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An analysis of New York's Summer 2019 fossil-fueled electric generation demonstrates that NYC commercial office buildings can dramatically reduce carbon emissions

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This technical analysis demonstrates that typical calculation methods for CO_2 emission rates (dramatically) undervalue peak period electric use – and so also undervalue EMeister and, more broadly, energy storage, peak period efficiency, and photovoltaics.

A properly calculated CO_2 emission rate captures NYISO's Security Constrained Unit Commitment ("SCUC") and the generators responsible for most of New York's CO_2 emissions. Buildings can help manage SCUC every week of the year by:

- reducing electric use during peak periods (energy efficiency);
- shifting electric use out of peak periods (storage); and
- providing operating reserves during peak periods..

Importantly, "when" electricity is used is just as important as "how much" is used.

Conservative Methodology

SCUC is complicated; and is best left to the professionals at the New York Independent System Operator. NYISO takes into consideration load forecast uncertainty; generator variable operating expenses; ramp rates; generator start-up, shutdown, minimum time between starts, and other generator constraints; local area protection, load pockets, and transmission constraints; part load and full load generator efficiency and emissions rates; and other factors. SCUC is at least a day-ahead decision.

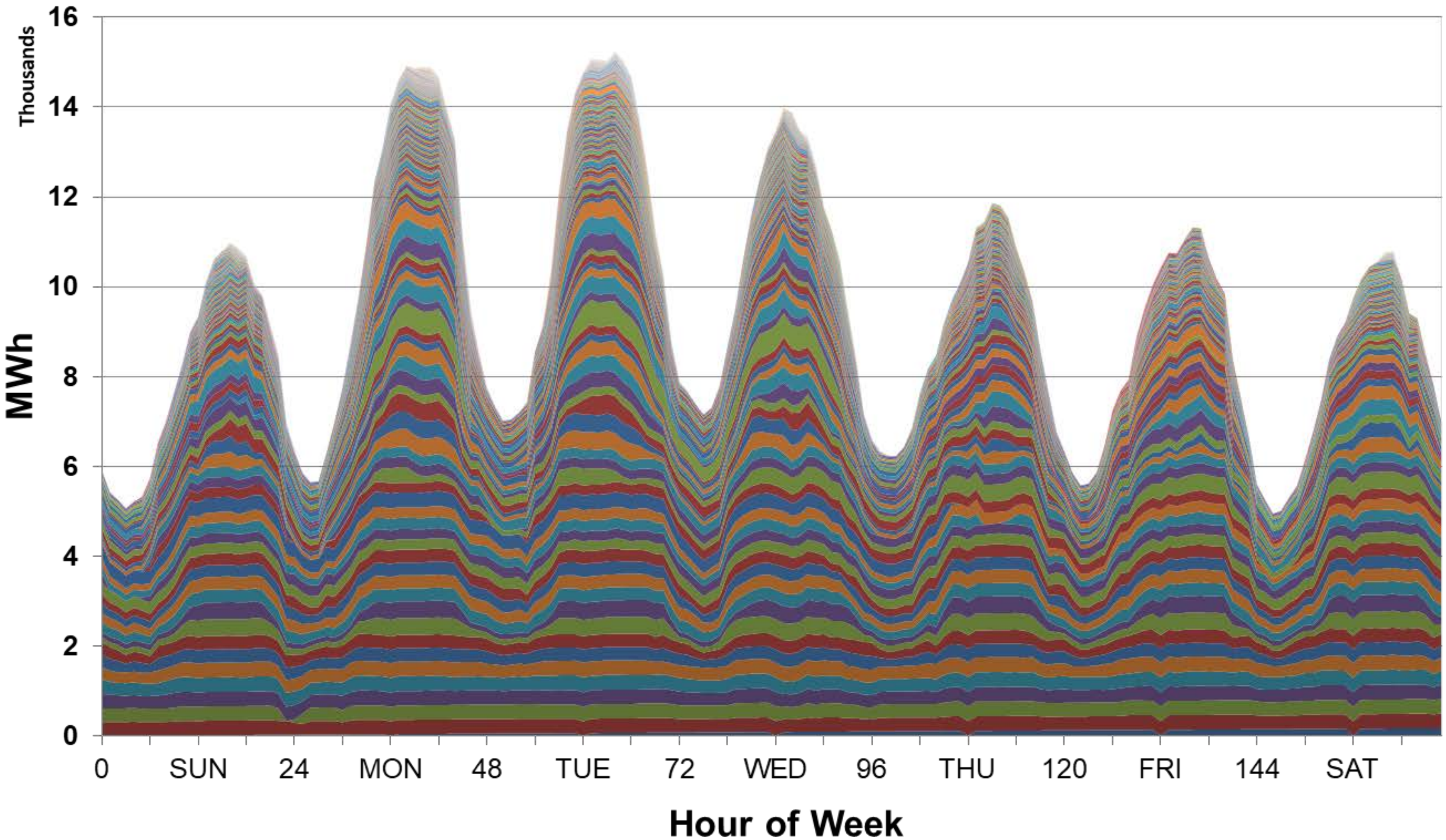
This analysis used explicit and implicit assumptions about some of these important factors – made easier by the fact that 1) the data reflect actual (not hypothetical or calculated) New York operations for a week as reported to the U.S. Environmental Protection Agency; and 2) the analysis aims at commercial buildings in New York City and Long Island, either of which location provides broad opportunity to help manage SCUC.

