RESOURCES for the FUTURE

Options for CO_2 Emissions Rates Reporting

Presentation to NYISO EAC

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Background

- Firms and governments are increasingly taking voluntary actions to promote carbon-free electricity (CFE) through their purchases
- Approaches to this activity are evolving
  - Net Zero: Purchase clean electricity sufficient to meet total demand on average over the course of a year
  - 24/7 clean: Match electricity consumption hour-by-hour with clean supply that is supplied directly to local grid
    - Both firms (e.g., Google, Microsoft) and the federal Government (President Biden Executive Order, 12/8/21) are pursuing 24/7 CFE
- Taking the 24/7 approach requires detailed information on grid emissions rates to inform decisions and to track progress

Many uses for emissions rate information

- To enable Scope 2 carbon emissions accounting
- To inform investment decisions by firms
  - Where to locate new sources of load to use more CFE
  - Where to invest in new CFE (to displace the most emissions)
- To optimize timing of flexible load (e.g., car charging, data backup)
- To track progress toward 24/7 clean electricity goals

- Recent SEC proposal for CO_2 emissions disclosure in 10K filings
  - Focused on annual reporting, but could evolve to more detail as 24/7 aspirations (claims) by electricity users expand

Data properties for newer data uses

- Associate emissions with sources of demand and not supply
- Disaggregate emissions by location
- Identify average and marginal emissions
- Need high frequency data to inform operating decisions
- Data users want data reported in as close to real time as possible
- Growing interest in public data to facilitate transparency and common approaches to producing data across locations

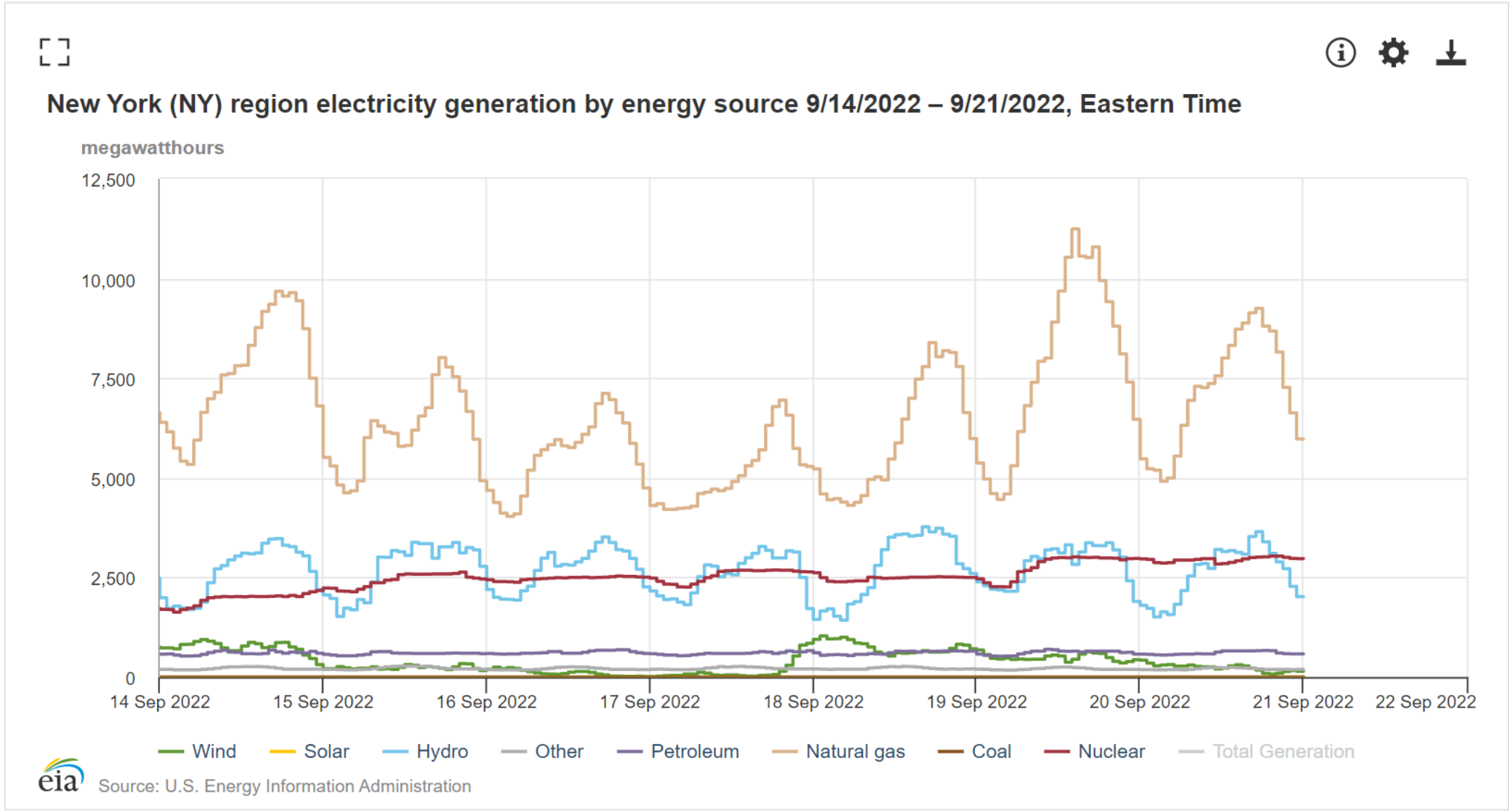
Existing government data sources/tools fall short

