What GHG Accounting Data do States Need?

MEASURING GHG EMISSIONS REDUCTIONS IN THE ELECTRICITY SECTOR

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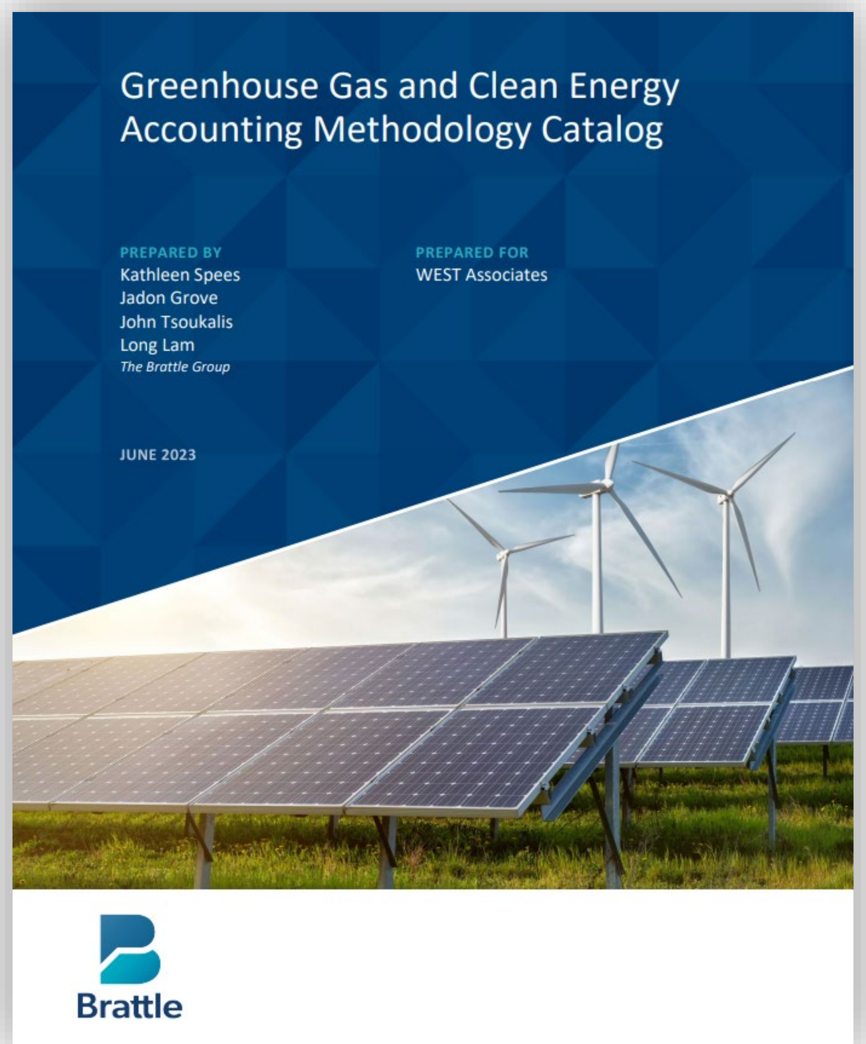
Brattle

How we do GHG accounting today

- Brattle developed a catalogue of GHG accounting practices in place today across the West (15 utilities, 13 states, 56+ different clean energy and GHG accounting programs)
- Observations:
  - No one does it the same way
  - No available system for tracking GHGs associated with trade across utility & state borders REC/CFE-based accounting does not match GHG accounting (100% RECs ≠ 100% clean electricity for most states)
  - Utilities, states, customers increasingly identify need to track GHG emissions and clean energy claims on a more granular basis (3 pillars: additionality, deliverability, 24x7 accounting)
  - RTO market dispatch does not match GHG accounting (and considers state policy requirements only to the extent they are reflected as explicit GHG price)
  - Utilities not sure how the definition of “100% clean electricity” will change as their states approach deep decarbonization (facing the dilemma that different definitions may dictate very different resource mix and costs)

What’s Missing: Multi-state GHG emissions tracking approach that is self-consistent with REC/CFE claims and RTO dispatch



See Full Catalog: West GHG Accounting Catalog

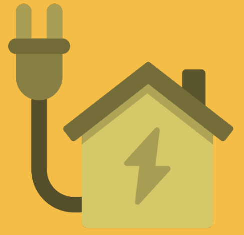
Refresher: Emissions scope reporting concepts in the GHG Protocol

Direct Responsibility

Scope 1: Direct GHG Emissions

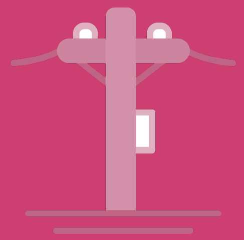
- Emissions from reporting entity's direct ownership and control
- **Example:** Generation owner reports direct power plant emissions