Next Steps

QCoefficient, Inc. has documented, vetted, and automated the methodology with the intent of:

- Replicating the analysis for the entire 2019 cooling season and calculating significant CO_2 reduction performance for its NYC large commercial building customers;
- Demonstrating the methodology and CO2 reductions in two 2021 New York City demonstrations sponsored by the U.S. Department of Energy.

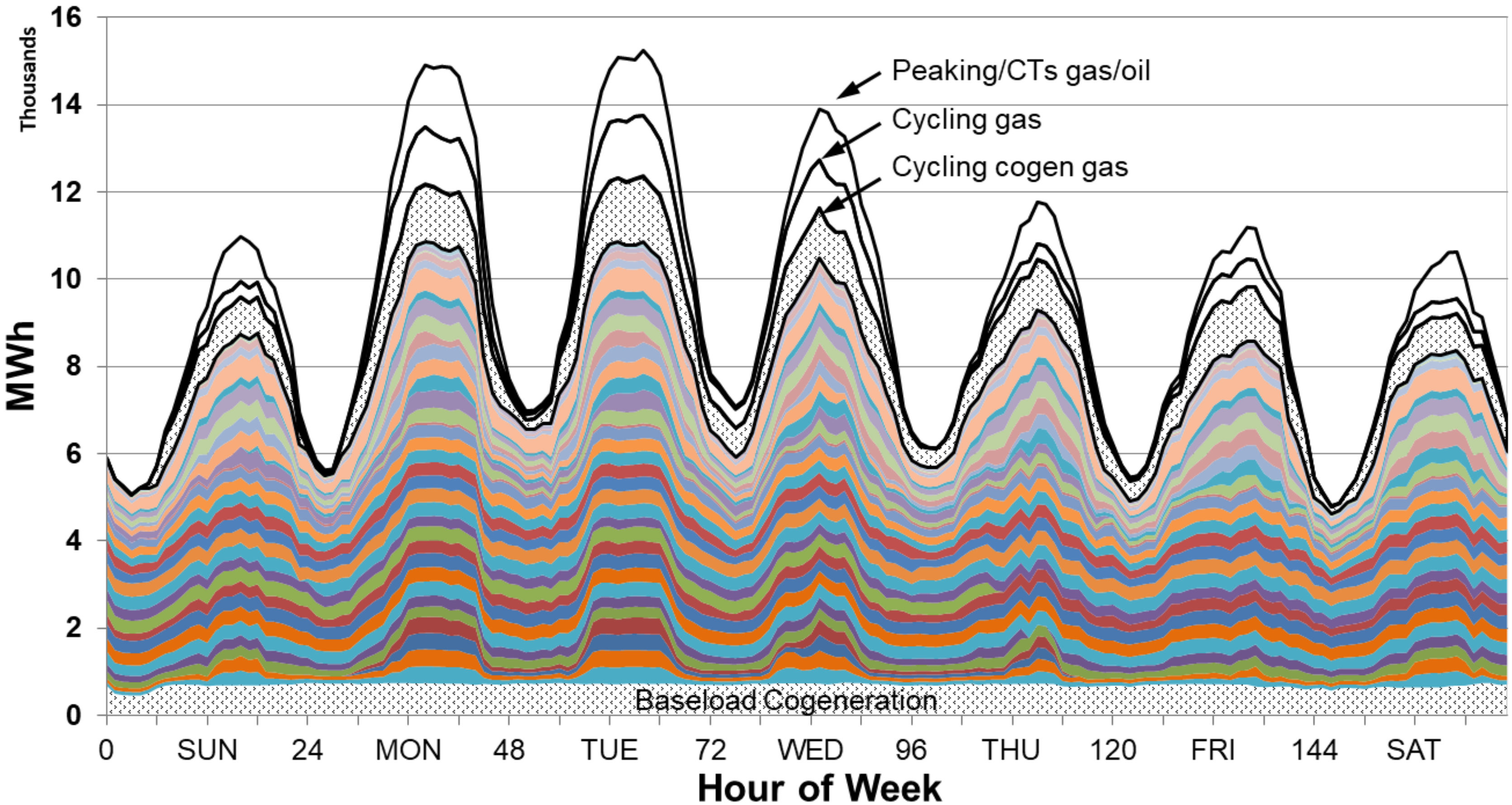
Figure 1: On a hot July 2019 week, NYISO used 168 fossil generating units to meet electric demand.