- EPA data sets and tools
  - EPA CEMS emissions and generation
    - By combustion unit, hourly, made public with a time lag of several months.
  - EPA EGRID emissions rates
    - 27 regions in US / demand associated / annual frequency / lag of 1-2 years in release
  - EPA AVERT Tool
    - 14 US regions / Demand associated/ Hourly / 1-2 year lag
- NREL tool and estimates
  - NREL Cambium Tool: Long run marginal emissions rates
    - 134 Balancing Areas (not Authorities)/ demand associated / month hour/ lag of 1 year

What about EIA?

- Energy Information Administration (EIA) is the natural entity to provide more granular data
  - Currently has an hourly electricity dashboard with information on grid mix by fuel type and generation and demand by balancing authority
  - EIA also reports information on emissions by generator and state on annual basis
  - More granular emissions data is needed to inform new data use cases.

EIA Hourly Grid Monitor: Generation, by Region



https://www.eia.gov/electricity/gridmonitor/

EIA Hourly Grid Monitor: Emissions by location

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Note: EIA recently added information on hourly national average emissions rates its website at eia.gov/electricity/ (available from 2015 through two days ago, updated daily).

https://www.eia.gov/electricity/gridmonitor/

Enter the US Congress

- The 2021 Infrastructure Investment and Jobs Act (IIJA) directs EIA to report geographically and temporally detailed information on *average* and *marginal* CO_2 emissions rates, where available, by late 2022
- RFF Report*: evaluates potential options for EIA to meet this request

*Note: This project was funded by Meta Platforms Inc., Apple Inc., Google LLC, and Microsoft Corporation in partnership with the Clean Energy Buyers Association.

Infrastructure Investment and Jobs Act Language

*"Administrator shall expand the Dashboard to include, to the maximum extent practicable, hourly operating data collected from the electricity balancing authorities…where available, the **estimated marginal greenhouse gas emissions** per megawatt hour of electricity generated–*

*(I) within the metered boundaries of each **balancing authority**; and*

(II) for each pricing node.

…

(1) … the Administrator shall establish…a system to harmonize [the above] operating data on electricity generation with [EPA, other relevant Federal agencies, and states or regional credit registries]

(2) Outcomes.--The system established under paragraph (1) shall result in an integrated dataset that includes, for any given time--

…

*(B) where available, the **average and marginal greenhouse gas emissions** by megawatt hour of electricity generated within the metered boundaries of each **balancing authority**.*

(3) Real-time data dissemination.--To the maximum extent practicable, the system established under paragraph (1) shall disseminate data--

(A) on a real-time basis; and

(B) through an application programming interface that is publicly accessible.