Shared Responsibility



Scope 2: GHGs from Electricity Consumed

- Emissions caused by reporting entity's electricity consumption
- **Example:** End-use customer reports estimated emissions from generators dispatched on their behalf



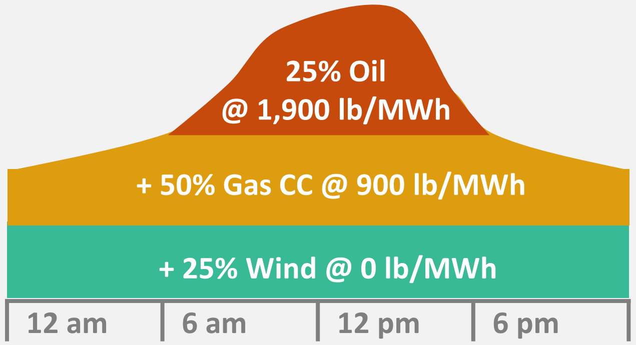
Scope 3: Indirect Upstream & Downstream

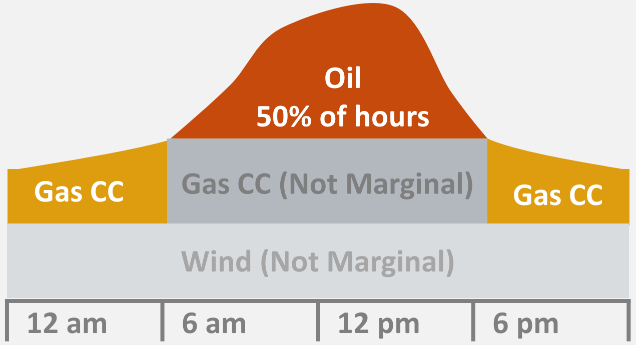
- Emissions caused by the reporting entity's activities, but created by sources under the direct control of another entity
- **Example:** Distribution-only utility reports emissions associated with electricity purchases that are later resold to customers

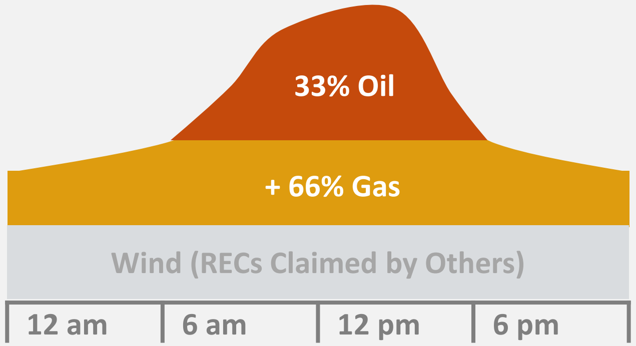
See overview of Scope 2 accounting concepts and references to primary sources in Chapter I West GHG Accounting Catalog

States & customers need at least three types of GHG data for different purposes

	Average Emissions	Marginal Emissions	Residual Grid Mix
What is it?	Average emissions of all generation	Emissions rate of the marginal generator (last or highest-cost MW turned on to serve demand)	Emissions rate of grid purchases, after subtracting out clean energy purchases claimed by others
Example	= 925 lbs/MWh over the day (up to 1,220 lb/MWh in peak hour)	= 1,400 lbs/MWh over the day (up to 1,900 lb/MWh in peak hour)	= 1,233 lbs/MWh over the day (up to 1,567 lb/MWh in peak hour)
How to use it?	• Track progress on total GHG emissions • Generation-based (where it comes from) for regulating in-state gen • Consumption-based (who it goes to) for measuring impact of consumption (including imports, minus exports), i.e. Scope 2 **location-based** method	• Measure GHG that can be avoided by a specific interventions (build renewable, pursue efficiency, operate a battery)	• Track progress on total GHG emissions, considering who pays for clean energy, i.e. Scope 2 **market-based** method • Goal is to enable self-consistent measurement of RECs (for 0% emissions power) and residual grid purchases (at residual mix rate), so that total GHG obligations equal total physical emissions







