



## Planning for the evolution of the electric grid with a long-run marginal emission rate

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# Agenda

- 1 Discuss recent study
- 2 Discuss NREL's Cambium database
- 3 Q & A

iScience

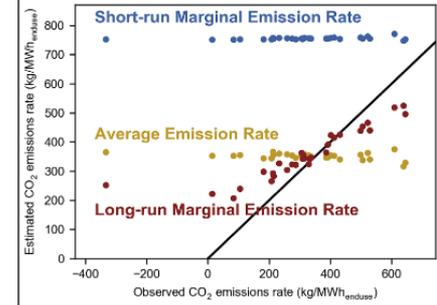
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## Article

Planning for the evolution of the electric grid with a long-run marginal emission rate

### How well can each metric estimate the emissions from electric-sector interventions?

The estimations from a well-performing metric would fall on the diagonal parity line



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#### Highlights

A long-run marginal emission rate captures both operational and structural impacts

A LIMER was compared against short-run marginal and average emission rates

The LIMER outperformed both the SRMER and AER at estimating emission impacts

Integrating SRMER across an intervention's lifetime may not describe its total impact

Gagnon & Cole, *iScience* 25, 102915  
March 18, 2022 © 2022 The Author(s)  
<https://doi.org/10.1016/j.isci.2022.102915>

# What is the point of this talk?

What metric is most suitable for estimating the emissions consequences of an electric-sector intervention?

If I install a heat pump, what electric-sector emissions will be induced?

If an energy efficiency measure is adopted, what emissions will be avoided?

What are the emission differences from charging my electric vehicle during the day versus during the night?

# 3 Types of Emission Metrics

## Average Emission Rates

Average emission rate of all generation in a given region  
*Examples: eGRID*

Attributional

## Short-run marginal emission rate

Emission rate of the next unit of electricity *considering the grid's structure as fixed*  
*Examples: AVERT, WattTime, RESurety, ElectricityMap, Carbonara, et cetera*

Consequential

## Long-run marginal emission rate

Emission rate of the next unit of electricity *considering the grid's structure as variable*  
*Examples: NREL's Cambium, CPUC Avoided Cost Calculator*

Consequential

# How did we test the 3 metrics?

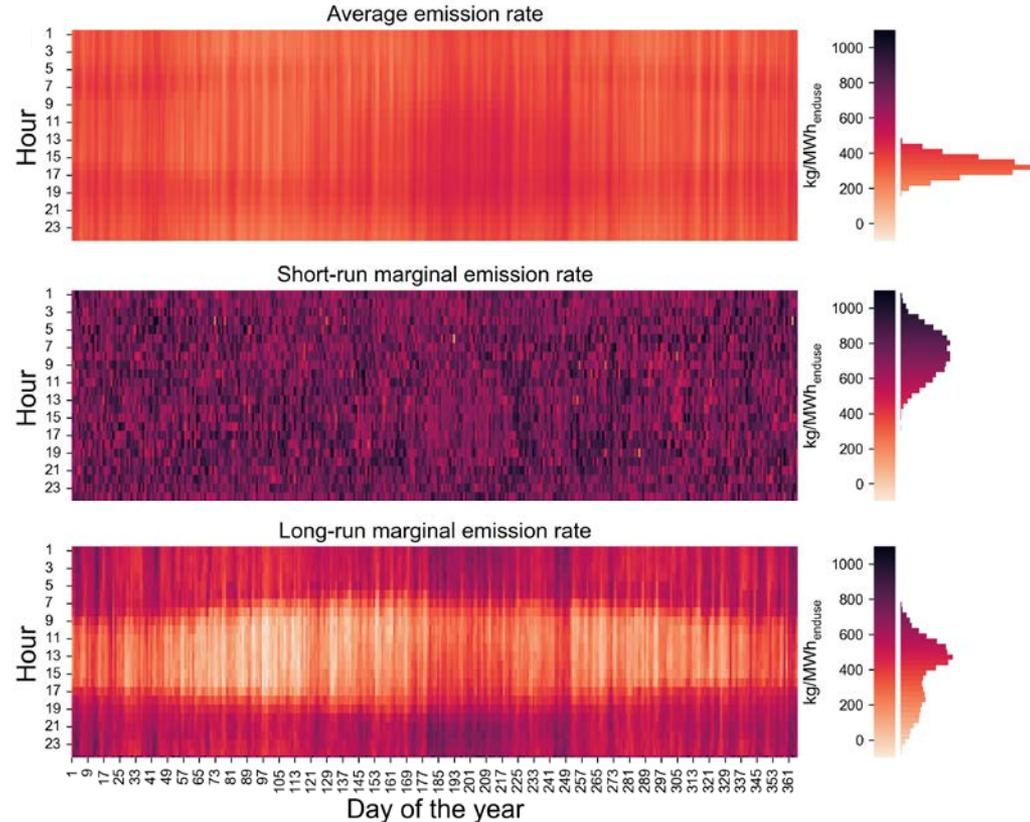
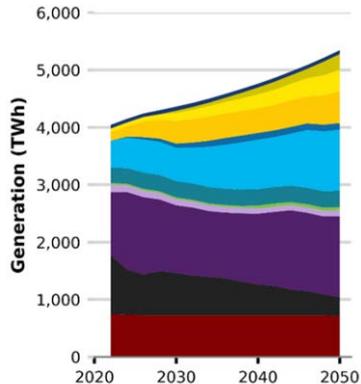
## The Method

