QCoefficient
Turning Buildings into Batteries™

Proposed Rules Regarding Local Law No. 97
Comments by QCoefficient, Inc.

November 13, 2022

EXECUTIVE SUMMARY

The QCo Team commends the NYC Department of Buildings staff for its extensive analysis and efforts to advance implementation of Local Law No. 97 ("LL97") and to reduce GHG and carbon emissions associated with energy use in NYC buildings.

The proposed rules indicate Herculean efforts to estimate emissions reductions from energy consumption reductions and market prices, given that ideal data does not exist in the public domain. However, the signals from these estimates do not provide efficient signals. In fact, they send signals that will slow carbon reduction, distort investments, and increase its expense.

The QCo Team believes strongly in the value of a TOU marginal emission rate. The Team recommends accelerated development of a NYISO TOU hourly marginal emissions rate forecast – for demonstration and use in 2024. The comments herein are offered in support of such an accelerated TOU rate development. The goal of these comments is to show that a sound TOU rate reveals and helps achieve significant emissions reduction opportunities. These comments also provide guidance on emissions rate design – in part based on experience developing comparable rules for electric generating plant SO2 and NOx compliance pursuant to the 1992 Clean Air Act Amendments.

In 2019, the QCo Team successfully deployed EMeister MPC in a large (1+ million square foot) commercial office building in Manhattan – in collaboration with an expert NYC building management company. The Team achieved significant electric energy, expense and emissions reductions – as summarized in attachment A. During the Covid pandemic, the Team, with support from the Solar Energy Technology Office of the U.S. Department of Energy, built on this success by expanding its EMeister MPC technology:

- To operate large commercial building HVAC systems in a manner that reduces NYC carbon emissions consistent with Local Law 97 ("LL97");
- To both take advantage and improve the effectiveness of increasingly greater amounts of zero carbon renewable energy, consistent with the Climate Leadership and Community Protection Act; and
- To examine how strategic application of EMeister MPC and distributed photovoltaics (PV) – at scale in NYC – could reduce NYISO security-constrained unit commitment of Brooklyn fossil fuel-fired electric generation for local reductions of carbon and other emissions far in excess of the percentage building energy reductions.

The QCo Team would be happy to explain this potential in public hearings or in closed meetings with NYC government, with newspaper editorial boards, or with other interested parties.

QCo reduced HVAC electric energy use by 20 percent, peak by 30 percent and expense by 25 percent in a building that was already highly efficient and expertly operated – and certified as a

LEED Gold building. With the benefit of a NYISO-designed hourly carbon emission rate forecast, the Team estimates that it also could reduce associated carbon and other local emissions by 90% (relative to the LL97 baseline). In partnership with NYC energy service companies, there are several hundred million square feet of large NYC commercial buildings in which to deploy EMeister MPC – with comparable emissions reduction success.

Perspective: EMeister MPC

EMeister model predictive control ("MPC") is the product of a multi-year collaboration of QCoefficient, Inc. electric system experts – electric markets, operations, emissions and regulation – and university commercial building experts – the University of Colorado Boulder, the Penn State University, and recently the Illinois Institute of Technology. (Collectively, the "QCo Team" or "Team".)

At the core, EMeister MPC is a SaaS platform that combines breakthroughs in building energy modeling and model predictive control to harness the drywall and concrete in large commercial buildings as a grid-scale thermal energy storage medium. EMeister MPC storage outperforms all other forms of energy storage … better efficiency, no capital expense, no space requirement, no equipment, and no permitting.

The technology has been developed and proved in several large commercial office buildings in Chicago and now New York City (Attachment A). Based on this success, QCo gained commitments to expand into 10 million square feet of Manhattan commercial office space for the summer of 2020. Then Covid-19 hit. All project commitments were voided. QCo is now re-connecting and restarting NYC deployment through local scale channel partners.

QCo's initial success led to a 2019-2022 $1+ million STTR award from the Solar Energy Technology Office of the U.S. Department of Energy that expanded EMeister MPC to enable portfolios of large NYC commercial buildings to meet and take advantage of the challenges and opportunities presented by LL97 and the CLCPA.

Comments and Recommended Improvements

First, carbon emission rates for electricity need to be the marginal hourly emission rates actually experienced on the grid for New York City (NYC). The QCo Team recommends development and demonstration of a robust methodology for use in 2024.

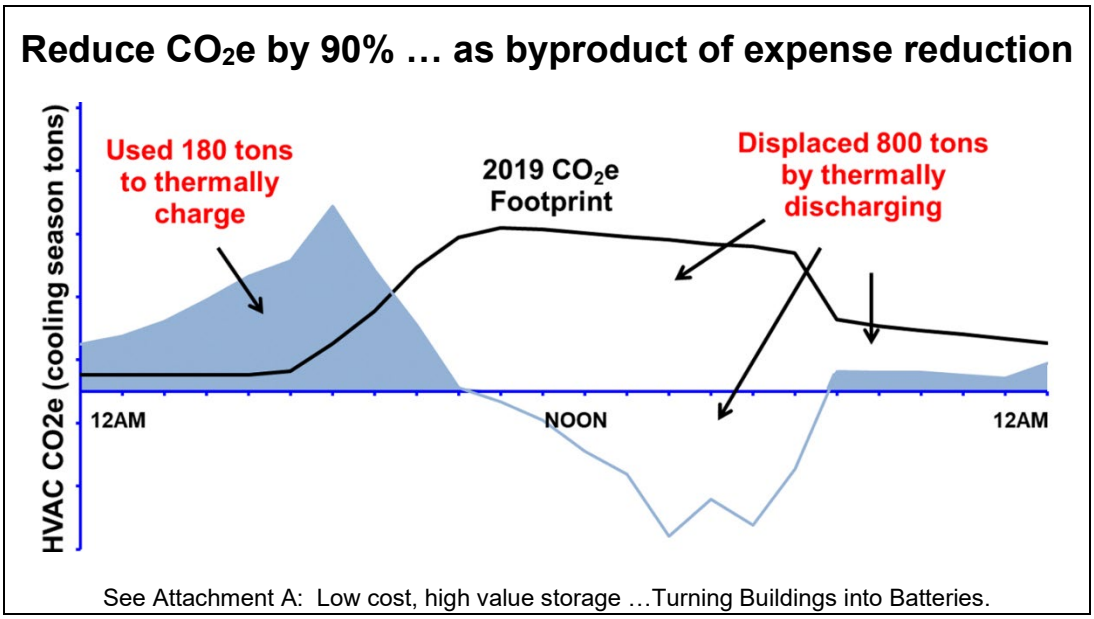
(Section 28-320.3.1.1 of the Administrative Code states that the TOU option is available commencing in 2024. The proposed rules create that option starting in 2030.)