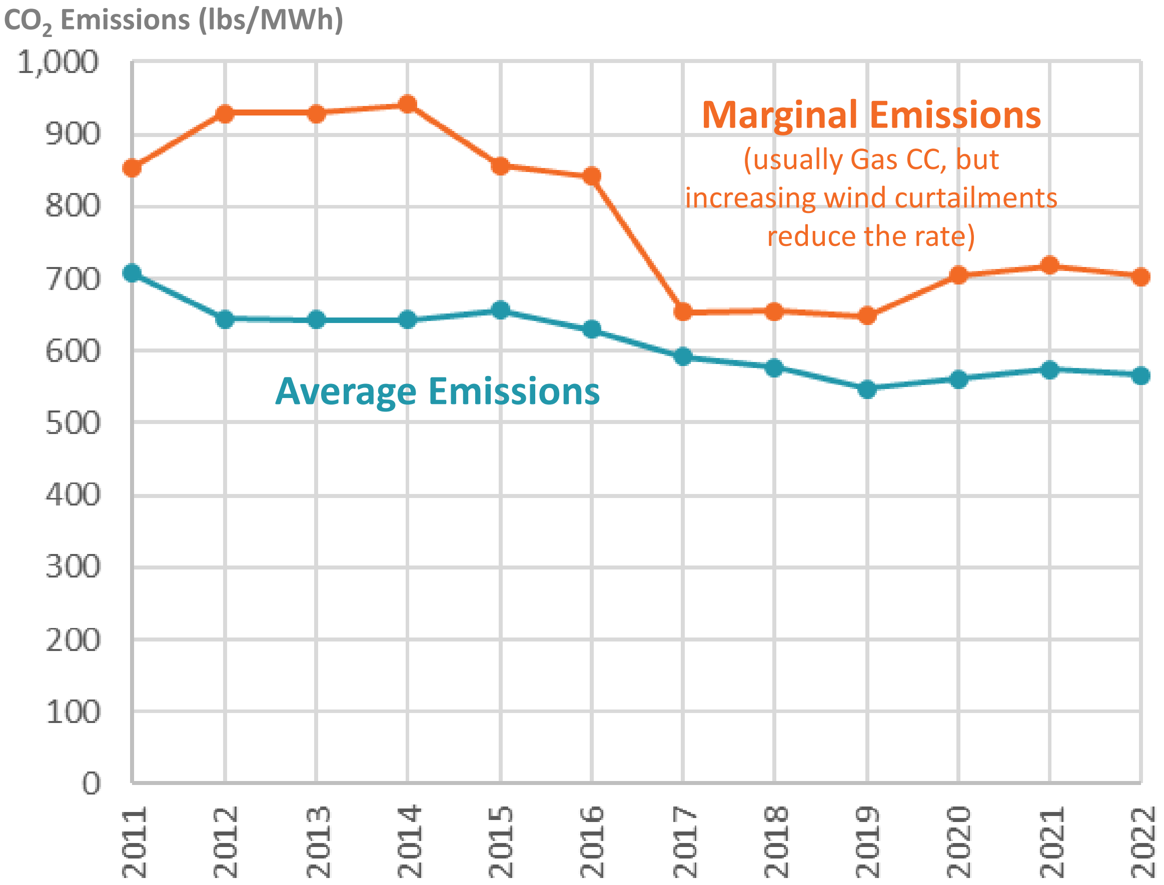
RTOs have started producing some (not all) of the GHG data states and customers need for developing policy & making decisions

Examples:

- **New England:** Marginal & average system-wide emissions rates (annual, monthly, on/off peak)
- **NYISO**: Coming soon: Average (2 state areas) and implied marginal (zonal) emissions rates (hourly)
- ✓ **MISO**: US-wide (BA level) hourly average emissions by gen type. Coming soon: Nodal, GHG flow tracing data
- ✓ **PJM:** Nodal, 5-min locational marginal emissions (plus annual aggregations of marginal and average)
- **CAISO:** 5-min average GHG data by resource type, including attributed to imports. GHG coordination group seeks to provide more data and market solutions for all states in the West
- **SPP Markets+:** GHG task force effort to support residual mix accounting & integrate into energy market dispatch