This is an analysis of actual New York fossil generation during a hot week in the Summer 2019. On Monday and Tuesday, New York City temperatures reached the mid-90's, on Wednesday through Friday the mid-80's. This graphic simply stacks the fossil generating units in order of their total weekly MWh. Obviously, to meet total New York demand, this generation was complemented by nuclear and renewable generation; by imports from neighboring markets; and by very small fossil DER not required to report to the U.S. EPA.

Source: EPA Continuous Emissions Monitoring Database.

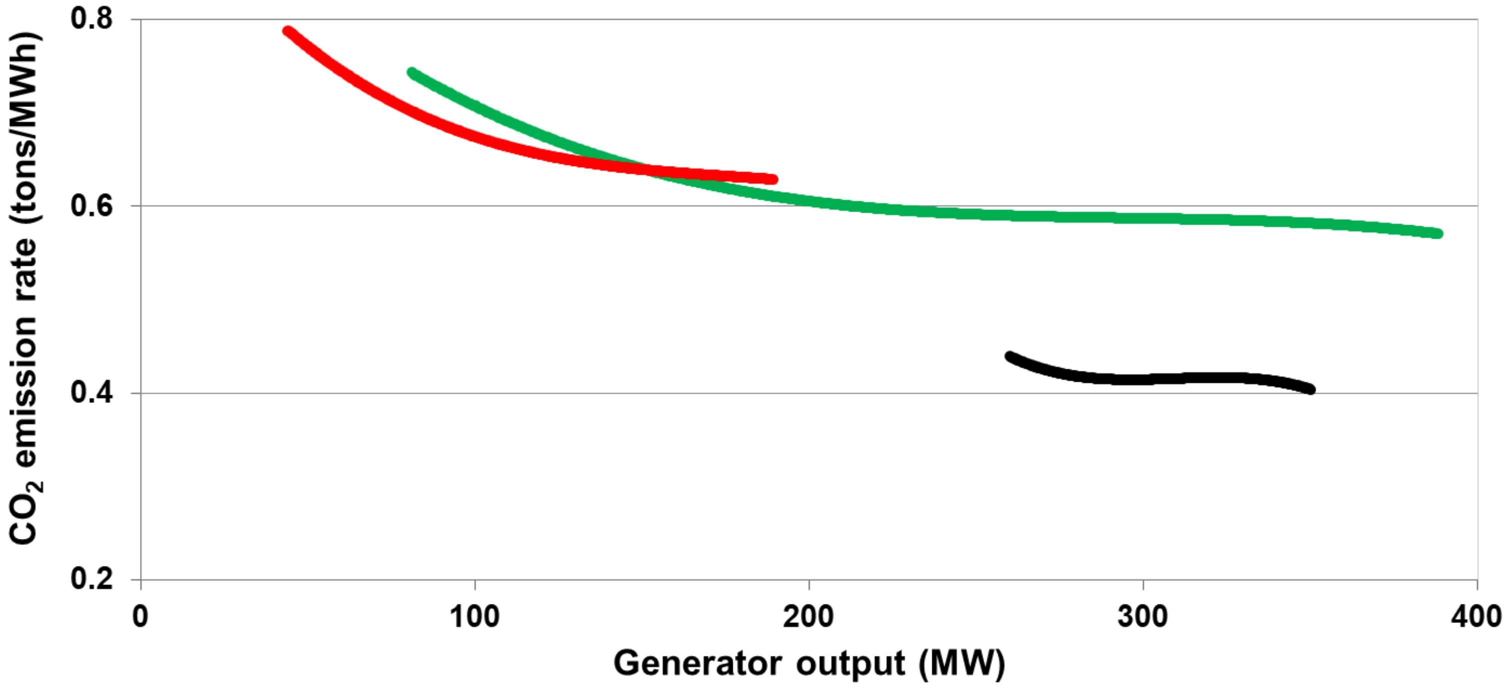
Figure 2: A more interesting view identifies 4 types of generating units and focuses on those (in color) that require security constrained unit commitment ("SCUC") in anticipation of peaks.