A robust methodology is the short-term priority because:

- Large commercial buildings have tremendous untapped operating flexibility that can only be encouraged and harnessed with time-differentiated carbon emission rates.

  As an example, QCo's EMeister model predictive control (MPC) technology achieved such flexibility in several very large and prominent Chicago and New York City commercial office buildings. (https://smartgrid.ieee.org/bulletins/march-2022/important-post-covid-opportunity-for-smart-grid-photovoltaic-and-building-grid-integration-to-jump-start-decarbonization-in-new-york-city-and-other-urban-centers and https://www.buildingsasbatteries.com/use-cases) EMeister MPC optimized daily HVAC operations against location-based marginal price ("LBMP") and other grid signals – substantially reducing energy use and carbon emissions as a byproduct of reducing cooling season electric expense. Regardless of LL97, EMeister MPC would have easily and inexpensively achieved greater carbon emissions reduction had

it also been guided by time-differentiated carbon emission rates. It is already capable of doing so – all that is missing is the emission rates.



See Attachment A: Low cost, high value storage …Turning Buildings into Batteries.

Large commercial building owners and operators have the sophistication and expertise to operate their buildings to hourly emission rates. This is no different than operating buildings to hourly locational-based marginal prices ("LBMP") – something that EMeister MPC has been successfully doing for over a decade. Buildings have the flexibility to operate both to LBMP and hourly carbon emission rates.

- Second best rates drive second best performance, technology, and innovation.

  The proposed default method – a single, flat carbon emission rate – is the worst form of a "second best rate". This is especially true as the NYC grid transitions to intermittent renewable energy – it becomes much more important that consumers know when best to use grid electricity and when best not to use grid electricity.

  Most storage technology – especially batteries (<< 100% electrical efficiency) and traditional "active" thermal energy storage (~100% electrical efficiency) – require time-differentiated carbon emission rates. EMeister MPC is "passive" thermal energy storage (>> 100% electrical efficiency) – it does not depend on time-differentiated carbon emission rates but is designed to take great advantage of such emission rates.

- Second best rates introduce obsolescence risk and so discourage investment.

  LL97 carbon emission rates are driving significant and long-lived commercial building investment and operating decisions. Getting it right up front – with confidence – will encourage investment and will enable financial risk management.

Second, hourly marginal carbon emission rates can be confidently forecast by the New York Independent Operator (NYISO).

- NYISO has all the information needed to provide an hourly day-ahead or week-ahead forecast, as a byproduct of its day-ahead and real-time electric markets.
- NYISO and its members have experience – they have embedded SO_2 and NO_x emission rates in their markets since the 1992 Clean Air Act Amendments.
- NYISO can expertly identify the right marginal emission rate for LL97 – differentiating amongst NYC generators dispatched for load, operating reserves, or morning ramp.
- NYISO generation traditionally follows load – determining marginal cost and marginal emission rates is intuitive. However, going forward NYISO generation will also serve to complement intermittent renewables. That is, distinguishing the marginal emission rate to serve loadd will become more complex.
- To that end, QCo is initiating discussion with NYISO, the U.S. Department of Energy and the Federal Energy Regulatory Commission.

Third, the largest emissions reduction opportunity for NYC – now and in the future – is that associated with local NYC generation subject to security-constrained unit commitment {"SCUC").

- The marginal SCUC generation must be physically and inefficiently operated overnight, though typically needed to provide reliability and economy to NYC for peak hours on just a couple of days each week. Targeting that marginal generating plant in the day-ahead market – every week – achieves carbon and other emission reductions that are a multiple of that targeted in either the proposed single or TOU emission rates proposed by these draft rules. The Team knows this because its principals have held leadership roles in the electric systems markets and operations and in development of the EPA regulations governing generating plants pursuant to the 1992 Clean Air Act Amendments.

  References

  QCoefficient, Inc., December 2020. "An analysis of New York's Summer 2019 fossil-fueled electric generation demonstrates that NYC commercial office buildings can dramatically reduce carbon emissions." https://www.buildingsasbatteries.com/carbon-reduction.

  For a NYISO description of security-constrained unit commitment, see (https://www.nyiso.com/documents/20142/2923301/dayahd_schd_mnl.pdf/0024bc71-4dd9-fa80-a816-f9f3e26ea53a)

- Especially important to NYC underserved communities, displacing that marginal generator each week provides the best opportunity for displacing local NYC carbon, SO_2 and NO_x emissions at scale. NYISO can define and quantify that opportunity each week.

Fourth, NYISO should develop a methodology as soon as possible. The interim proposed TOU emission rate methodology should be abandoned.

See attachment B: Technical Review of Proposed Emission Rate Method dated November 12, 2022.

- Most importantly, the methodologies for calculating and accounting for hourly marginal carbon emission rates should be so attractive, straight-forward and low-risk that buildings will uniformly prefer to adopt them. The method proposed in the draft rules is not.

From experience the Team knows that, as the electric industry and its regulators embraced retail electric deregulation, the industry regressed from utility time-of-use rates to simpler deregulated flat electric rates. Absent an attractive hourly marginal carbon emission rate methodology, NYC buildings will likely adopt the proposed simpler annual carbon emission rate offered as the default method.

To make hourly marginal carbon emission rates more attractive, mitigate emission rate risk. For example, remove oil-fired generation from these rules – there are better ways and reasons to eliminate/mitigate oil-fired emissions from grid operations. As an example, to avoid similar financial risk, building owners opt for a single electric rate; that is, LBMP or TOU electric rates otherwise impose price risk on the building owner and its tenants. A properly-designed TOU emission rate method can largely eliminate "rate" risk.