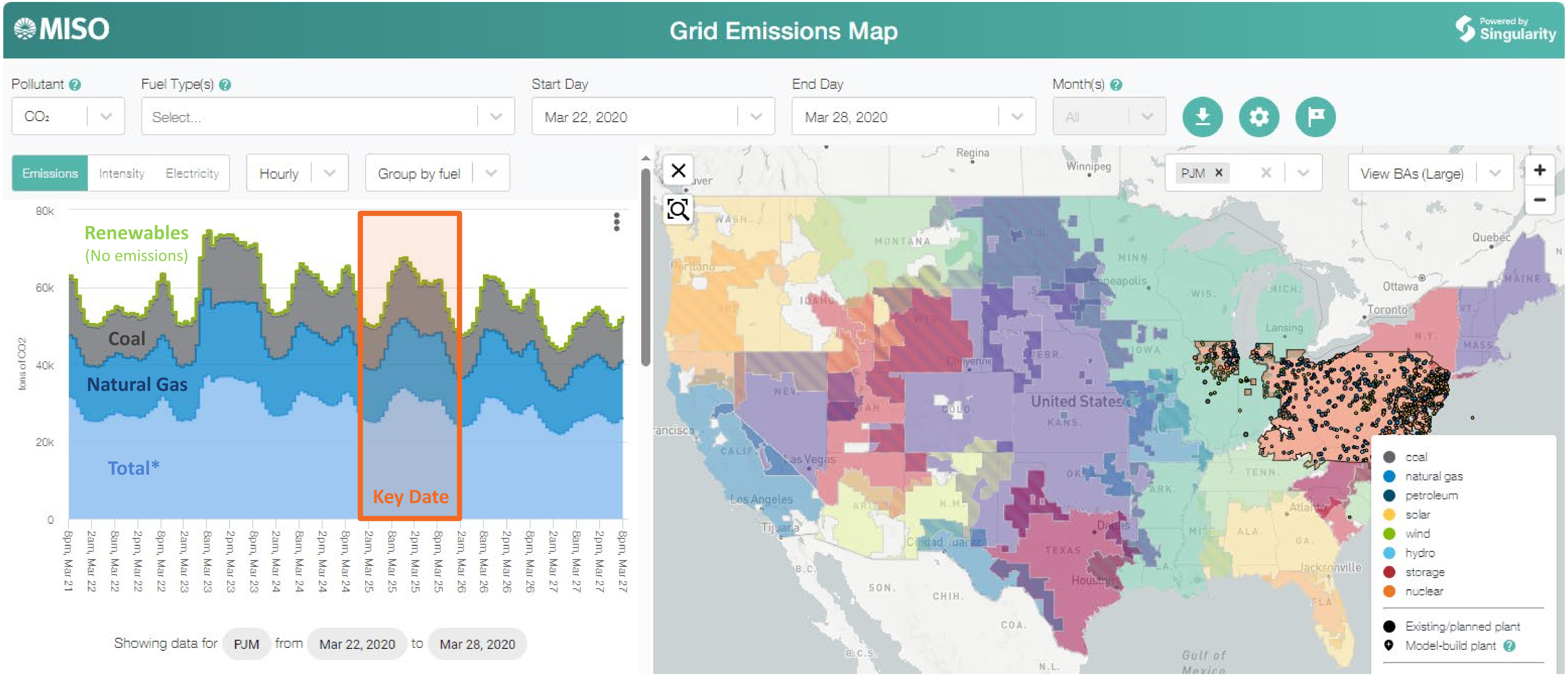
✓ **Deeper dive in upcoming slides**

NEW ENGLAND CO_2 EMISSIONS RATES



Source and notes: Data shown are system average emissions rate with imports, and time-weighted all-units locational marginal unit emissions rates. ISO-NE. Electric Generator Air Emissions Report.

MISO: Hourly GHG average data for all Balancing Areas



See MISO Grid Emissions Map. Developed by Singularity.
Data provided are average BA-wide hourly generation by type, CO2 emissions by fuel type, and intensity (time delay of ~1.5 years). Generation reporting only (no consumption-based data).
*Total is not additive to the emissions produced by fuel type.

MISO Coming Soon: Nodal GHG “Flow Tracing” Data

Illinois Commerce Commission’s Renewable Energy Access Plan requested that PJM and MISO begin providing complete GHG accounting data to support state policy:

- Average, marginal, residual mix (average flow-based data coming first)
- Nodal, 5-minute
- Aggregate to zone & state levels (account for all GHG imports & exports)
- Provide maps
- Provide data publicly and as close to real-time as possible to support decision-making and real-time operations