Larger, more efficient generating units are typically thermally inflexible, and so must be committed at least a day in advance of need. They can be backed down but not turned off overnight. The "Security Constrained" in SCUC means that the grid operator distributes such units to satisfy local area transmission constraints expected during peak periods, e.g. into New York City and Long Island.

These 35 committed generating units (out of the 168) are identified in color. 26 of these units operated for the entire 168 hours. They supply the bulk of the fossil energy every week – and are responsible for the bulk of the carbon emissions every week. All but one is fueled by pipeline natural gas. In this graphic, such units are simply stacked in order of their reported CO_2 emission rate. If the NYISO-proposed carbon price is adopted, this stacking would also reflect their economic order.

Figure 3: Generators have widely varying efficiencies and emission rates. Generators are most efficient and emit less when fully loaded. SCUC precludes continuous operation of the most efficient generators at full load.

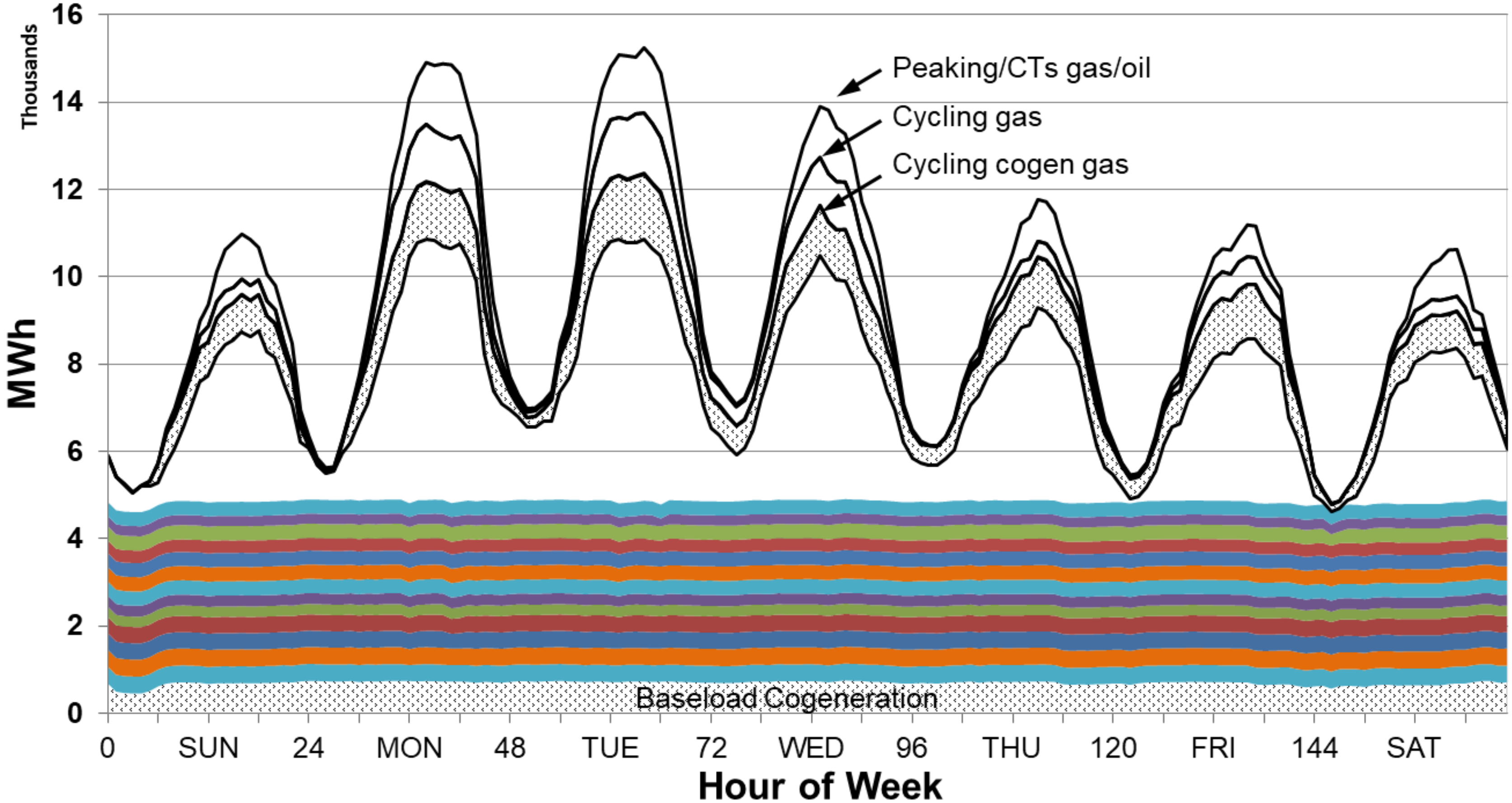


As an example, for this week … in Figure 3, the lowest emitting generator (black line) is a combined cycle with a maximum output of 332 MW and a very inflexible minimum of 275 MW. It operated for 107 hours through mid-day Thursday.

By contrast the larger, but higher emitting generating unit (green line) operated all 168 hours. Because of SCUC, this generator was forced to reduce output to an inefficient minimum load in 70 overnight hours. Unfortunately, at minimum load the emission rate is 34% higher than at full load.

This suggests an objective for commercial buildings in New York City – that is, reduce electric demand in the few hours every week that set the peak and that dictate commitment of the marginal unit … so that the least efficient and highest emitting generator need not operate that week … which in turn then allows the most efficient generator to remain on at efficient full load overnight.

Figure 4a: Properly calculated marginal carbon emission rates are dramatically different than the typically calculated rates. Typical calculation methods do not capture SCUC effects and so undervalue peak period energy reduction.