1. Calculate each metric using power system models
2. Define a set of load shapes
3. Use each metric to estimate the emissions induced by each load shape
4. Put each load shape directly into the model and see what emissions are induced
5. Compare the two values

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## The Method

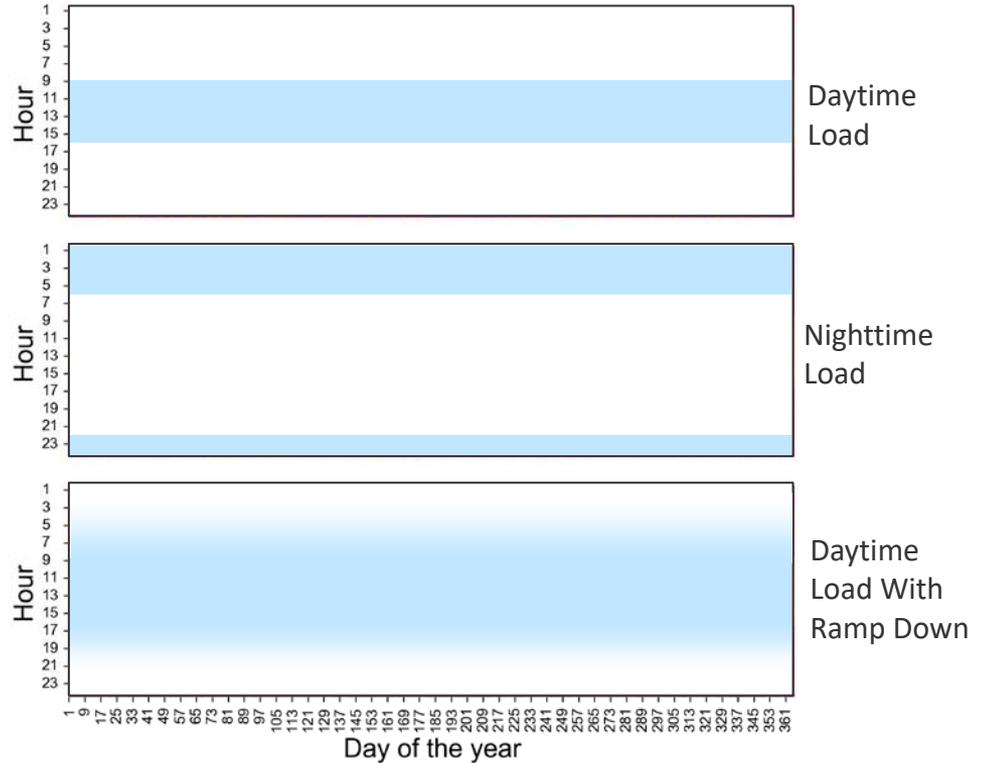
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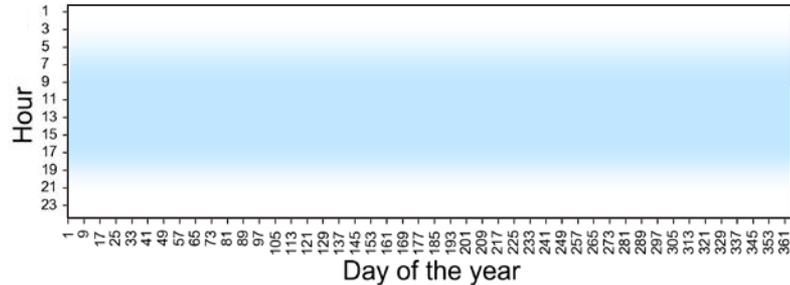
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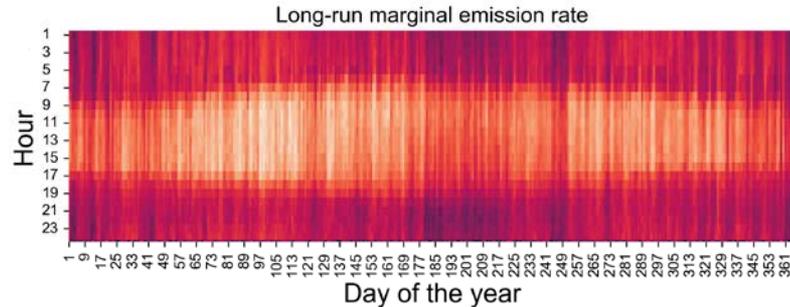
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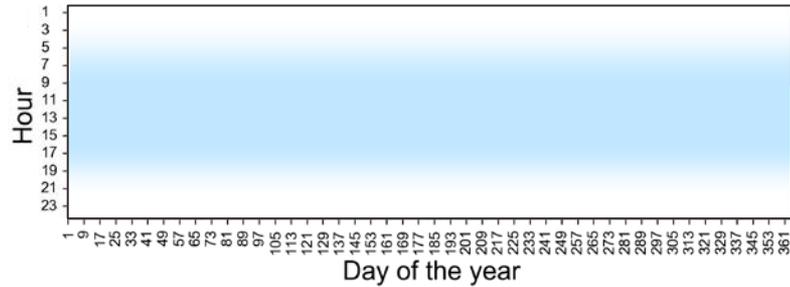
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284 kg of CO<sub>2</sub> per MWh