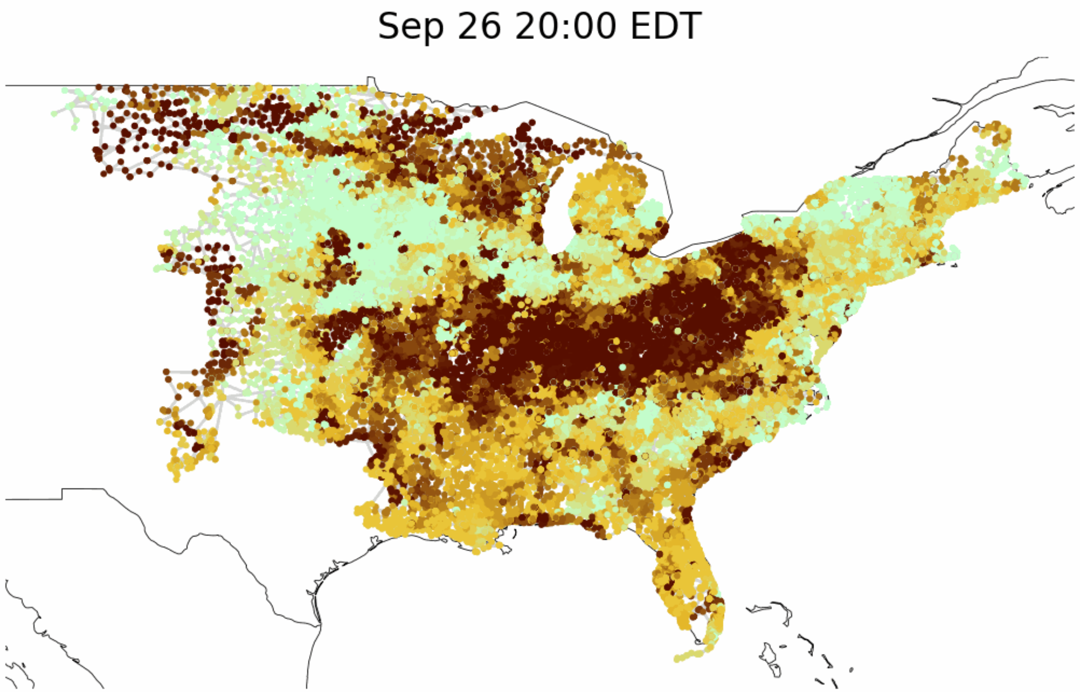
Method: First-of-a-kind nodal flow-tracing GHG data.

- Each 5-min interval, review MW injected to the grid & associated GHG rate
- Trace GHG emissions as they follow MW flows across all transmission lines through the system (flows data taaken from real-time dispatch)
- GHG emissions obligation is “deposited” with each MW of consumption withdrawal across the grid
- Resulting GHG emissions allocations to each customer node, with total system-wide allocations equal to system-wide generation emissions

Use Case: Nodal, 5-min equivalent of average, location-based Scope 2 accounting

Future: Method can be extended to residual mix accounting

SINGULARITY FLOW TRACING DEMONSTRATION



Source: Singularity (MISO’s GHG data vendor)

PJM: Nodal “Locational Marginal Emissions” Data

States have asked PJM to provide more GHG data. As of

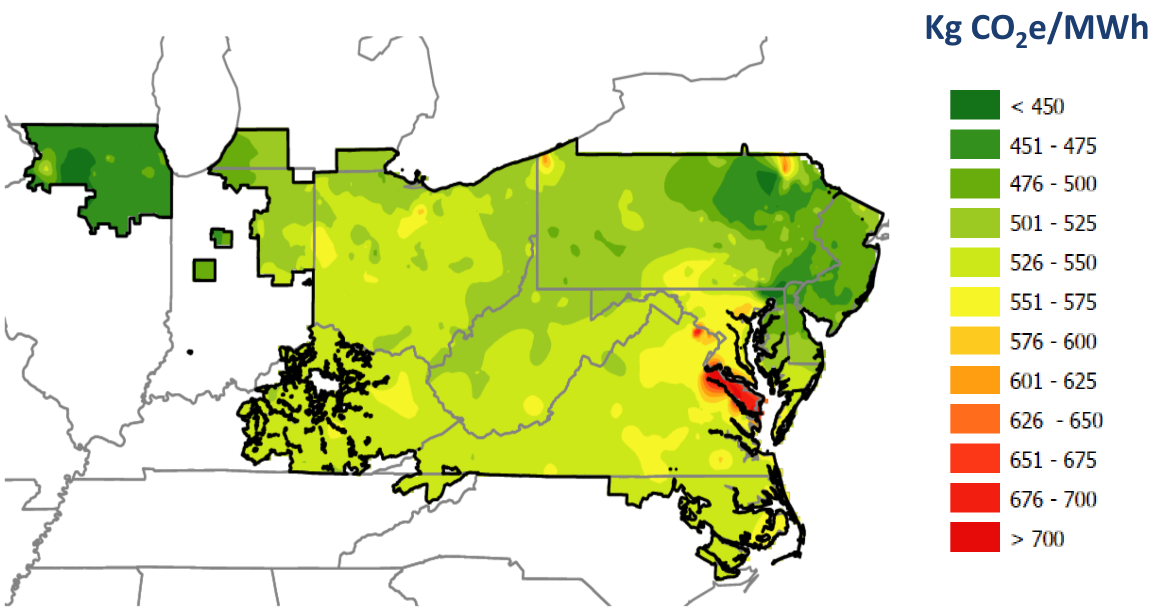
- PJM now publishes marginal emissions data in near-real-time (alongside publication of real-time locational marginal price (LMP)
- 5-minute granularity, published at load/demand nodes
- Marginal emissions rates (incremental emissions caused by last MW of demand consumption)

