Renewable Energy Purchasing Guidance Quantitative Appendix and Pilot

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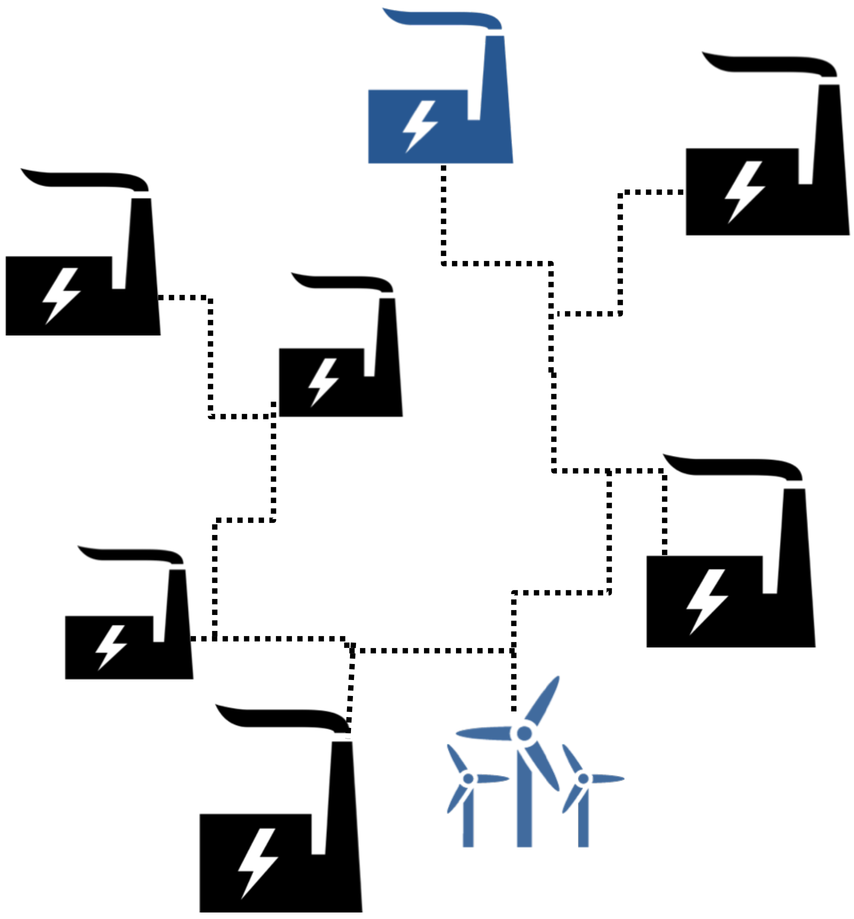
Meister Consultants Group
Boston Green Ribbon Commission
Harvard Office for Sustainability
WattTime

About WattTime

- New tech nonprofit spinning out of UC Berkeley
- Started with students at Berkeley, MIT, Stanford, Williams
- + 200 technical volunteers from Google, WRI, DOE…
- Now we help shift energy to cleaner times (and places)

Context: breakthroughs in emissions measurement



- Data and algorithms to measure renewable energy impacts have improved dramatically over the past 5 years
- Over a dozen journal articles
- Upgraded data from EPA
- WRI/Google's PowerWatch database
- WattTime project

Outline of Presentation

- Introduction & Purpose
- Section 1 – Methods of Calculating Renewable Energy Impact
  - Overview of different methods
  - Differences in GHG calculations between methods
  - GHG impacts of different projects
  - Health impacts and academic considerations
  - When to use different methods
- Section 2 – Methods of Reducing Emissions Through Timing

Method A: Carbon Footprint Emissions Accounting

- Main standard is the Greenhouse Gas Protocol.
- Voluntary standard, but complying institutions *must* apply method A
- Does **not** directly measure emissions reduced/avoided; instead provides rules for emissions a university is "responsible for".
- Electricity consumed is multiplied by an average emissions factor for electricity in the given location.
- The method indirectly assigns **equal weight to all megawatt-hours of generation** regardless of quality or location.