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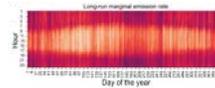
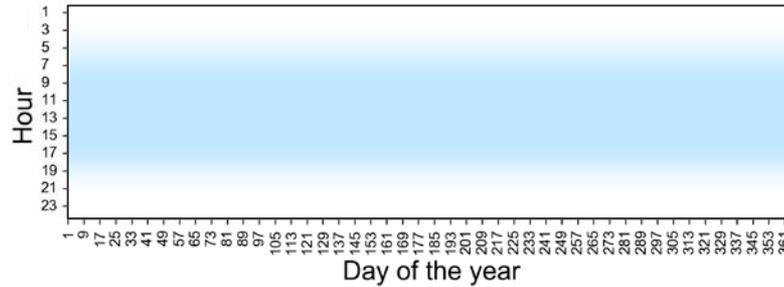


215 kg of CO<sub>2</sub> per MWh

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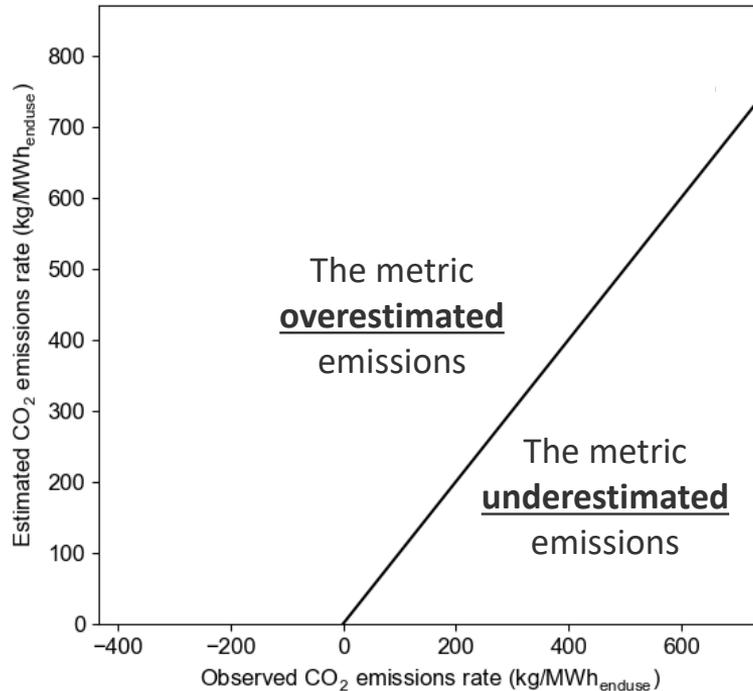
215 kg/MWh