- With more and more renewable energy, LBMP becomes an increasingly important signal communicating dynamic supply/demand conditions. Going forward, the City and State want buildings that contract for LBMP-based electricity and that operate to LBMP. Any carbon emission rate methodology must complement LBMP. Certainly, a flat emission rate does not.
- The Team understands that the TOU emission rate methodology proposed in the draft rules is interim, that it is important to start with something. However, based on our necessarily brief review during the comment period, the QCo Team recommends that it be abandoned. The Team has many concerns, both principled and mathematical.

  For a detailed critique, see Attachment B.

  In our significant experience, LBMP is a crude surrogate for carbon emission rates – but only on peak days and so only for 10% of the annual hours. Moreover, since weather and LBMP and emission rates are correlated, the proposed 8760-hour average of historical implied heat rate appears volatile as a function of historical weather times emission rates – for example, a hotter than normal summer with accompanying higher than normal emission rates could bias the baseline implied heat rate calculation for the following nine months.

Fifth, the electric utility industry and its regulators adopted several practical measures in the 1992 Clean Air Amendment ("CAA") regulations, some of which may apply to LL97:

1. As with electric generating plants, buildings make annual plans and budgets based on averages and expectations, for example, regarding weather, occupancy, equipment downtime, utility/ISO demand response events, seasonal and hourly electric price patterns, etc. In practice, "average" years do not occur – again, see attachment B.

   The CAA adopted emissions banking to manage year-to-year weather risk; and introduced portfolio compliance to manage diversifiable risks.

   (As an aside, for operations and investment decisions, the building industry typically uses building energy models that assume TMY or typical-meteorology-years weather data. Going forward, TMY does not suffice. By contrast, to capture the correlation among weather, LBMP and emission rates, the QCo Team uses actual historical hourly data for all studies and analyses for all three variables.

2. As with electric generating plants, building capital improvements are expensive, long-lived and lumpy (not incremental). Moreover, as recognized by federal, state, and utility energy efficiency financing programs, major retrofits make economic sense for some building assets, minor retrofits for others. Again, the 1992 CAA regulations maintained such efficient capital budgeting by adopting emissions banking and portfolio compliance.

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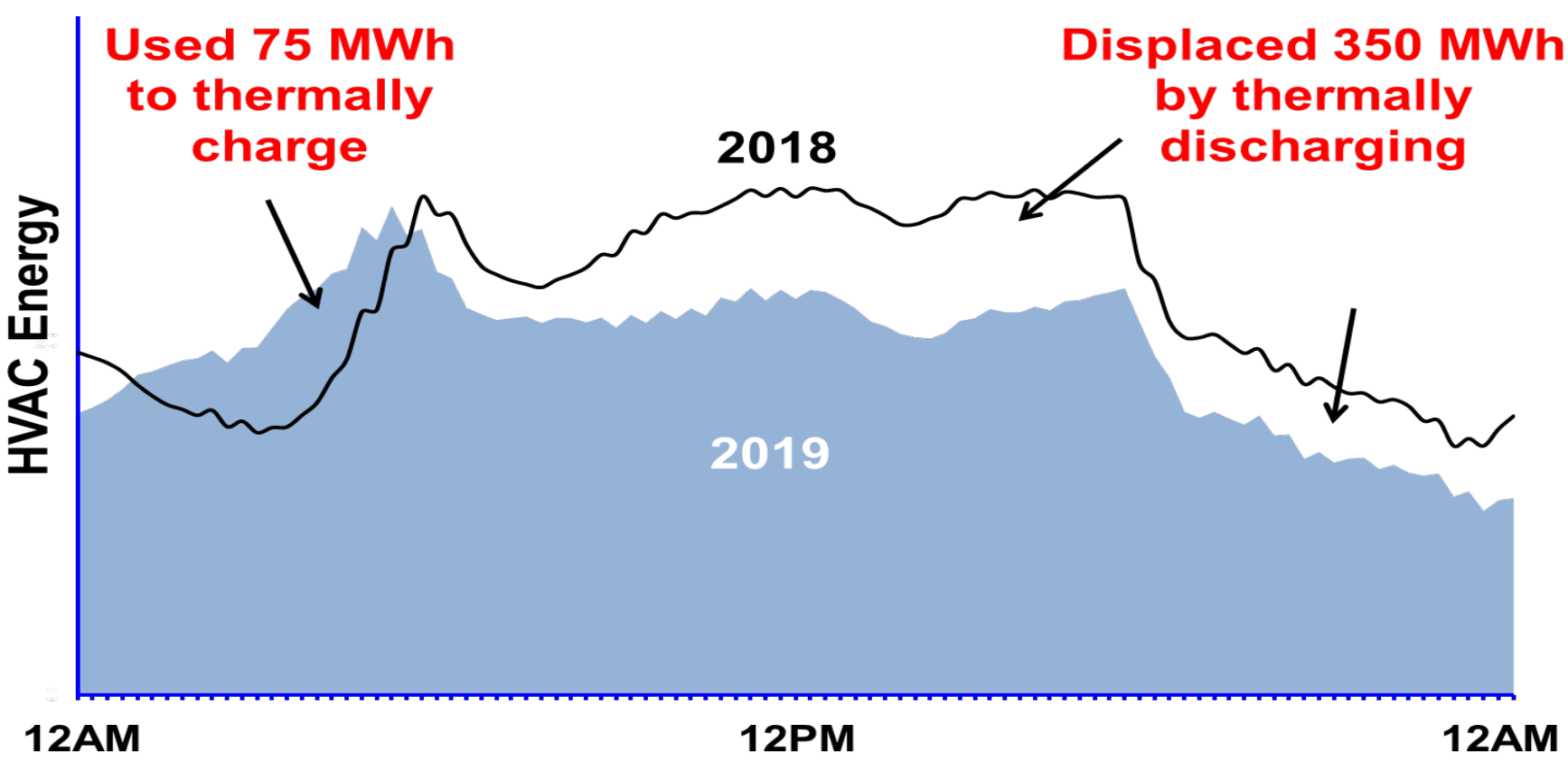
Attachment A