Method B: Avoided Emissions Supplemental Calculation

- Also part of the GHGP, is an optional additional calculation
- **Directly quantifies the emissions impacts** of RE
- Methodology key steps:
  1) Identify a baseline of what power plant(s) would generate electricity if the project did **not** occur.
  2) Estimate or determine the amount of electricity generated.
  3) Multiply that electricity by relevant **marginal** emissions factors.
- Projects must 1) be **additional**; and 2) **not** occur in a region with an emissions trading program.
- Applicable to all RE, but most commonly applied to offsite

Method C: Carbon Offset Accounting

- No single dominant protocol; instead many protocols, and multiple calculation methodologies within each.
- All use very similar fundamental logic, slight differences details of these calculations.
- Key difference from avoided emissions is how to test for additionality.
  - Carbon offset frameworks have strict, binding tests: essentially, show the project wouldn't exist without the offset purchase.
  - This **typically** rules out projects in regions with emissions trading
- Some renewable energy (not carbon claims) require RECs, i.e. the footprinting method

Subsection A: Differences in calculations between methods

GHG emissions reduced/avoided according to different accounting frameworks (in pounds CO2 equivalent per MWh of renewable energy generated)

Accounting framework	Carbon Footprinting	Avoided Emissions	Carbon Offset
Local (Massachusetts) wind farm caused by your purchase	578	0	0
Local (Massachusetts) wind farm not cause by your purchase	578	0	0
Nonlocal (Texas) wind farm caused by your purchase	578	1,265	1,265
Nonlocal (Texas) wind farm not caused by your purchase	578	1,265	0

» Carbon footprinting treats all projects equally

» Other methods measure higher impacts for additional projects, but treat non-additional projects as 0

» Carbon footprinting and avoided emissions typically agree

Subsection B: GHG impacts of different projects

GHG emissions reduced/avoided according to location
(in pounds CO2 equivalent per MWh of renewable energy generated)

	Avoided Emissions Method (wind)	Avoided Emissions Method (solar)
ISO-NE (New England)	803	791
ERCOT (Texas)	1,265	1,278
PJM (MidAtlantic)	2,176	2,187
MPCO (Montana)	2,054	2,050
NPPD (Nebraska)	1,914	1,916
SECI (Kansas)	1,866	1,881
MISO (Midwest)	1,707	1,718

- Avoided emissions and carbon offset methods: results by location
- Emissions avoided higher almost anywhere *except* New England
- Almost 3x the impacts in certain regions (where coal is marginal)
- Wind and solar surprisingly similar

