%**
U.S. Average Coal Plant	2,249	773	1,476	**66%**

And once again, when running on a renewable fuel like biogas, Bloom Energy systems offer a 100% CO_2 reduction for every MWh of energy produced. This can make a dramatic impact on reducing a company's absolute CO_2 emissions.

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