Error of +69 kg of CO<sub>2</sub> per MWh

# How did the three metrics perform?

## How well does each metric perform?

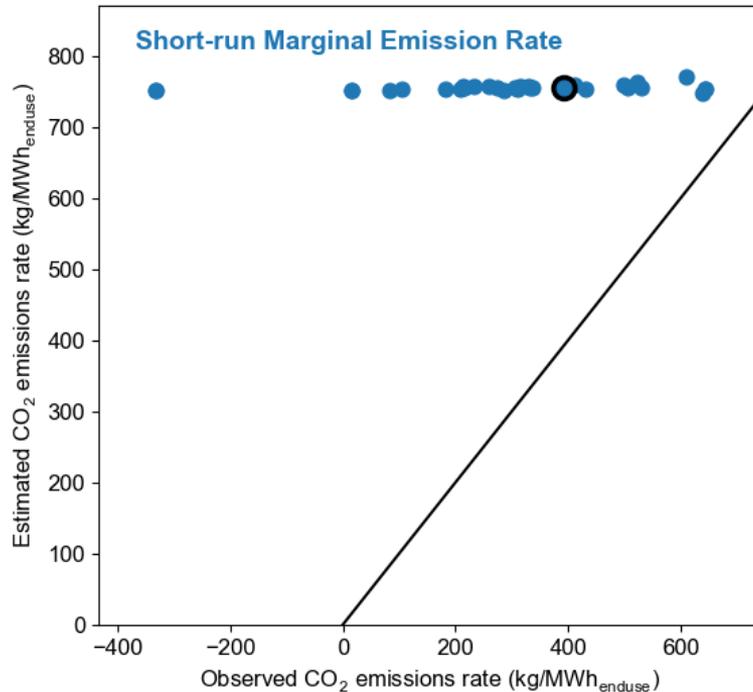
The estimations from a well-performing metric would fall on the diagonal parity line



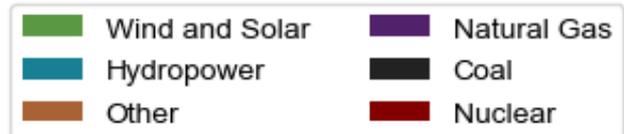
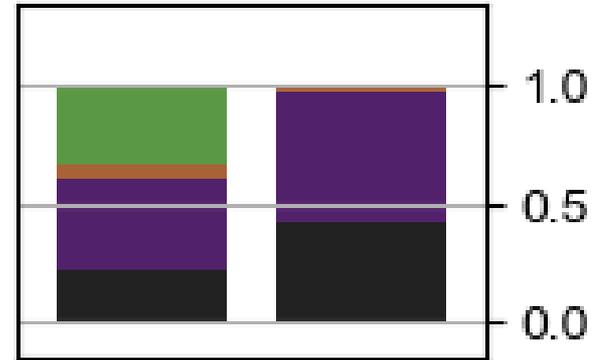
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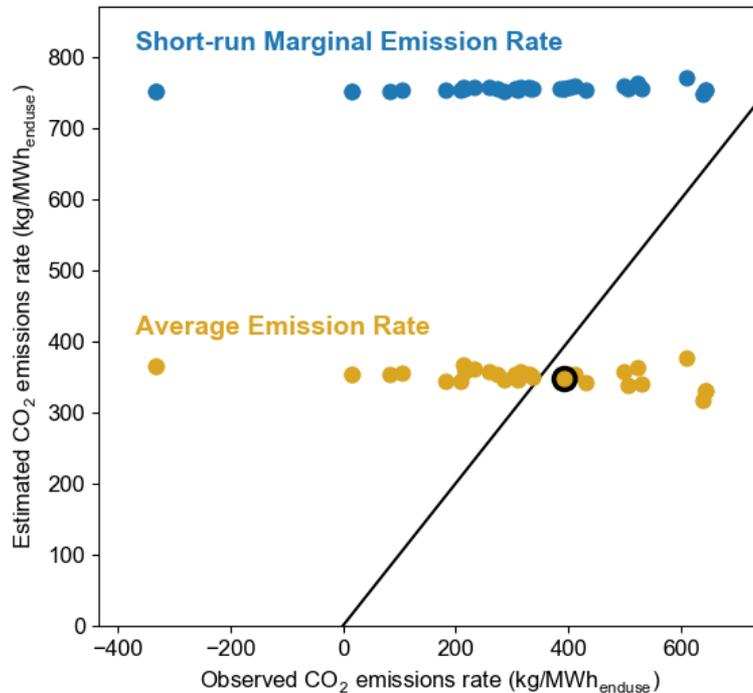
Observed Mixture      Estimated Mixture