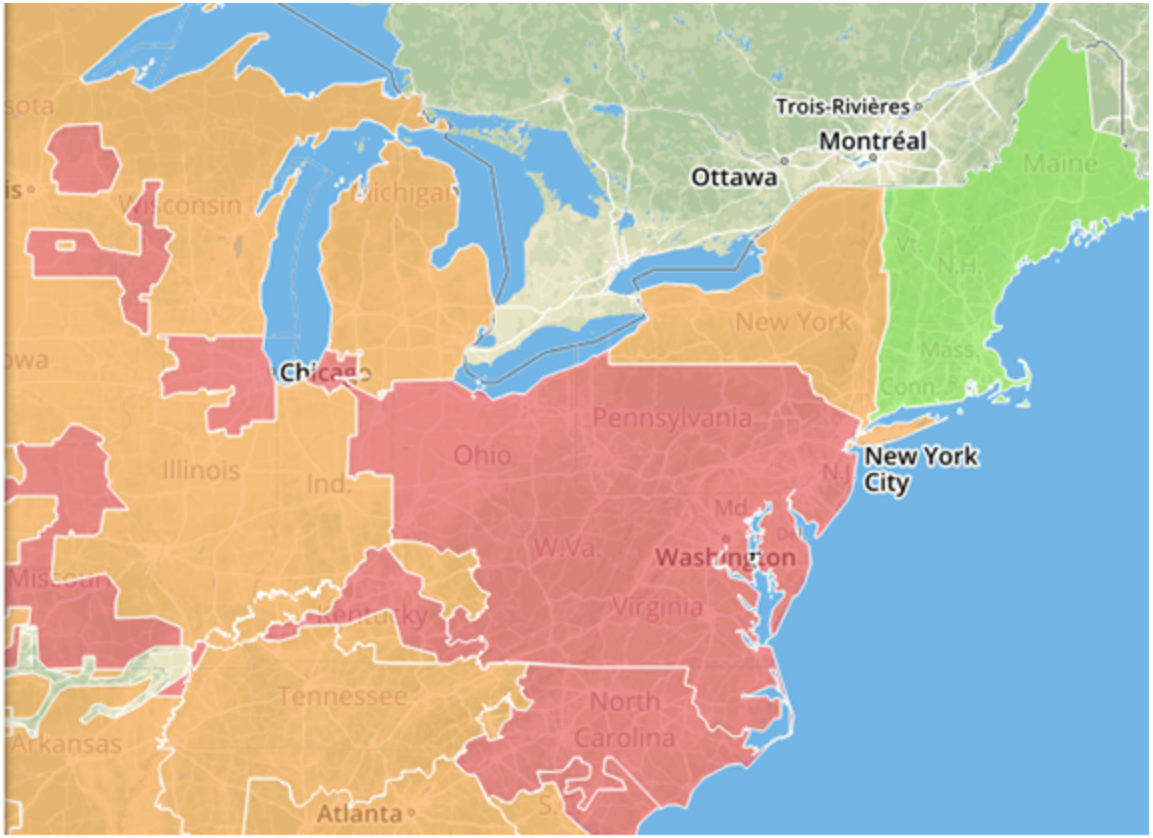
Renewable Energy Measurement Pilots

- Results presented are for a hypothetical typical project
- Able to measure specific GRC member projects
- Consider:
  - All three impact measurement techniques
  - Location-specific, time-specific emissions factors
  - Weather, production forecasts
- Just need to know project type, size, location

Visual representation of avoided emissions by region

Grid regions are colored by the current value of the marginal carbon emissions in that region.

Cleaner	0-1000 lb CO_2/MWh
Dirtier	1000–1800 lb CO_2/MWh
Dirtiest	1800–2200+ lb CO_2/MWh



Additional factors examined

- Health impacts
  - No generally accepted methodology exists
  - SO_2 and NO_X emissions generally correlated with GHG emissions
  - Exceptions, e.g. Duke Energy (North Carolina) reduces much SO_2, little NO_X
  - Plant-by-plant differences much greater due to control technology
- Discussion of context in the literature
  - Remarkable academic consensus across a dozen articles
  - Generally most consistent with avoided emissions method
  - Some differences: ignores build margin effects, additionality, emissions trading

