On the Importance of Marginal Emissions Factors for Policy Analysis

Environmental nonprofits WattTime and Rocky Mountain Institute recommend marginal rather than average emissions factors be used for analysis of policies whose goal is to reduce carbon emissions. This primer explains why.

The purpose of average emissions factors is to apportion environmental responsibility.

A common technique in environmental analysis is to divide responsibility for cleaning up pollution equally between the different actors in a power grid on the basis of their relative power consumption. For example, if a given city consumes 5% of all the electricity produced in a given power grid, it is simple and intuitive to call it responsible for 5% of all the emissions in that grid.

The virtue of this technique is its simplicity. Each city or company on a power grid can simply calculate the average emissions per each kilowatt-hour on its local power grid; measure its own kilowatt-hours consumed; and multiply to determine its "share" of a given grid's pollution.[1]

Average emissions factors should *not* be used to measure environmental impact.

Historically, average emissions rates have been a convenient way to apportion "ownership" of different organizations' responsibility for emissions. Unfortunately, as momentum builds for institutions to more actively manage emissions, a worrisome trend is the growing number of organizations mis-applying average emissions factors to estimate the impact of environmental decisions. Yet this approach does not accurately measure environmental consequences. Returning to the previous example, it's entirely possible that the exact 5% of the grid's electricity that city is consuming comes predominantly from aging natural gas power plants, which would mean comparatively high emissions.

The correct way to measure environmental impact is using marginal emissions factors.

To protect against this mistake, the correct way to measure the impact of environmental decisions is to use *marginal* emissions factors.[2] Marginal emissions factors measure the actual environmental consequences of taking different potential actions on the power grid.

If the example city is evaluating an energy efficiency measure to conserve one megawatt-hour of electricity consumption, this program will reduce local emissions by reducing output at one or more power plants. But *which* power plants? Many sources of power, for example most solar panels, are designed to send all the energy they can to the power grid no matter the level of energy demand. Thus, they will be completely unaffected.

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[1] See, e.g. the GHG Protocol Corporate Standard.

[2] See, e.g. the GHG Protocol for Grid-Connected Electricity Projects.

Conserving energy only affects some power plants: those which can scale up or down in response, known as the "marginal" power plants. Marginal emissions measure the emissions per kilowatt-hour only from these power plants, thus accurately measuring real-world results.

Why using average emissions can lead to incorrect policy conclusions.

When a power grid experiences a change in energy demand—for example, adding electric vehicles, or installing new clean power—that changes the emissions from local power plants. But some power plants are completely unaffected, for example, most solar panels and nuclear plants.

Using average emissions factors to measure the effect of environmental decisions implicitly assumes that energy policy-making affects all power plants equally. This overestimates the effects on these unaffected plants, and underestimates the effects on the marginal plants which actually do change in response to policy. If these plants have different emissions rates, this can lead to incorrect measurement of policies.

This is a growing problem because the more "always-on" clean energy a region installs, the more inaccurate any analyses using average emissions factors become. For example, on Friday May 3rd, 2019 at 1:30 PM, the CAISO website reported the following data regarding real-time energy supply and emissions. CAISO was delivering 23, 690 MW of power at an emissions rate of 3,042 $mTCO_2$/hour. Nearly 50% of the total supply (12,086 MW), was from renewable sources. Using an approach of average emissions, one would say that the current emissions rate was 283lbs CO_2/MWh.[3]

However, the marginal emissions rate for the same time was much higher, at 927 lbs CO_2/MWh. Despite the high penetration of midday solar, if 1 MWh of load was added to the grid at this time, the solar plants would likely not be the type of fuel responding to the increased load. It is more likely that an inefficient gas generator would ramp to meet the increased load, thus creating an emissions impact of 927 lbs of CO_2.[4]

As seen here, true emissions rates can be up to four times higher than average emissions-based estimates would imply, with major consequences for policy evaluation.

If policymakers were to only allow technologies that were below the average emissions levels, they might inadvertently allow existing, inefficient generators to operate more than they intend. The result would be restricting projects are that good for the environment, instead of encouraging them.

[3] California ISO real-time energy data.
[4] WattTime marginal emissions data.

Common situations in which marginal emissions is most important.

Marginal emission factors should nearly always be used in environmental impact analysis. Leading researchers apply them when measuring everything from renewable energy, to electric vehicles, to energy storage.[5] But they have particular importance for public policy whenever a policy measure is comparing different options, for example:

- *Comparing what times are best to use or store energy*. Marginal emissions should be used to select which times are cleanest, such as for energy storage.[6]
- *Comparing where is best to site a new energy asset*. Marginal emission rates should be used to measure the impact of new renewable energy, particularly in selecting locations.[7]
- *Evaluating electrification*. Marginal emissions rates should be used when evaluating the environmental impact of electrifying fossil fuel technologies such as vehicles, water heaters, and appliances. For example, in some coal-heavy regions, switching from a gasoline-powered car to an electric vehicle can actually increase, not decrease emissions.
- *Evaluating low-emissions energy sources*. Marginal emissions rates should be used to evaluate the environmental impact of low-pollution electricity generation technologies such as fuel cells and biomass. These technologies are sometimes mistakenly thought to increase emissions if they emit more than the local average emissions rate. But in reality they reduce emissions anywhere they less than the local marginal emissions rate.

For more information about average vs. marginal emissions, see this joint WattTime-RMI post.

How to properly design policy based on data-driven marginal emissions rates

Several large, influential public agencies (the CPUC), and private customers are committed to accurately reducing carbon emissions by using marginal emissions analysis. In December of 2018, the CPUC staff released a draft regulation directing the commission to require entities utilizing public incentives in the Self Generation Incentive Program (SGIP) to use marginal emissions rates to determine the net GHG impact of their project.[8]

Creating effective regulations and policy, as the CPUC has done, requires thorough data analysis and stakeholder engagement. As an independent, third-party non-profit, WattTime was founded to guide policy makers and regulators through this process to ensure that their efforts accurately reduce greenhouse gas emissions.

[5] See, e.g. Hittinger and Azevedo (2015), Callaway et al (2017) or Fares and Weber (2017).
[6] E.g. the California Public Utilities Commission's decision to use marginal emissions in real time for energy storage.
[7] See, e.g. Boston University's recent decision to buy renewable energy outside Boston using marginal emissions.