Method: Locational Marginal Emissions

- Each 5-min interval, run RTO dispatch and set LMP
- Identify, for each node, the “marginal resource” that set the LMP. This is assumed to be the marginal resource dispatched to provide energy to customers at that node (can be multiple plants, considering complex transmission constraints)
- Apply the emissions rate of the marginal resource to estimate the marginal GHG/MWh impact of consuming 1 MW more (or less) at each location

Use Case: Support decision-making on resource investments and operations to focus effort where and when it will displace the most GHG emissions

PJM ANNUAL AVERAGE LME (2022)



Source: Contour map developed using interpolation. Data from REsurety LME data product, derived from PJM Interconnection 5-minute, nodal LME data.

See PJM method primer on LME. Spees & REsurety: Locational Marginal Emissions discussion paper.

LMP = Locational marginal price
LME = Locational marginal emissions

Examples: Using Marginal Emissions for EV Charging

- **DC [Electrification Roadmap]: ** Focuses on key use cases for marginal emissions to drive GHG emissions:
  - EV fleet charging: 3-12% reduction in GHG emissions if charging relative to marginal emissions rate
  - Flexible buildings operations: 6.5% reduction in total building emissions reductions (48% reduction for flexible loads)
- **New Jersey:** Storage incentive program (policy goal is 2,000 MW by 2030). NJ BPU staff proposed incentive structure:
  - Partly fixed ($/kWh of installed)
  - Partly GHG "pay for performance" calculation derived from PJM marginal emissions rate data ($/ton avoided)
  - Net GHG impact measured as: (a) emissions *displaced* by MW injected, minus (b) emissions *caused* by charging