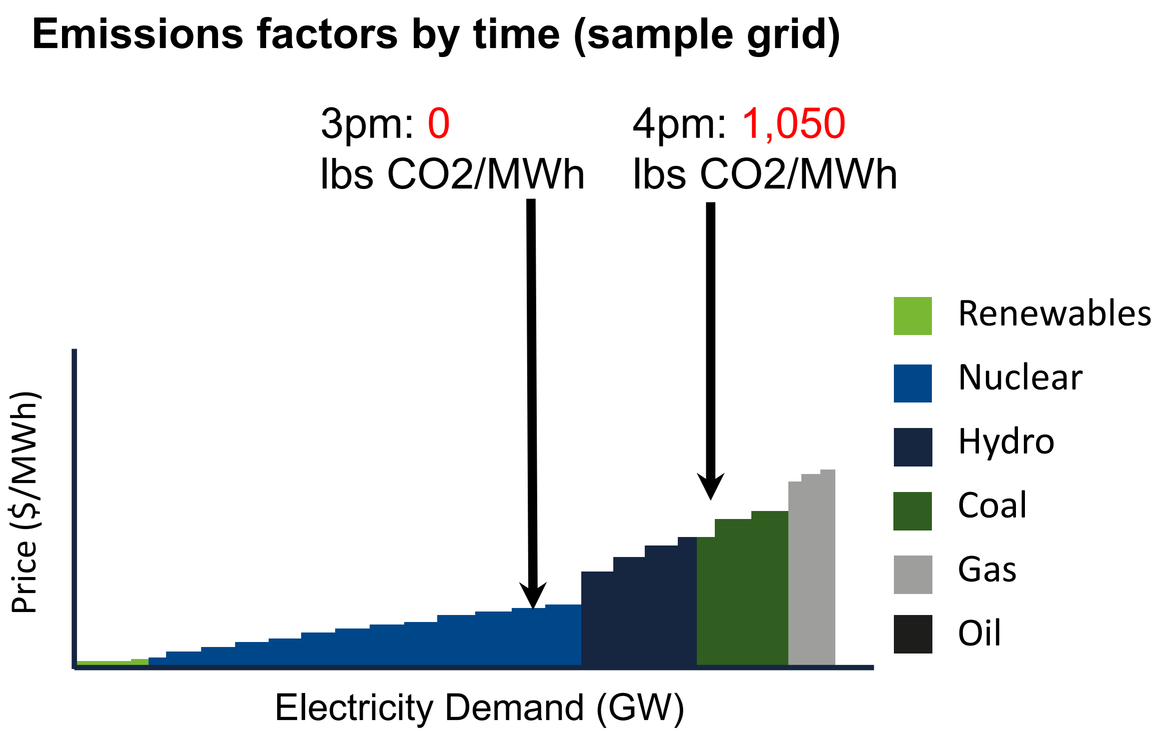
Which method should schools use?

- Three methods to quantify emissions impacts of RE
  - Carbon footprinting, avoided emissions, offsets
- Not mutually exclusive
- Accuracy
  - Project-level accuracy: avoided emissions, carbon offsets
  - Inventory-level accuracy: footprinting
- Additional factors on which to choose
  - Impact: Avoided emissions and offsets incentivize higher-impact projects
  - Eligibility: New England projects typically only eligible for footprinting
  - Administrative complexity: Offset projects have stricter quality criteria
- Recommendation: consider common GRC-level guidance

Energy Timing Pilots

- Background: emissions factors vary over time
- Automated Emissions Reduction (AER) technology
- Pilot opportunities for GRC members

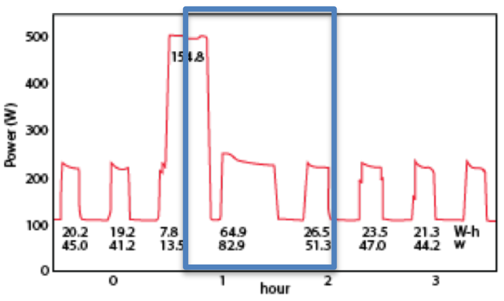
Emissions factors vary throughout the day