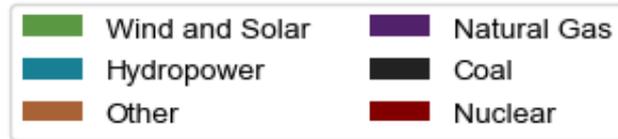
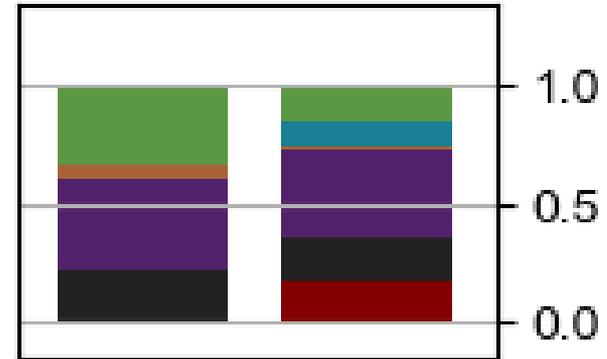
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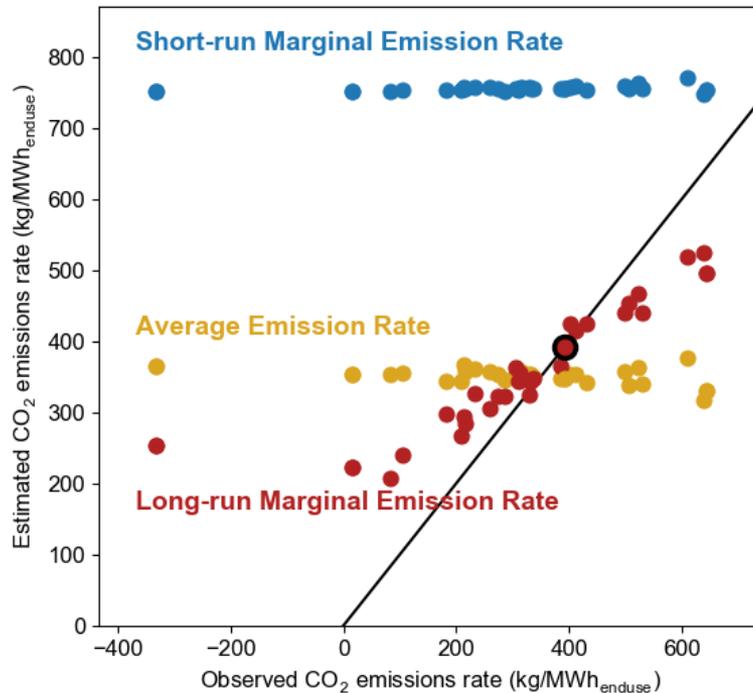
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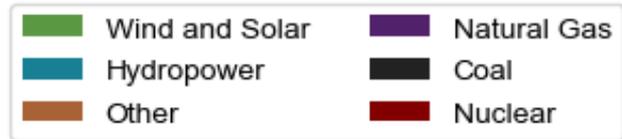
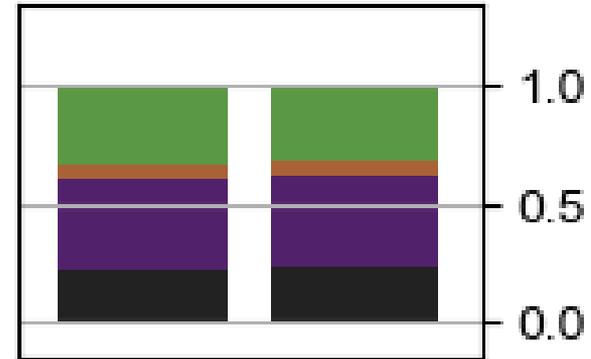
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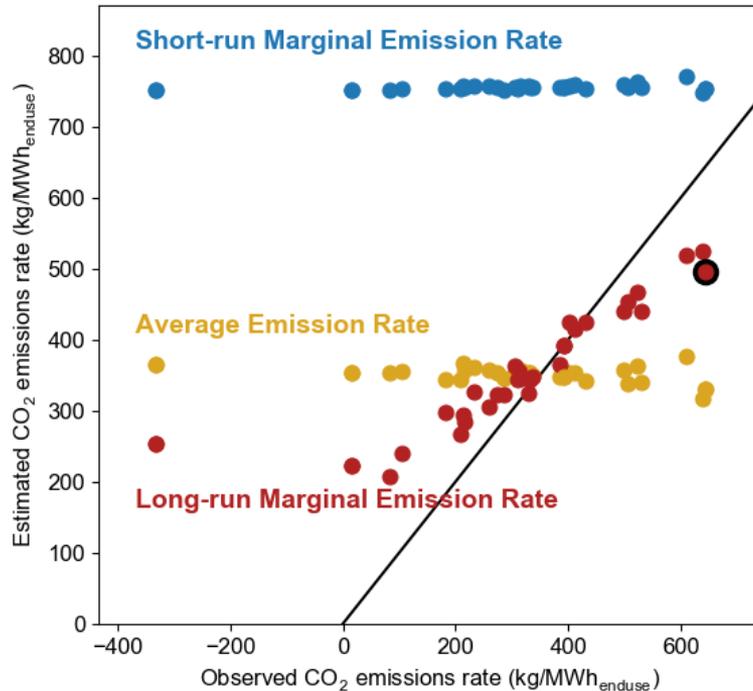
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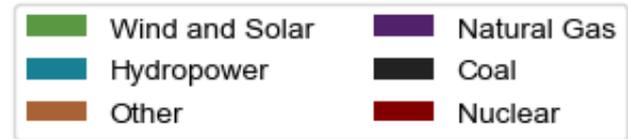
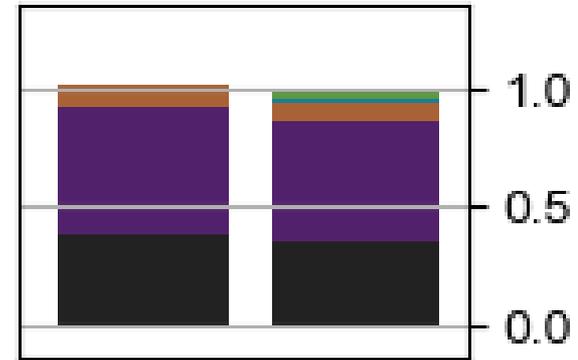