EV CHARGING "STANDARD" VS. "EMISSIONS OPTIMAL" CHARGING

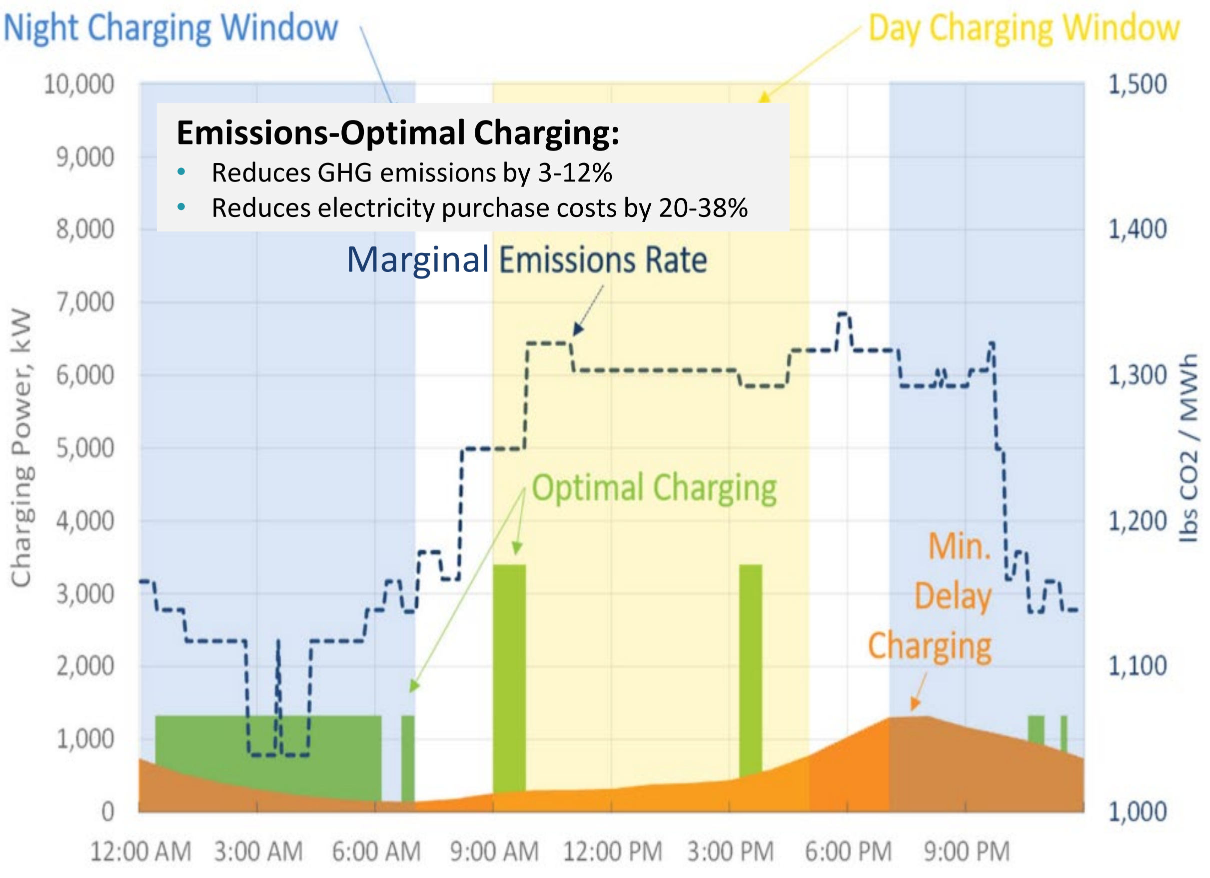
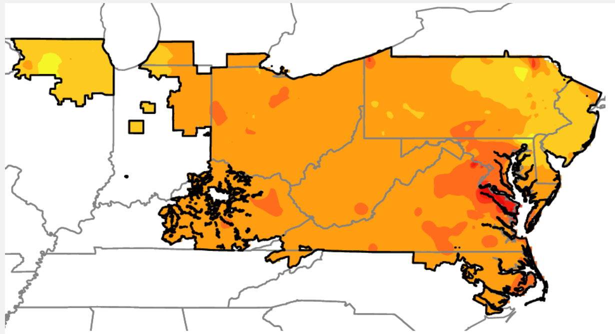
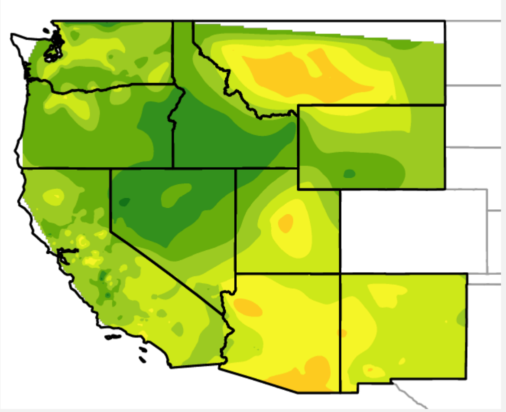
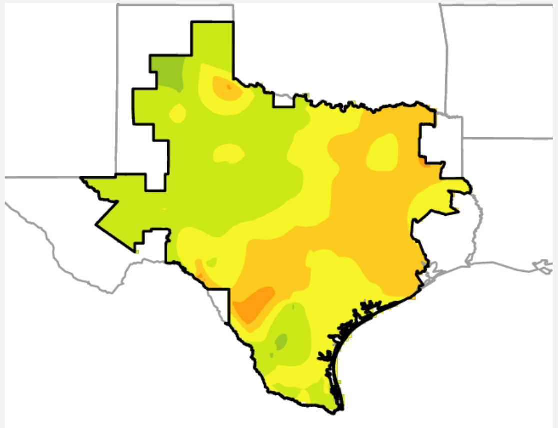
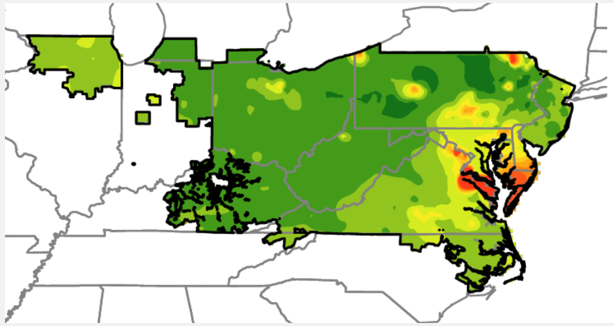
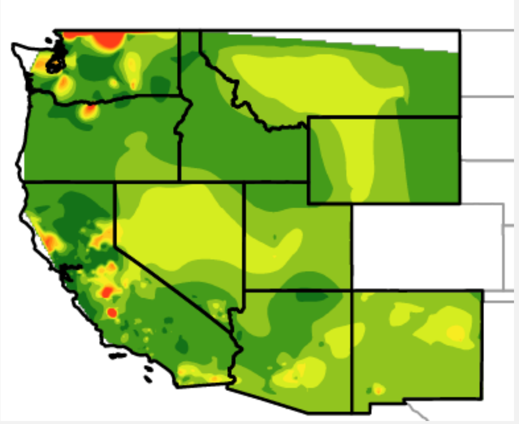
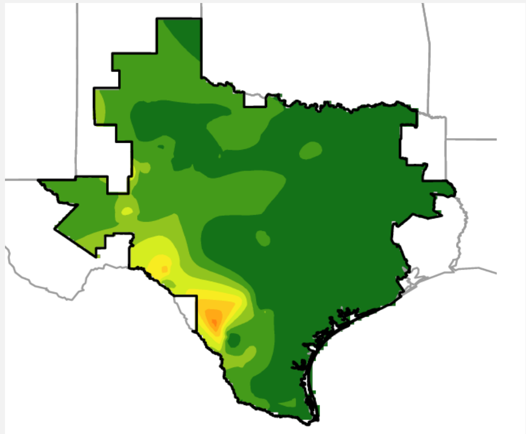
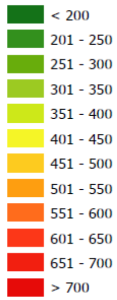