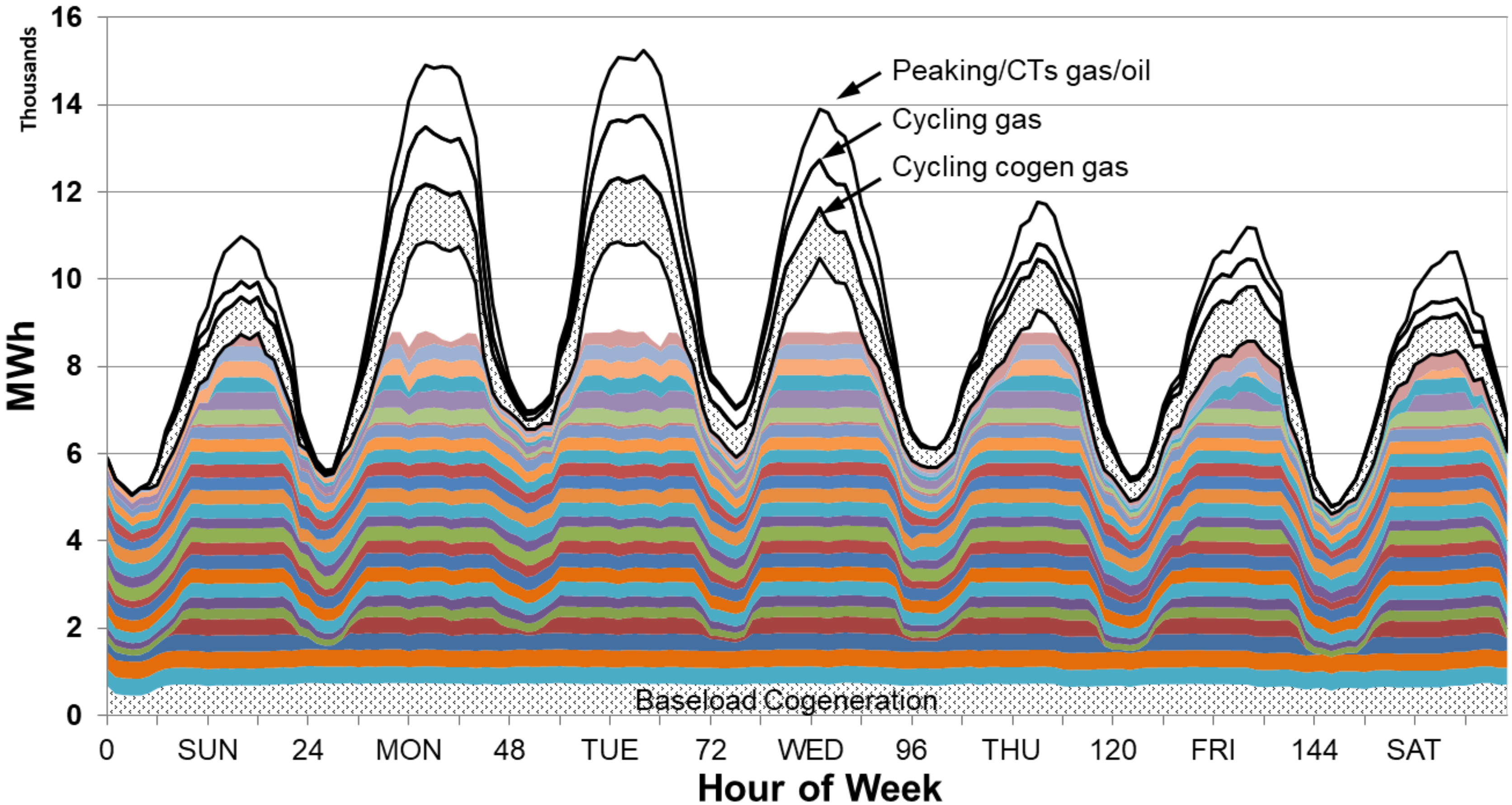


In hours 147 and 148 (2am-4am Friday night), the lowest weekly demand can be entirely met by the most efficient 13th of 35 generating units. Contrast this to Figure 2. In hours 147 and 148:

Full load CO_2 emissions rate of the marginal 13th unit:	0.42	
Marginal CO2 emissions rate that captures SCUC:	0.42	tons per MWh
Average actual CO2 emission rate (Figure 2):	0.49	

The average actual CO2 emission rate is higher because higher demand in other hours dictates commitment of additional, higher emitting units that then must continue to operate Friday and Saturday night … as shown in the figures that follow.

Figure 4b: Properly calculated marginal carbon emission rates are dramatically different than the typically calculated rates. Typical calculation methods do not capture SCUC effects and so undervalue peak period energy reduction.