Low cost, high value storage …
Turning Buildings into Batteries®

November 2022

Reduced energy 20%, peak 30%, expense 25%, CO_2e 90%



>1M sqft corporate headquarters

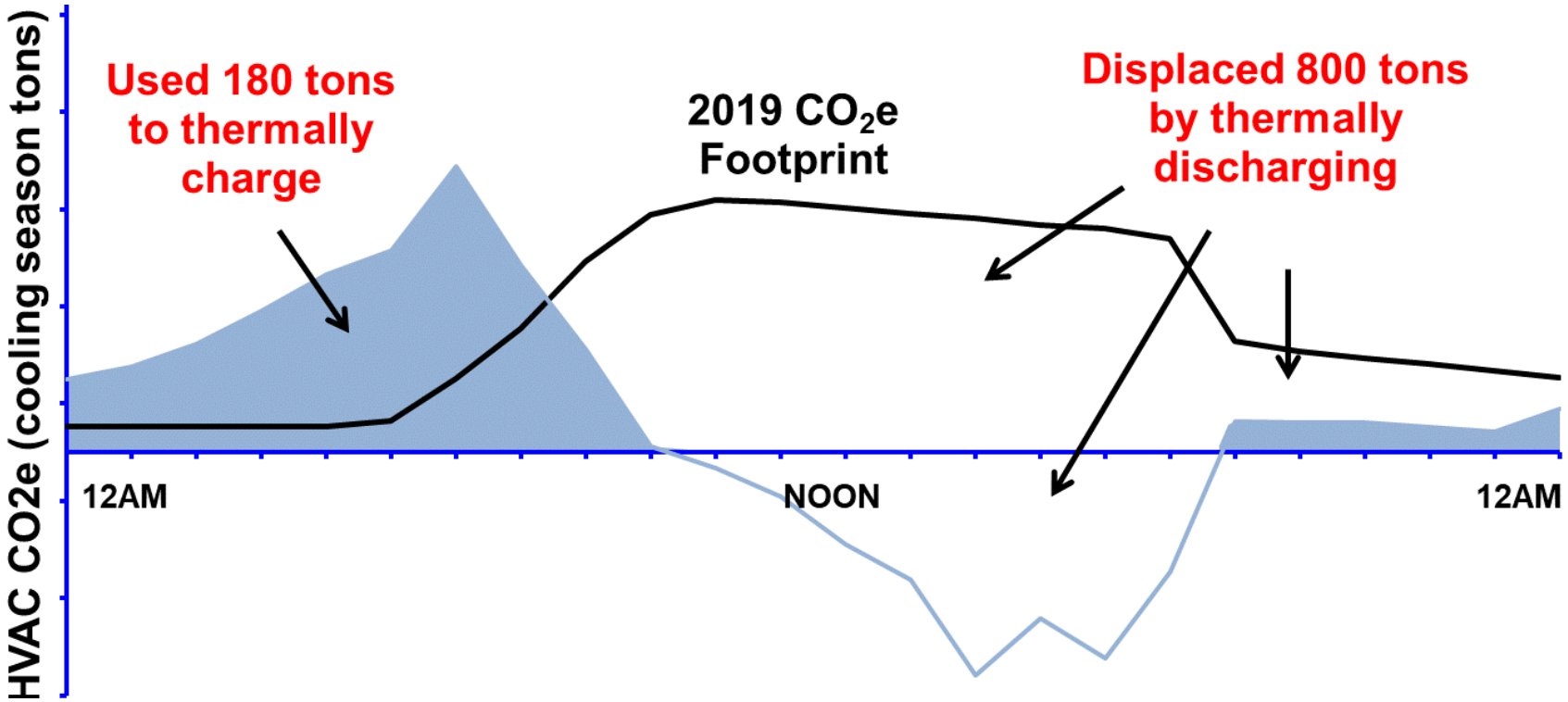
LEED Gold

NYSO SCR Demand Response

Block & index electric rate

ConEd DLRP and CSRP

Reduce CO_2e by 90% … as byproduct of expense reduction



>1M sqft corporate headquarters

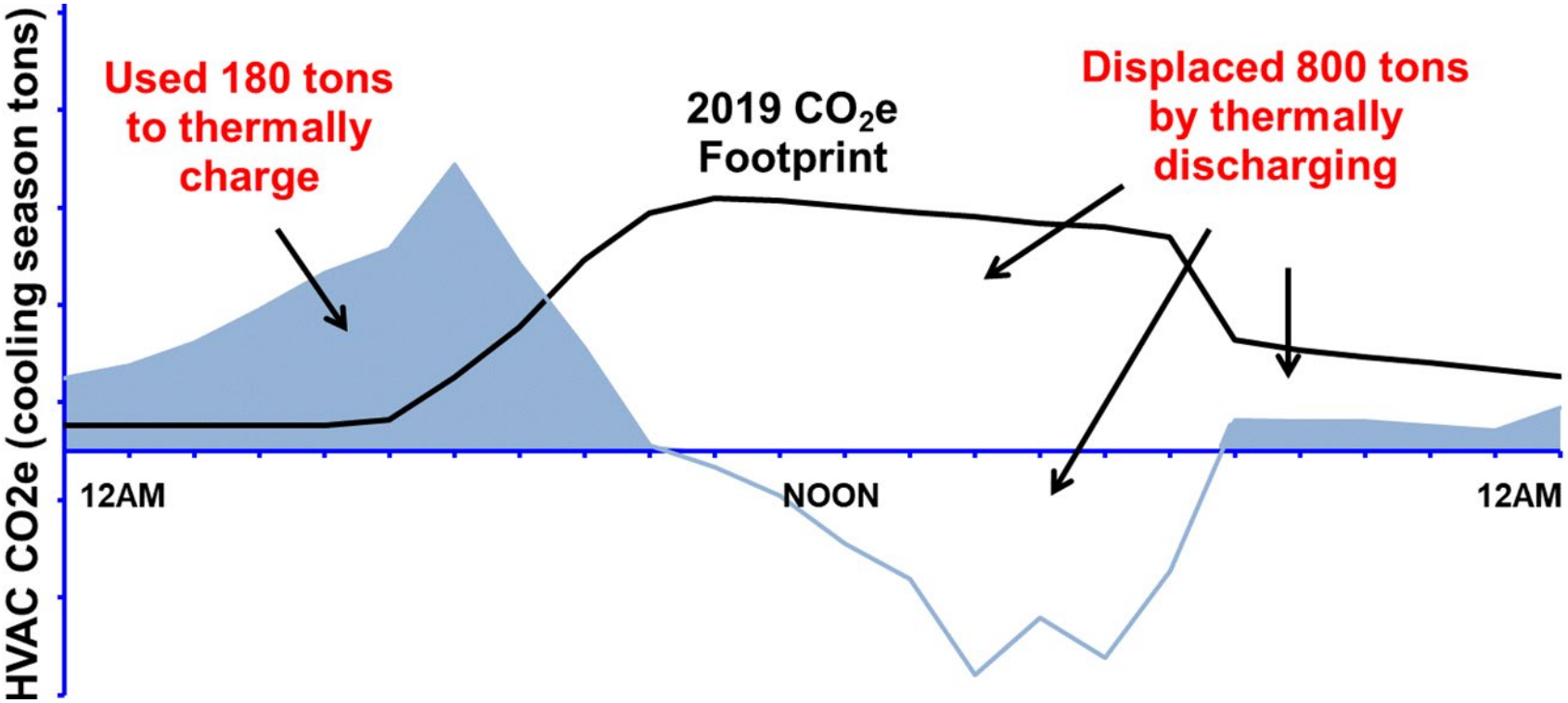
An hourly marginal CO_2e emission rate is needed to target & measure success.