Figure source: District of Columbia Strategic Electrification Roadmap

Examples: Where do renewables & batteries displace the most GHG?

	PJM	West	ERCOT
Where to locate renewables? **Profile**: Flat production (can be renewable-profile adjusted)	Average MW Profile 	Average MW Profile 	Average MW Profile 
Where to locate batteries? **Profile:** Charge in lowest 4 LME hours daily (discharge in highest 4 LME hours)	4-Hour Battery Profile 	4-Hour Battery Profile 	4-Hour Battery Profile 

(kg CO_2/MWh)



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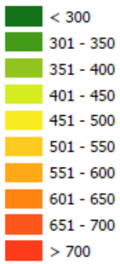

Source: *Hourly LME data not modified to account for renewable output profiles.
Data from REsurety LME data product, year 2022 data.

So what counts as 100% clean electricity?

It Could Mean (Not Mutually Exclusive):	State-Wide GHGs: Is it Really 100% Clean?	Do Tracking & Enforcement Mechanisms Exist?	What is the Cost?
100% Annual Clean Energy Supply Matching	Probably Not	Yes	Lowest
100% In-State Fossil Phase Out	Probably Not	Yes	High
Net Zero Emissions from Import/Export (time granular GHG tracking, emissions netted annually)	Yes (if all states use the same approach)	No	Low/Mid?
Strict Zero Emissions from Imports (time granular GHG tracking, no-GHG-imports enforced at all times)	Yes (likely net negative)	No	High
Cut the Wires: No Trade with Fossil Regions	Yes	Yes	Highest

What GHG accounting data do states need?

How hard is it?

- ✓ (green) Easy, status quo
- ✓ (yellow) Harder, but it's been done
- ✓ (orange) Hardest, new approaches needed

What states can do on their own

- ✓ (yellow) Clarify the definition of 100% clean (advanced definitions likely to be aspirational until data/markets become available)
- ✓ (green) Annual or monthly GHG and REC accounting
- ✓ (yellow) Hourly in-state, generation-based emissions accounting
- ✓ (orange) Define "next generation" RECs and policies (e.g. 24×7 measurement, LME-based)

What states need from RTOs or Balancing Authorities

- ✓ (green) System-wide generation- & consumption-based accounting (annual, monthly, hourly)
- ✓ (yellow) Hourly, nodal marginal emissions (e.g. PJM data)
- ✓ (yellow) Hourly, nodal consumption-based GHG (e.g. MISO, aka "GHG flow tracing")
- ✓ (yellow) Aggregations of hourly data to utility and state levels (to enable GHG import/export accounting)

What states can only do together

- ✓ (yellow) Regionally self-consistent GHG accounting and REC tracking (annual or monthly)
- ✓ (orange) With RTO/BAA: Nodal, hourly residual grid mix (regionally self-consistent with GHG and REC tracking)
- ✓ (orange) With RTO/BAA: Reflect state policy and customer preferences in real-time dispatch (market results self-consistent with GHG obligations)

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Her expertise focuses on environmental policy and wholesale electricity market design, economic analysis, and modeling. For RTO market operators she supports implementation and development of wholesale markets including energy, ancillary services, capacity, FTRs, clean energy attribute markets, and integration of emerging technologies. She supports regulators, NGOs, and utilities to develop GHG reduction policy alternatives, conduct impact analysis, conduct power sector and economy-wide modeling of GHG abatement pathways, and assess benefits/costs in the context of policy reforms for clean energy transition. For energy-intensive companies pursuing net zero commitments, Dr. Spees offers economic advice for designing internal GHG pricing and abatement incentive programs, estimating fleet-wide GHG abatement cost curves, identifying least-cost pathways to net zero, designing internal GHG pricing and incentive programs, and conducting due diligence analysis of GHG-abatement investments.

Dr. Spees earned her PhD in Engineering and Public Policy within the Carnegie Mellon Electricity Industry Center and her MS in Electrical and Computer Engineering from Carnegie Mellon University. She earned her BS in Physics and Mechanical Engineering from Iowa State University.