Different metrics and different uses

- Average emissions rate: $\frac{total\ CO_2}{total\ MWh}$

  …in a chosen region and time interval
  - Production-based
  - Consumption-based

- Marginal emissions rate: $\frac{dCO_2}{dMWh}$

- Residual mix: $\frac{total\ CO_2}{total\ MWh - voluntary\ RE\ MWh}$

- Also, short-run versus long-run values of these metrics

- Varied uses, such as:
  - **Short-run Marginal Emissions**: timing flexible load
  - **Long-run Marginal Emissions**: siting data centers, procuring clean energy
  - **Average Emissions**: location-based accounting
  - **Residual Mix**: market-based emissions accounting

- *Important for EIA*: focus of IIJA seems to be short-run average and marginal

Marginal Emissions Rate Estimation Methodologies

- Major categories of methodologies
  - Dispatch-model approaches: explicit representation of dispatch used by system operators
  - Statistical/econometric approaches: e.g., infer emissions rate from data on how much emissions change when load changes
- Challenges:
  - Different assumptions in each
  - No “ground truth” is necessarily available to verify estimates
  - Some approaches may not scale easily to entire US (e.g., just regions with organized markets)

Table 2. Summary of Existing Methodologies for Estimating Operational Marginal Emissions Rates and Other Metrics

Organization	Approach	Temporal resolution	Data release lag	Geographic coverage	Geographic resolution
PJM	Economic dispatch model	5-minute	5-minute	PJM	Wholesale pricing node
ISO-NE	Economic dispatch model	5-minute, hourly	1–2 years	ISO-NE	Balancing authority
REsurety	Economic dispatch model	Hourly	60–90 days	ERCOT and PJM, (CAISO/WECC planned 2022)	Wholesale pricing node
electricityMap	Statistical and machine learning models	Hourly	Unknown/1 day	On-demand global	Balancing authority
WattTime	Statistical and machine learning models	5-minute	1 month/5-minute	Contiguous US, Canada (partial), more	Balancing authority
Singularity	Combined approaches	5-minute or 1 hour, by region	5-minute for ISO-provided, 1 day for other regions	Contiguous US, Canada (partial), 8 major ISOs	Balancing authority, some subregions

Table excludes Kevala which provides estimates of total carbon emissions by address at high frequency.

Outline of Report

- **Executive Summary: Summary of Findings and Recommendations**
- Introduction
- Metrics and Use Cases
- Evaluation of Existing Methods and Data
- Data Standardization
- Barriers for EIA to Reporting Residual Mix
- Potential Pathways for EIA
- Appendix