In this 2019 cooling season example, EMeister MPC reduces CO_2e emissions at the margin by 620 tons net … as a byproduct of reducing HVAC electric expense. Comparable percentage reductions achieved for particulate, SO_2 and NO_x.

2019 cooling season HVAC CO_2e footprint: 660 tons

Reference: Huetteman, Justine, Travis Johnson, and Jeremy Schreifels. "Using eGRID for Environmental Footprinting of Electricity Purchases." U.S. Environmental Protection Agency. 2020; and Section 28-320.3.1.1 of the NYC Administrative Code (0.000288962 tCO_2e/kWh for 2024)

Reduce CO_2e by 90% … as byproduct of expense reduction



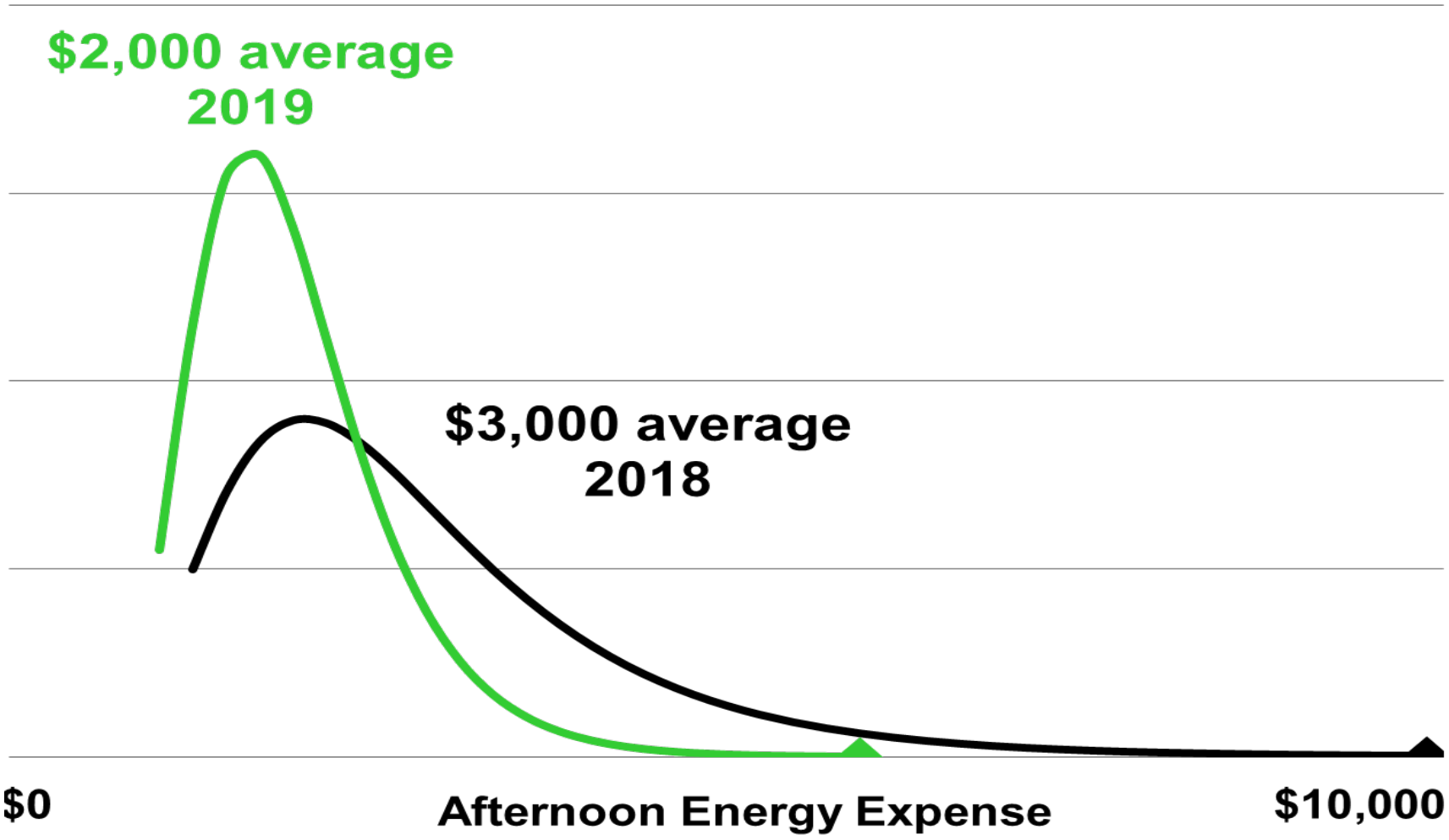
>1M sqft corporate headquarters

QCo Team derives 2019 hourly marginal CO_2e emission rate forecast for NYC.