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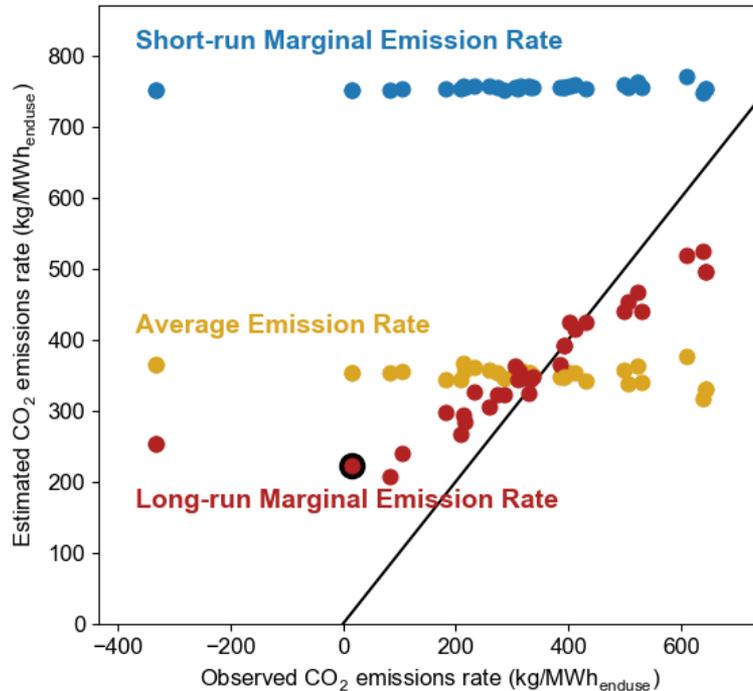
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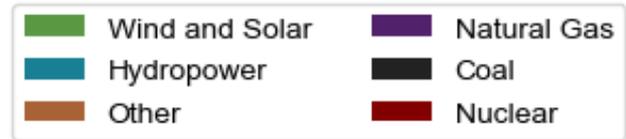
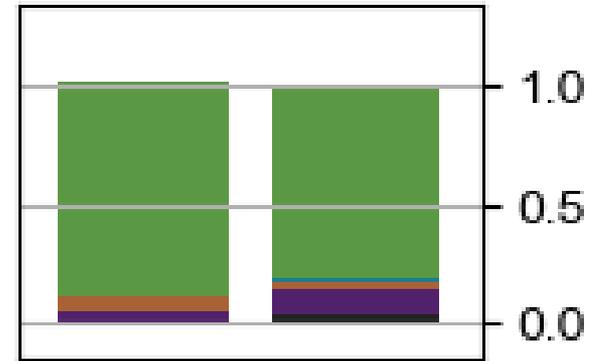
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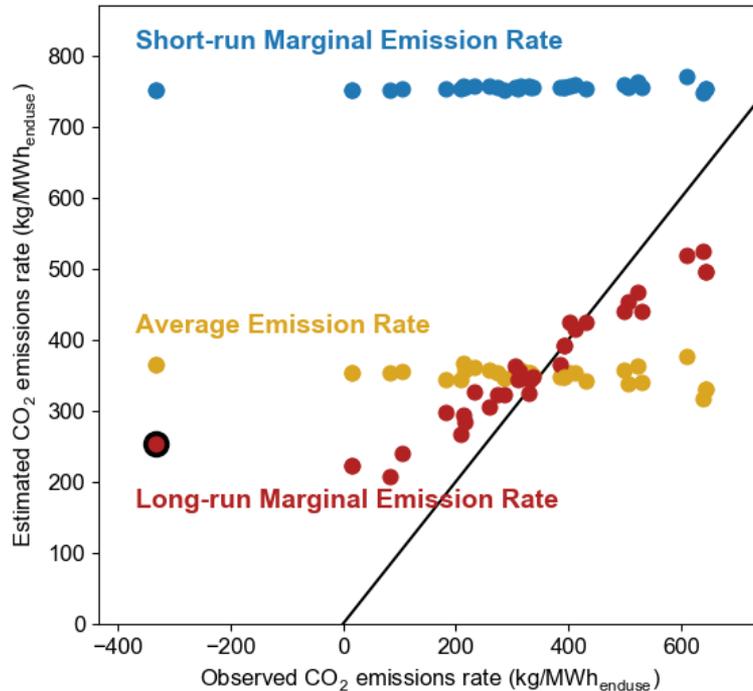
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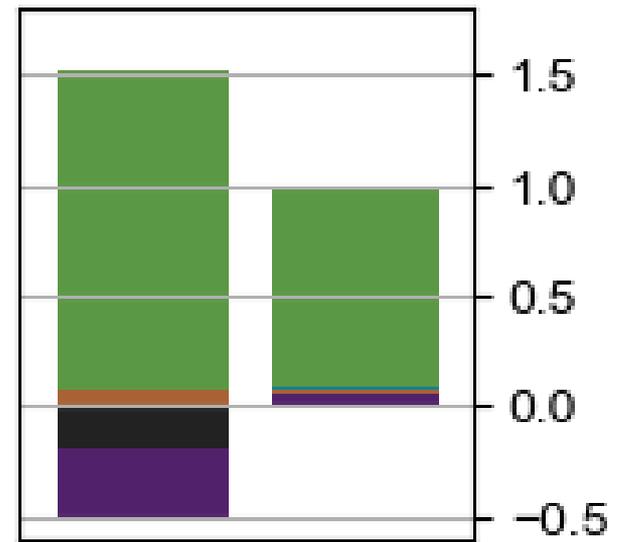
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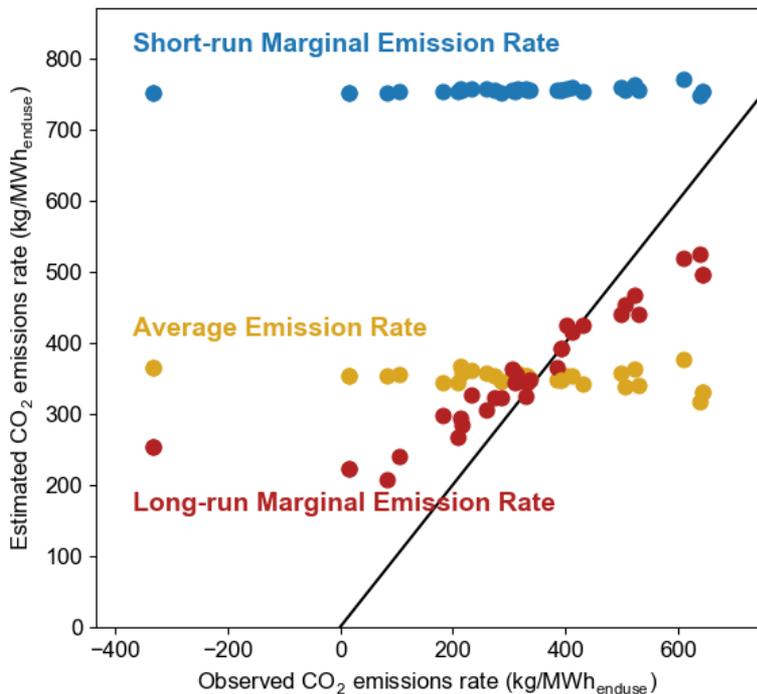