Findings

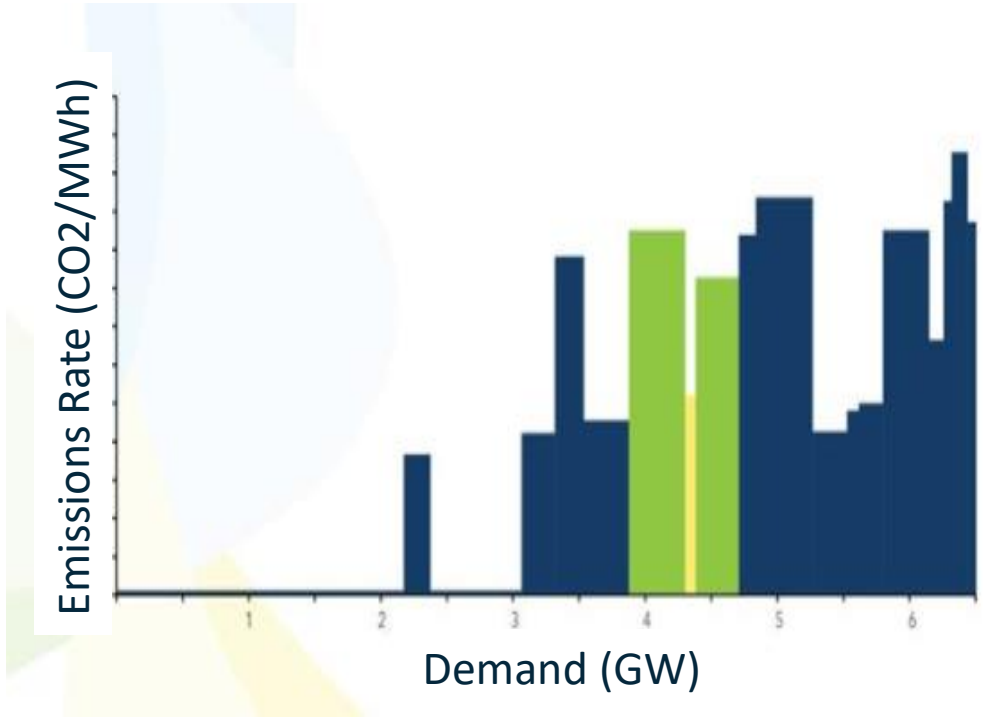
- The emissions metrics requested of EIA are relevant to both emissions accounting (mainly hourly average emissions rates) and near-term operating decisions (short-run, hourly marginal operating emissions, at the balancing authority or nodal level, and in “real time”).
- The primary approaches for calculating real-time operating marginal emissions rates are
  - (1) economic dispatch-based approaches
  - (2) statistical and machine learning models

Findings (cont'd)

- There are important tradeoffs between economic dispatch and statistical approaches to calculating marginal emissions rates.
  - Economic dispatch-based approaches reflect the algorithms used by grid operators and can yield granular nodal estimates, but they require access to detailed data often known only to grid operators.
  - Statistical approaches are more scalable to new regions because they rely primarily on publicly available data, but such approaches can struggle to produce reliable estimates at the very disaggregated nodal level.

Findings (cont'd)

- All emissions rate estimation methodologies are imperfect for one reason or another.
  - Estimates produced by economic dispatch-based approaches are only strictly valid for small changes in load (say, 1 MW or less). A change in load large enough to change which generator is marginal will lead to a different marginal emissions rate, and the magnitude and direction of this difference is not necessarily known.
  - Estimates produced by statistical models inevitably involve assumptions and approximations that also lead to imperfect estimates.



Source: WattTime

Findings (cont'd)

- Approaches yielding geographically and temporally detailed data require aggregation to create hourly estimates and estimates for BA or larger sub-BA regions
  - Geographic aggregation is necessary when transmission is constrained, and emissions rates are reported at the nodal level. Load weighting of emissions rates can yield aggregate values.
  - Temporal aggregation is necessary to create hourly values.
    - PJM presents five-minute values (does not aggregate)
    - ISO-NE uses both a time-based approach and a marginal load-based approach to weighting five-minute estimates to provide two different estimates of hourly marginal emissions rates.

Findings (cont'd)

- Providing information on the emissions rates for the residual mix is challenging for EIA in the near term because information on privately procured clean energy (outside the transactions directly involving the utilities from whom they typically collect information) is limited.

Recommendations

- Average emissions rates: EIA has a clear path forward for producing average emissions rates through an extension of the methodology underlying its recently released hourly national average emissions rate estimates.
  - In extending those methods to produce consumption-based average emissions rate estimates at the balancing authority (rather than national) level, EIA should account for interchange between regions, for example by using flow-tracing algorithms mentioned in this report.
  - Other improvements can be made on an ongoing basis, for example by using more regionally and temporally granular and representative estimated emissions factors.