The Team derived marginal CO_2e emission rates from actual New York State 2019 generating plant operations. Importantly, the rates reflect NYISO security-constrained unit commitment (”SCUC”).

References: United Sates Environmental Protection Agency (EPA). 2022. “Emissions & Generation Resource Integrated Database (eGRID), 2020” Washington, DC: Office of Atmosphere Programs, Clean Air Markets Division; and QCoefficient, Inc., December 2020. “An analysis of New York’s Summer 2019 fossil-fueled electric generation demonstrates that NYC commercial office buildings can dramatically reduce carbon emissions.”

Financial risk management: savings concentrated on hot, high-priced days



>1M sqft corporate headquarters

Scalability / Replicability / Impact

The benefits of storage to regional electric markets are well documented.

EMeister MPC takes it to the next level – harnessing the free drywall and concrete in large commercial buildings for grid-scale energy storage in urban centers.

- *Faster market penetration of, and more effective, energy efficiency* – EMeister improves the ROI on HVAC efficiency investment; and aligns long-lived building and HVAC investments with rapidly evolving electric grids and increasingly aggressive carbon objectives.

- *Freeing utility capex for better use* – EMeister storage at local scale substitutes for expensive underground distribution system improvements, increasingly risky long-term investments in the face of a growing energy efficiency mandate. (For example, the ConEd Non-Wires Program.)

- *Mitigating electric price/volume volatility* – for a building, a portfolio of buildings, or an entire urban market, by providing demand elasticity, especially on the hottest days with the highest prices.

- *The best environmental opportunity* – All kWh are not the same. An improved carbon metric reveals emission rates (and opportunities) that vary by region, season, weather, weekday, and hour. EMeister's multi-objective optimization protocols reduce and shift demand from less efficient, higher emitting generators operating at the margin during the afternoon to more efficient, lower emitting generators operating at the margin at night. When deployed at scale, QCo aspires to displace the marginal generator from unit commitment every week for greatest environmental benefit.

Deploying QCo storage technology at scale in the urban core provides a strategically located grid resource (without battery safety or siting concerns) – for hedging electric price/volume risk, for local generating plant emissions reduction, and for local grid frequency regulation and operating reserves needed to leverage intermittent wind and solar energy resources.

Thank you

Turning Buildings into Batteries®

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Attachment B
Technical Review of Proposed Emission Rate Method

Compliance Risk

For commercial buildings, the natural year-to-year variation in weather causes a corresponding variation in commercial building electric use ("volume risk") and electric price ("price risk") – and, now going forward, carbon emissions.

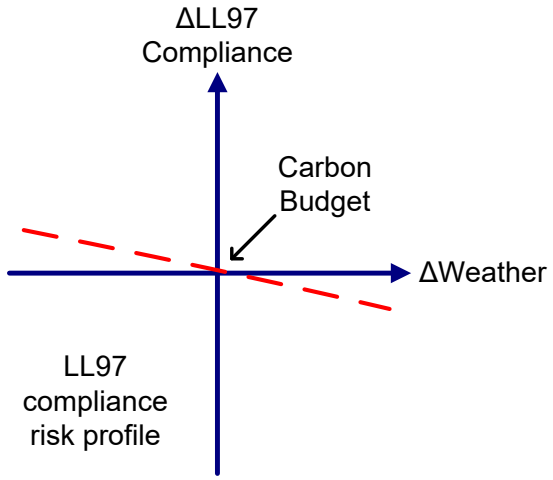


Figure 1

In Figure 1, the (0, 0) point is defined as the annual carbon compliance budget for a building, assuming expected annual weather and a fixed carbon emission rate.

Moving to the right – a warmer than expected summer means more than expected electric energy use and carbon emissions – and possible LL97 under-compliance and associated financial penalties.

Moving to the left – a cooler than expected summer means less than expected electric energy use and carbon emissions – and LL97 over-compliance.

This "volume" risk applies to all commercial buildings, commencing 2024, pursuant to section 28-320.3.1.1 of the Administrative Code at a fixed carbon emission rate of 0.000288962 tCO_2e/kWh.

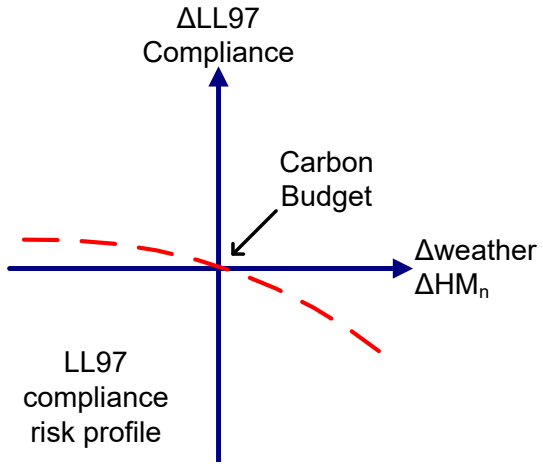


Figure 2

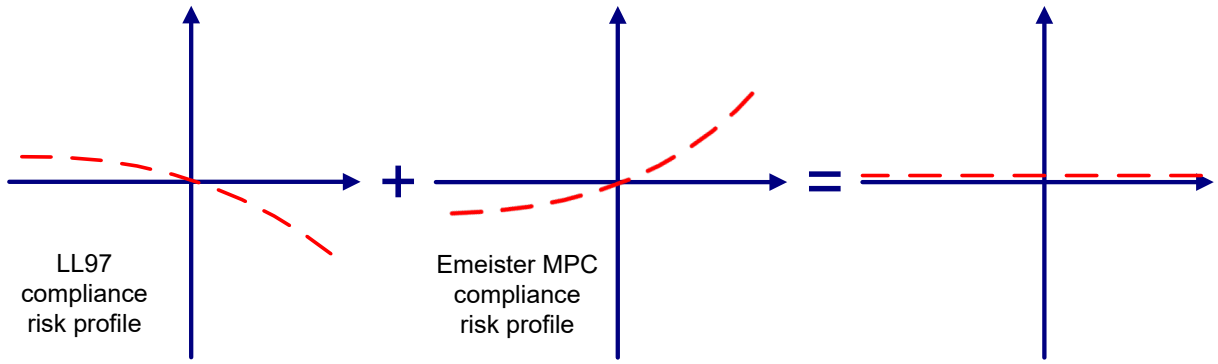
For commercial buildings adopting a TOU rate method, the compliance risk profile is more severe – because weather and price and carbon emission rates are correlated.