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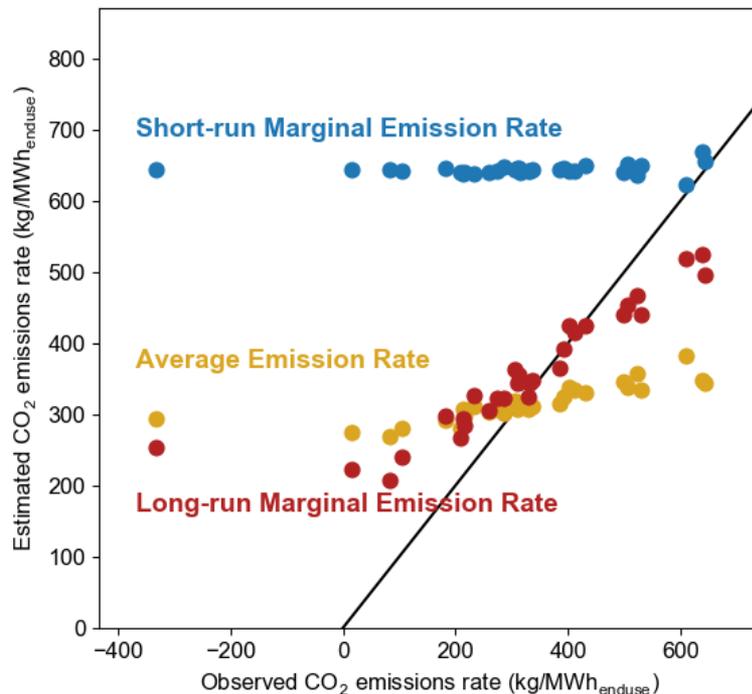