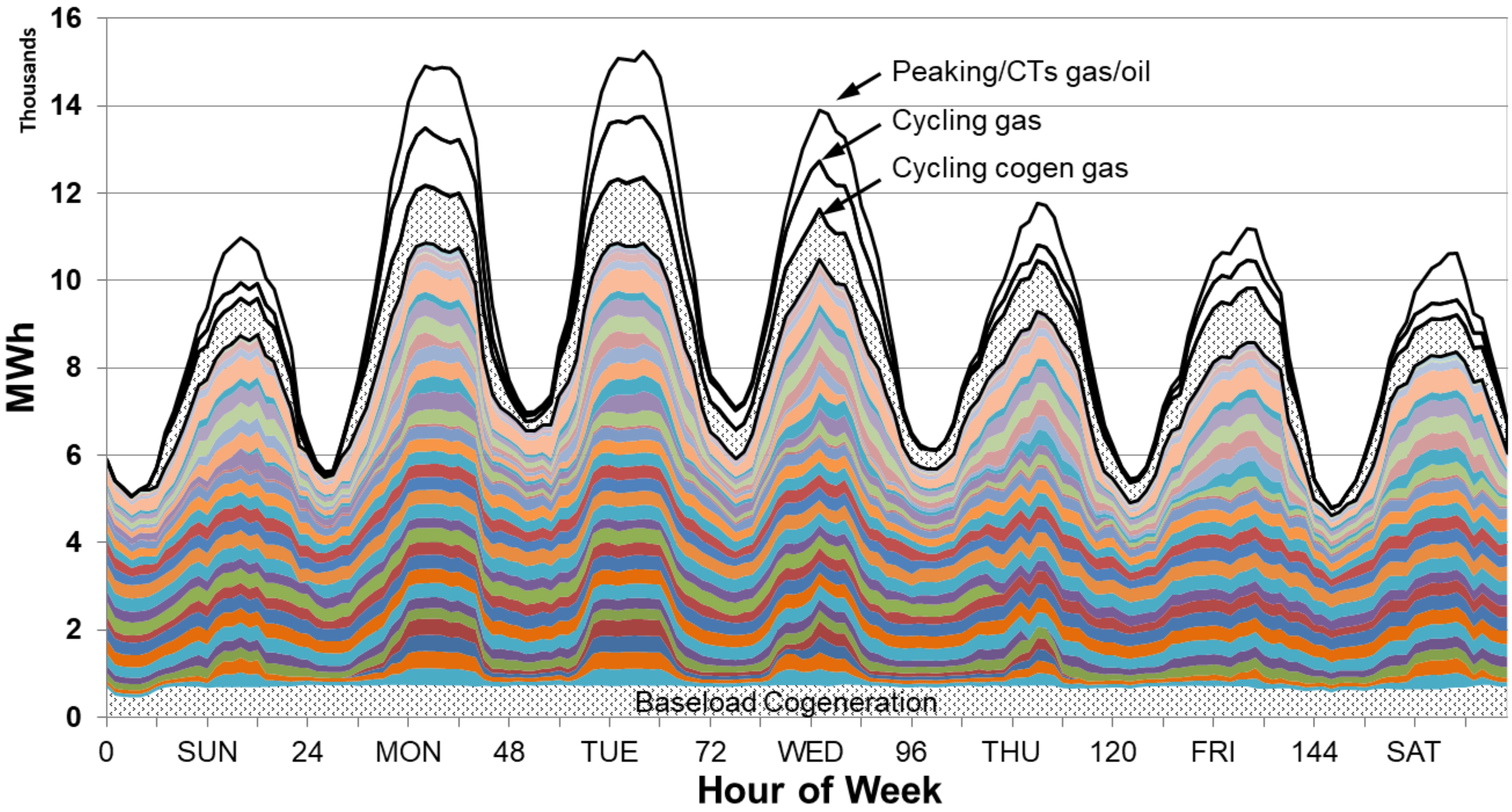


On Friday and Saturday, the demand is entirely met by the 26th of 35 generating units. Contrast this to Figure 4a. Displacement (and so higher emissions) in already satisfied off-peak hours is dictated by unit commitment needed to meet daily peaks. The added CO2 emissions in these off-peak hours is properly assigned to the peak hours dictating unit commitment. In the Saturday peak hour:

:	Full load CO_2 emissions rate of the marginal 26th unit:	0.58	
	Marginal CO2 emissions rate that captures SCUC:	0.69	tons per MWh.
	Average actual CO2 emission rate (Figure 2):	0.50	

The marginal CO2 emissions rate includes the added emissions in already satisfied hours dictated by commitment of the 26th unit.

Figure 4c: Properly calculated marginal carbon emission rates are dramatically different than the typically calculated rates. Typical calculation methods do not capture SCUC effects and so undervalue peak period energy reduction.



On Monday and Tuesday, the peak demand is finally met by committing the 35th of 35 generating units. Contrast this to Figures 4b. Significant displacement (and so higher emissions) in already satisfied off-peak hours is dictated by commitment of this 35th unit. Added CO_2 emissions in such hours is properly assigned to the Monday and Tuesday peak hours that dictated such commitment:

:	Full load CO_2 emissions rate of the marginal 35th unit:	0.66	
	Marginal CO_2 emissions rate captures SCUC:	2.90 to 5.90	tons per MWh.
	Average actual CO_2 emission rate (Figure 2):	0.48	

The marginal CO_2 emissions rate properly captures the added emissions in non-peak hours dictated by commitment of the 35th unit.