That is, a warmer than expected summer means more operation of more expensive, less efficient, and higher emitting generating plants. So, weather and emission rates compound for greater possible LL97 undercompliance and penalties.

Buildings adopting TOU pursuant to §103-14(d)(3)(ii-iii) are taking both "volume" and "rate" risk.

Observations regarding compliance risk

First, QCo's EMeister MPC mitigates volume, price and emission rate risk – as a byproduct of reducing electric expense – by using existing building thermal mass to reduce and shift energy use out of high-priced and high-emissions hours. Batteries similarly mitigate risk, though less effectively because of their <<100% electric efficiency.



Second, volume risk implies that NYC buildings might, as a group, under-comply with LL97 in years with hotter-than-expected cooling seasons, roughly half of the years. Why cooling season? Because 40%+ of carbon emissions in NYC occur during the June to September cooling season. With electrification, heating season will introduce additional volume risk.

(Data source: United Sates Environmental Protection Agency (EPA), 2019, Clean Air Act Markets Program Data, Washington, DC: Office of Atmosphere Programs, Clean Air Markets Division)

Third, the LL97 rules should be modified expressly to mitigate or eliminate such risks for buildings. Buildings should instead focus on achieving carbon emission reduction.

> This risk is similar to that faced by buildings with respect to their electric expense budgets. In our experience, commercial buildings typically take electric "volume" risk but understandably leave "price" risk to retail energy suppliers who are more expert at managing such risk. This is done typically by contracting for a fixed annual electric price. The QCo Team similarly expects commercial buildings to avoid risk by avoiding the LL97 TOU option. That would be unfortunate.

Fourth, to manage a similar weather risk the electric industry adopted "banking" for emissions compliance under the 1992 Clean Air Act Amendments. That is, over-compliance carried forward – in effect, generating plants only had to pay for under-compliance in a year if they under-complied cumulatively through multiple years.

Accelerate Development and Use of NYISO TOU Method
Abandon Proposed TOU Method

The proposed TOU methodology in §103-14(d)(3)(ii-iii) should be abandoned in favor of accelerated development of an accurate and robust method by the NYISO. The QCo Team understands that TOU methodology development by NYISO is a Department of Buildings (DOB) priority; that is, this proposed TOU method is an interim method. The Team offers to help develop, test and demonstrate a NYISO methodology in large NYC commercial buildings in 2023.

Whether a fixed emission rate or a TOU emission rate, EMeister MPC substantially reduces NYC building carbon emissions. However, an hourly marginal CO_2e emission rate is needed to target & measure success – whether for EMeister MPC or others' efficiency technologies.

At least as important, an accurate and robust TOU emission rate forecast for carbon creates a substantial opportunity for reducing all Brooklyn electric generating plant operation and emissions, including particulate, SO_2 and NO_x.

Technical Critique – Summary

What follows is a technical critique of the proposed TOU method with the intent of informing development of an improved method – which the DOB and NYISO intend to do. If time and resources permitted, the QCo Team would have also tested the proposed TOU method over several historical years to develop a true understanding.

The bottom line – any TOU methodology necessarily requires mathematical compromises and simplification. The QCo Team lacks confidence in the proposed methodology because it includes too many such compromises – it is not intuitively apparent to QCo's electric grid experts that the proposed TOU method produces a good result.

Technical Critique – Introducing Equation 103-14.2

For reference, equation 103-14.2 is the fundamental proposed TOU equation. The hourly carbon marginal emission rate (TOU_n) is normalized to an annual average by applying a marginal variance ($HM_n – RAM_n$) to a fixed annual average emission rate (g_{ue}):

$$TOU_n = (HM_n – RAM_n) + g_{ue} \qquad \text{(Equation 103-14.2)}$$

where HM_n is the marginal emission rate and RAM_n is the rolling-average marginal emission rate for the prior year or 8760 hours. Normalization is required because marginal emission rates are higher than the average emission rates against which LL97 compliance is measured.

Technical Critique – Detail

- The rolling average marginal emission rate (RAM_n) reflects the prior year's weather – and so may be completely divorced from the current hour (HM_n). Moreover, this rolling average calculation is subject to the same volume/rate risk as explained in Figure 2 – the prior year's weather and emission rate variability can compound to produce a bizarre rolling average.
- Supporting equation 103-14.3 calculates the marginal fuel emissions coefficient for the marginal fuel. Section 103-14(a) defines marginal fuel as the lesser of spot natural gas or fuel oil price in that hour. Lesser price is not intuitive as an indicator of marginal fuel.

Regardless, the two fuels have entirely different emission rates (MF_n) that introduce more cooling season compound weather/rate volatility to HM_n and RAM_n. Oil represents only 3.5% of total New York State annual carbon emissions. The most carbon-intensive of these generating plants are inefficient diesel-oil-fired generating plants – operated primarily during cooling season – which account for 0.4% of total New York State annual carbon emissions.

(Data source: United Sates Environmental Protection Agency (EPA), 2019, Clean Air Act Markets Program Data, Washington, DC: Office of Atmosphere Programs, Clean Air Markets Division)

Oil-fired electric generation should be mitigated or eliminated altogether. There are far more effective ways to do so than by consumers through LL97.

- Supporting equation 103-14.4 introduces the concept of an implied heat rate (or marginal generating plant efficiency) as a function of four variables:

  Hourly location-based marginal price (LBMP)

  Fuel price for the generating plant

  Emission allowance cost for the generating plant

  Other variable O&M for the generating plant

  It is not so important to understand this formulation as to understand that the formula is an over-simplification of electric markets and operations that often creates unintended effects.