Recommendations (cont'd)

- Marginal emissions rates: EIA has several options that we would endorse. Our preferred approach would be to request the data to be reported by the balancing authorities, from whom EIA routinely collects grid operating data in real time. PJM and ISO-NE are examples of a balancing authorities already producing marginal emissions estimates, and some other balancing authorities could also produce analogous estimates.
- Below are three potential approaches that a balancing authority could take, listed in order of preference, contingent on implementability, which may vary by balancing authority

  (i) Adopt a methodology similar to that of PJM and ISO-NE, which use economic dispatch algorithms to identify marginal generators

  (ii) Extend the balancing authority's existing methodologies that identify marginal sources of generation (e.g., MISO reports data on marginal fuel types) and then apply emissions factors. EIA could also do this kind of calculation in-house.

  (iii) Partner with existing data providers to develop such estimates (e.g., the model used by the California Self-Generation Incentive Program).

Recommendations (cont'd)

- Public Quantitative Comparison of Data and Methodologies: Some BAs will be unable to produce marginal emissions rate estimates right away; so, EIA may need to tap other data sources to be nationally comprehensive. Although some existing methods can produce geographically comprehensive estimates of marginal emissions rates for all BAs in the contiguous 48 states, public comparisons of their methodologies and estimates are lacking.
  - We recommend that an independent organization compile a comprehensive set of marginal emissions rate estimates and quantify their similarities and differences to assess their relative reliability.
  - This compilation and quantitative comparison would allow data users to better understand the differences among alternative estimates.
  - Such a comparison would also enable data providers and other analysts to improve, compare, validate, stress test, and harmonize their methods and data products.

Recommendations (cont'd)

- Pathway to Republishing Existing Data: Such a public quantitative comparison would inform EIA's task of providing marginal emissions rates in regions where BAs may not yet be able to produce the necessary data. With such a public data comparison in place, EIA could then consider publishing data provided by third-party organizations, such as those discussed in this report, while including clear and appropriate data definitions, descriptions, and caveats.

Recommendations (cont'd)

- Informing Research: If multiple approaches to estimating a particular emissions rate metric are available and deemed to be reliable, EIA should consider presenting more than one set of estimates so that data users and researchers can compare the various methods to understand their differences.
- Presenting multiple estimates for the same metric
  - should include clear definitions of the data, include caveats and note the underlying methodology (e.g., economics dispatch, statistical)
  - is valuable regardless of the entity presenting standardized estimates—be it EIA or an independent third party.

Recommendations (cont'd)

- Anticipate Data Standards: Entities—including balancing authorities, utilities, private companies, and government agencies—can work now to build flexibility into their data publishing systems so that they can more easily adapt those systems to any future data standards.
  - This is relevant both for data used as inputs to the estimation of emissions rates as well as for the publication of emissions rate estimates themselves.
  - EIA should consider making its emissions rates and other data conform, as applicable, to any future standard(s).

Recommendations (cont'd)

- Data Transparency: For emissions-rate data specifically, data publishers should be transparent and provide documentation for their metrics.
- Documentation and transparency ensure that data consumers have a clear understanding of what the data mean and how they should be used
- It also sets the stage for future, standardized data definitions that might look to both incorporate and differentiate the metrics provided by different entities.

Recommendations (cont'd)

- Residual Mix: As part of the IIJA's required data harmonization process, EIA should coordinate with EPA, including the Green Power Partnership that has expertise in voluntary renewable procurement, in anticipation of future demand for data on residual mix emissions rates.

Overview of Recommendations

1. **Average emissions rates**: extend existing methods to BA level
2. **Marginal emissions rates**: request from BAs, dispatch model where possible (ISOs like PJM/ISO-NE), fill in gaps with other methods where needed
3. **Public Quantitative Comparison of Data and Methodologies**: EIA may need to tap other data sources to be nationally comprehensive. The quality of alternative data sources should be vetted by an independent organization through a comprehensive comparison marginal emissions rate estimates.
4. **Pathway to Republishing Existing Data:** such public comparison would inform EIA's task extending estimates to more regions
5. **Informing Research:** if presenting multiple estimates, include clear data definitions
6. **Anticipate Data Standards:** build flexibility into data publishing systems to more easily adapt to future data standards.
7. **Data Transparency:** provide clear documentation and keep an eye on future standards
8. **Residual Mix:** coordinate with EPA Green Power Partnership