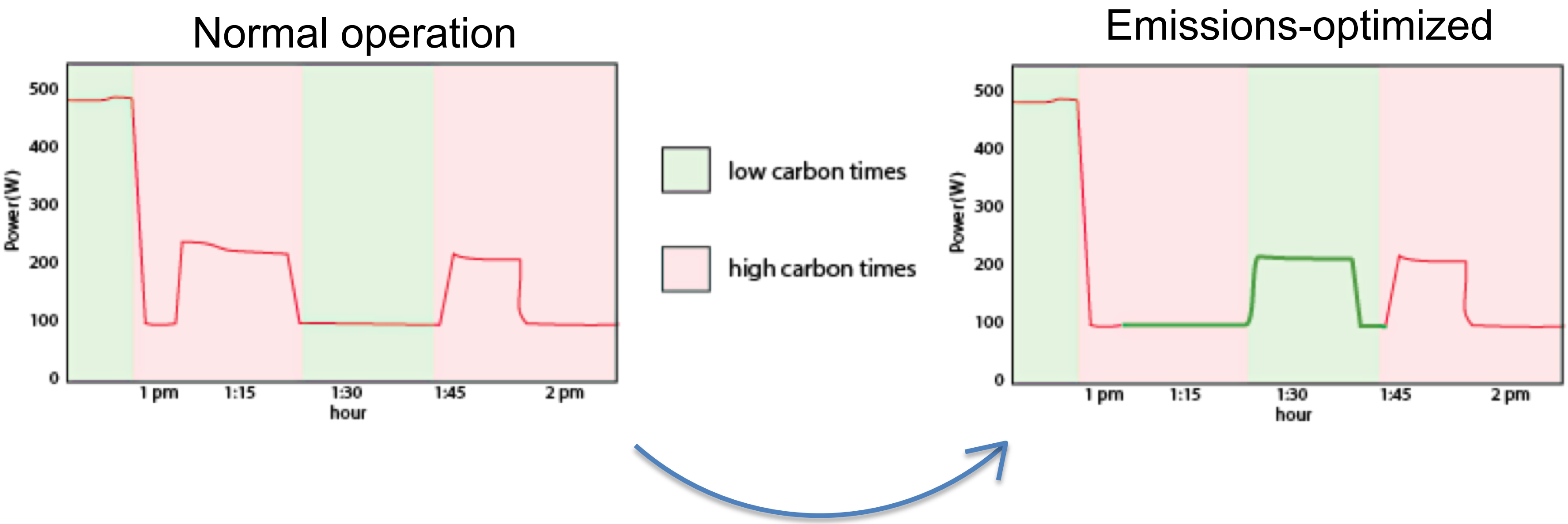


Reducing emissions through timing

- Much electricity use is at least partially flexible in time
- E.g. devices with compressor cycles can sync cycles to cleaner moments

Example: fridge cycles





Automated Emissions Reduction (AER) software

AER is embedded in a growing number of devices

Companies supporting AER today

artisenergy™
Advanced Microgrid Solutions
eMotorWerks SMART [GRID] EV CHARGING
THG
ENERGATE interactive energy management solutions

Building now

Microsoft
Nest
GE
Whirlpool
Tesla (cars)
Ecobee
Honeywell
+12 others

Likely available 2019

Stem
Demand Energy
Tesla (batteries)
EnerNOC
+ 4 others

Piloting AER

Three ways to pilot AER

BMS	Integrate your HVAC, etc directly with your BMS (e.g. Princeton does this with Microsoft)
Load controllers	Add load controllers directly to devices that do not access your network (e.g. Berkeley does this with Building Clouds)
DR	Layer on top of DR programs (e.g. UC Merced does this with THG)

Free to all GRC members

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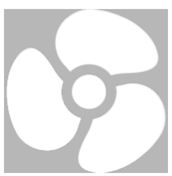
Appendix: How AER works

Grid operators constantly update power plant output levels

Cloud-based server continuously monitors power grids to determine CO_2 emissions per KWh in any area



Keep all DR, cost and comfort settings exactly the same, but *within* those constraints sync cycles to cleaner times

Users get to know they selected which power plants to use, we can verify the change & CO_2 savings

Appendix: Key Data Sources

- Power plant pollution data from US EPA Continuous Emissions Monitoring System (CEMS) or local equivalent
- Matched with real-time power market data from Independent System Operators (ISOs) or local equivalent
- Algorithms developed by UC Berkeley PhD students