  First, hourly grid prices (LBMP) are explained by much more than these variables. There are many reasons. A relevant example – the Midwest experiences very low and sometimes negative prices at night, caused by security-constrained unit commitment ("SCUC") and night-time wind generation. That is, prices drop below the marginal cost of production. The opposite occurs during the day – prices exceed the marginal cost of production.

  Second, the referenced fuel price reported by EIA is for New York City. The proposed method does not specify a price that would apply when a non-NYC natural gas plant is the marginal unit. The difference would be a function of natural gas pipeline congestion.

  Third, the resulting implied heat rate is bound – at a minimum/best generating plant efficiency of 5 MMBtu/MWh and a maximum/worst of 17 MMBtu/MWh. Below 5, the formula assigns a value of zero that results in a marginal emission rate $HM_n = 0$. Referring back to equation 13-14.2, this produces a negative TOU emission rate:

  $$TOU_n = (0 – RAM_n) + g_{ue} \qquad \text{(Equation 103-14.2)}$$

  An implied efficiency better than (lower than) 5 MMBtu/MWh means that electric market price has dropped below the marginal cost of production. In actual New York State operation, heat rates below (more efficient than) 7 MMBtu/MWh are mathematical anomalies. Below 5 does not mean negative emissions. The practical effect? A low or negative night-time emission rate does incentivize the use of storage to displace day-time fossil electric generation.

Conversely, the upper bound or worst efficiency of 17 MMBtu/MWh reflects vintage, inefficient utility generating plants that should no longer exists in NYC or the U.S. In actual New York State operation, heat rates above 11 MMBtu/MWh largely reflect vintage diesel-oil-fired combustion turbines located in Brooklyn, Queens, and Long Island.

As stated previously, the most carbon-intensive of these generating plants are inefficient diesel-oil-fired generating plants – operated primarily during cooling season – which account for only 0.4% of total New York State annual carbon emissions. To accomplish important CO_2e reductions, a TOU rate methodology should focus on large emissions sources.

(Data source: United Sates Environmental Protection Agency (EPA), 2019, Clean Air Act Markets Program Data, Washington, DC: Office of Atmosphere Programs, Clean Air Markets Division)

Oil-fired electric generation should be mitigated or eliminated altogether. There are far more effective ways to do so than by consumers through LL97.

The practical effect? NYC hourly electric prices are amongst the most volatile in the country – reflecting transmission congestion typical of most large cities. So high prices occur often – especially in a hotter than expected summer – but reflect a small volume of actual emissions. Again, such a high emission rate will exacerbate the compound weather/rate variability risk for the rolling-average emission rate, RAM_n, as described in Figure 2.

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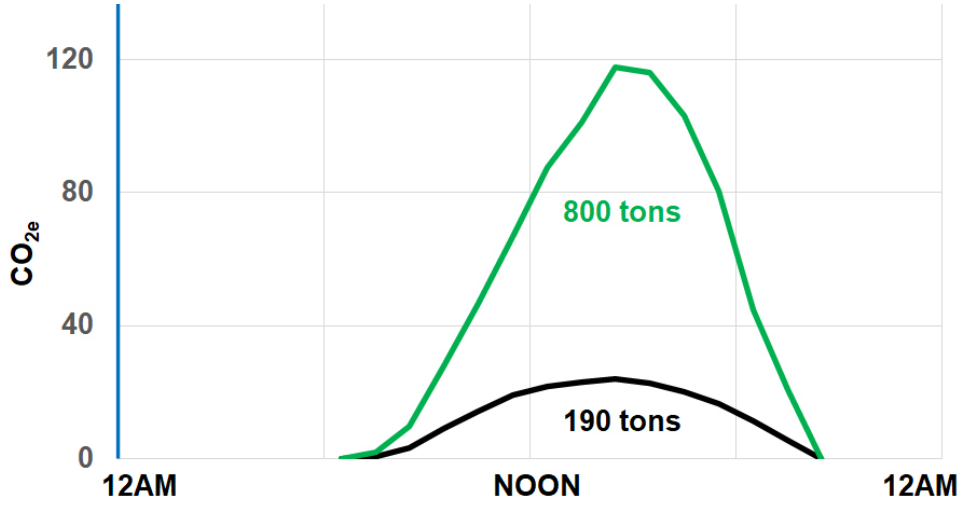
Attachment C

Marginal carbon emission rate needed to properly value PV

During the 2019 cooling season, 1 MW of local distributed PV in New York City would have displaced 800 tons of CO_{2e} – by helping remove the Brooklyn/Queens marginal baseload generator from NYISO security-constrained unit commitment ("SCUC") each week.

Marginal CO_{2e} emission rates both reveal the opportunity and coordinate the necessary NYC capital and operating improvements. Anything other than a marginal emission rate undervalues and misdirects investment in local PV, energy efficiency. energy storage and demand response.

NYC cooling season PV production is coincident with high NYC electric demands and high NYC fossil-fueled generation and associated emissions. So, PV displaces CO_{2e} (and other emissions) well beyond the default annual average emission rate.



Graph Explanation

- 1 MW of distributed PV would have generated 660 MWh during the 2019 cooling season (June 10 to September 27, 2019). For this example, PV azimuth (230°) and tilt (25°) were selected to maximize PV production during ConEd distribution system peak hours. The location is approximately Central Park, for proximity to Manhattan commercial buildings.
- 190 tons: multiply 660 MWh times a carbon emission rate of 0.000288962 tCO_{2e}/kWh, the default rate proposed for LL97 for 2024. Reference: Section 28-320.3.1.1 of the NYC Administrative Code.
- 800 tons: instead, multiply hourly PV energy times the corresponding hourly marginal CO_{2e} emission rates for NYC. Reference: QCoefficient, Inc., December 2020. "An analysis of New York's Summer 2019 fossil-fueled electric generation demonstrates that NYC commercial office buildings can dramatically reduce carbon emissions."

NOTE: This Attachment was not provided to the NYC DOB as part of QCo's November 14, 2019 filing. Instead, it was developed pursuant to the hundreds of verbal comments made at the DOB public hearing on that same date.