Properly calculated marginal carbon emission rates are dramatically different than the typically calculated rates. Typical calculation methods do not capture SCUC effects and so undervalue peak period energy reduction.

Period:	Figure 4a Minimum Load	Figure 4b Intermediate	Figure 4c Peak	
Full load CO_2 emissions rate of the marginal unit	0.42	0.58	0.66	
Marginal CO_2 emissions rate that captures SCUC	0.42	0.69	2.90 to 5.90	tons per MWh
Average actual CO_2 emission rate (Figure 2):	0.49	0.50	0.48	

Observations

Coal-fired generation requires special attention. In 2019, New York operated one coal unit. This analysis removed the coal unit because it is slated for mothballing, is not relevant to NYC local area protection and is not representative of the future. The full load CO_2 emissions rate of that coal unit in the week used for this analysis was actually 1.05 tons per MWh, considerably higher than that of a comparable natural gas-fired generator. Similarly, the marginal CO_2 emissions rate capturing SCUC effects was actually a very large 5.85 to 9 tons per MWh. So coal makes a dramatic difference.

Power purchases from neighboring markets do cause significant CO_2 emissions … if they increase that market's SCUC. Similarly, power sales from New York cause significant carbon emissions if they increase New York SCUC.

Some states and countries have incorrectly adopted average actual hourly CO_2 emission rates to penalize off-peak vs. day-time purchases of electricity from neighboring markets. Especially in coal-dominated markets, off-peak average CO_2 rates are always higher because of the trauma imposed by SCUC, that is, because of the trauma imposed by peak period electric demand.