# What if the average and short-run metrics are also calculated from projections of the future?

## SRMER and AER Calculated From First-year Values



## All Metrics Calculated From Full 20-year Timeframe



# Conclusions

## Short-run marginal emission rate:

- Does not comprehensively reflect the consequences of an intervention
- In our study, often significantly overestimated induced emissions
- Integrating SRMER over time does not capture full consequences

## Average emission rate:

- Mean error was less than short-run metrics, but this was mostly by happenstance
- Did not capture diurnal trends well in our nation-wide analysis

## Long-run marginal emission rate:

- Outperformed both the other two metrics, but still not perfect
- See caveats on the next slide!

# Discussions and Limitations

## General comments:

- For unexpected or unplanned interventions, a phased short-run/long-run approach would likely be appropriate
- The LRMER metric is only as good as the underlying model
- This study only examined a priori planning assessments, but the concepts likely apply to many real-time operational decision as well
- We only examined CO<sub>2</sub>, but the concepts here apply to other emissions as well

## Limitations of our study:

- Our scenarios had curtailment occurring ~1% of the time (and often in locations with relatively little load) – SRMER might perform better when there is significant curtailment
- This paper only examined our “Mid-case” projection of the future
- This paper only examined performance when the future unfolded as expected
- This paper only examined the nation as a whole

# NREL's Cambium Project

NREL's annually-released data sets contain hourly emission, cost, and operational metrics for modeled futures of the U.S. electric sector

Website for updates: <https://www.nrel.gov/analysis/cambium.html>

Workbooks with LRMER data: <https://data.nrel.gov/submissions/183>

Scenario Viewer and Data Downloader: <https://scenarioviewer.nrel.gov/>

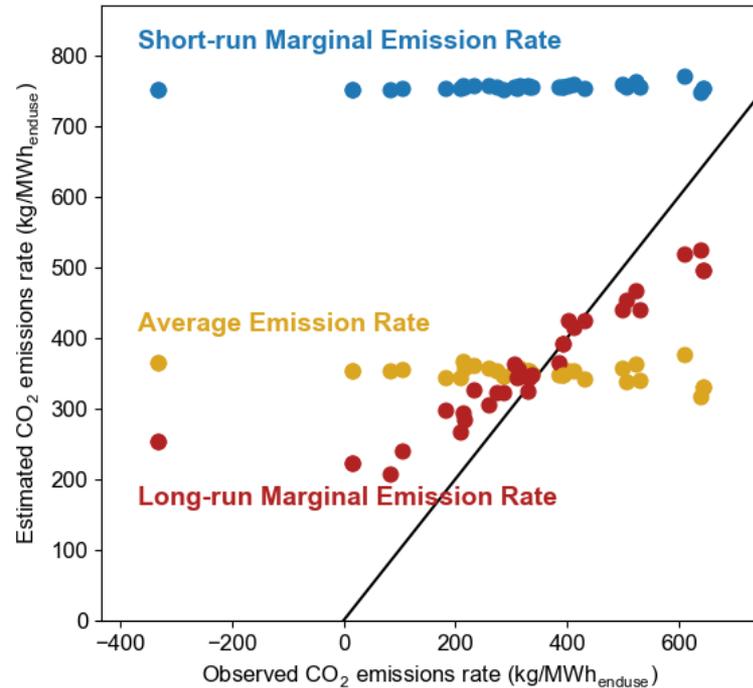
Point of contact: [Pieter.Gagnon@nrel.gov](mailto:Pieter.Gagnon@nrel.gov)

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# Questions?

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