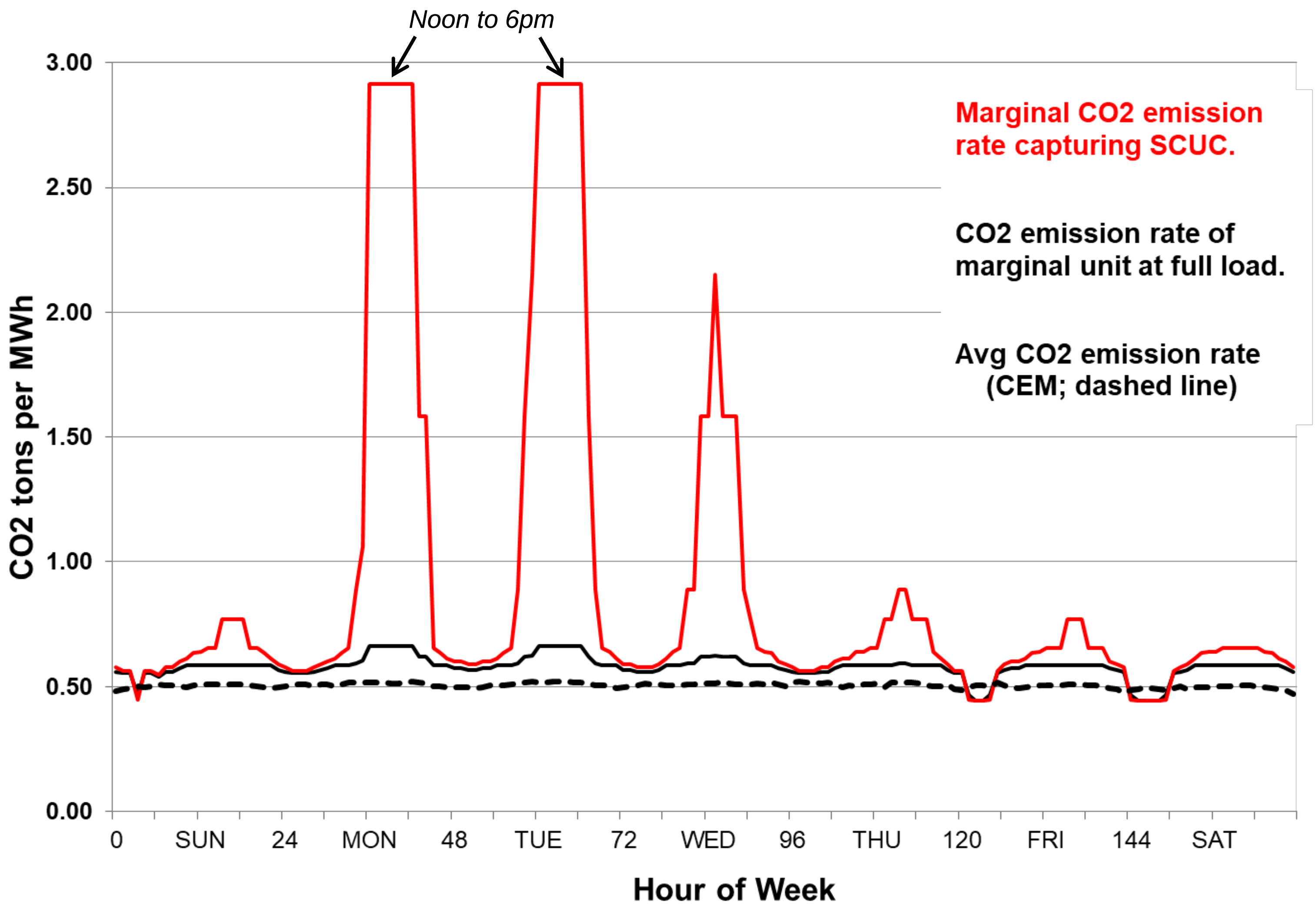
Combustion turbines have a CO2 emission rate of 1.00 tons per MWh (typical). Most combustion turbines are so small and emit so few emissions annually that they have LME or "Low Mass Emissions" status. That means that their emissions reported to the CEM database are not measured, but calculated using industry standard emission rates. In 2016, they represented only 5% of New York's annual CO_2 emissions from fossil-fueled generation and only 0.5% of such emissions on hot summer days.

References

"Source Energy and Environmental Impacts of Thermal Energy Storage," California Energy Commission, P500-95-005, February 1996.

"IPPTF Carbon Pricing Proposal," New York Independent System Operator, December 2018.

Figure 5: Sub-optimal off-peak emissions are caused by SCUC and so properly attributed to weekly/daily peak hours that dictate SCUC (red)



When you use electricity is as important as how much you use.

Buildings as Batteries®

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