Combined Heat and Power vs Carbon Tax: An Overview

The current climate change challenges have pushed governments, cities, associations, companies & institutions in NYC to implement initiatives for reduction of greenhouse gas emissions. As a result, a carbon tax [LL97] has been implemented in NYC to attempt a 100% reduction in GHG emissions by 2050.

The goal behind LL97 is an enormous gap to bridge and the electrification process plus the phase-out of fossil fuels is increasing stress on the grid as predicted by NYISO.

In previous years, utility companies and energy, research & development institutions in NYC incentivized Combined Heat and Power technologies to improve resilience & overall emissions in the NYC's grid infrastructure. By integrating CHP systems throughout NYC, the grid regained a portion of the resiliency needed to maintain the electric demand.

However, with the current flip to phase-out fossil fuels including electrification, NYC buildings will experience an enormous power constrain in the near future. Based on the current trend, the grid will have to withstand the current electric demand, electrification, and the 1.8 GWs load covered operating CHP systems in NYC, if forced to shut down due to a very aggressive carbon tax.

On the other hand, CHP Systems can simultaneously provide thermal energy to offset heat demand in buildings which is often overlooked and not recognized inside the new carbon tax laws in NYC.

In the CHP world, technologies such as microturbines can utilize net zero carbon fuels (e.g. hydrogen, RNG) making this technology potentially a net zero solution for electric and thermal needs in buildings. Unfortunately, local policies are not incentivizing the production of low/zero carbon fuels.

70%

Of greenhouse gas emissions in NYC is produced from buildings.

446 MWs

Shortage by 2025 in NYC, according to New York Independent System Operator [NYISO].

1.8 GWs

Of power generation by CHP systems throughout NYC. Many sites are considering shutting down first day of 2030 due to the excessive increase in the carbon tax.

Low/Net Zero Carbon Fuels

CHP technologies such as microturbines, only need net zero carbon fuels to be a net zero power generation technology capable of offsetting thermal energy and electricity reducing stress on the grid.

Safety

There are approximately 450 CHP installations in NYC. Buildings in residential, healthcare, or government applications benefit from CHP providing a backup energy source to keep the occupants safe during storms or utility outages.

Introduction

In 2019, New York City enacted Local Law 97[1] to reduce greenhouse gas (GHG) emissions from buildings. This law places limits on CO_2 emissions through 2050 with reductions every 5 years. In December 2022, NYC Department of Buildings finalized Rule 103-14 for Local Law 97 to specify the carbon coefficients (metric tCO2/sq.ft) across 60 types of property usage in NYC. In other words, every covered building under LL97 has an established "carbon budget" starting 2024 and decreases every 5 years until reaching net zero by 2050.

Every year, NYC building owners report their building's energy usage to the city through the US Environmental Protection Agency's ENERGY STAR Portfolio Manager (ESPM) tool under Local Law 84[2]. This tool allows users to benchmark building's energy usage to a yearly baseline. Using this energy summary, ESPM quantifies the total GHG direct emissions by applying regional GHG factors for each energy source (electricity – grid purchase, natural gas, fuel oil, district steam, and so on). In the case that the total GHG direct emissions is higher than the carbon budget established by NYC DOB, the building owners have to pay the difference in penalties to comply with LL97.

Currently, NYC legislation[3] is pushing building owners to electrify their buildings to reduce their carbon footprint. By phasing out onsite fossil fuel consumption in exchange of electrification, every building owner relies on the carbon footprint exhausted by the power plant (offsite power) and paying the penalties to the city. NYC's long-term goal is to make a transition in buildings energy usage and clean the electrical grid with solar, wind and other sources of green power. However, the enormous gap in this transition is affecting the grid's reliability & causing building owners economic challenges and potential bankruptcy.

The New York Independent System Operator (NYISO) identified a deficit of 446 megawatts (MW) of electricity for the NYC area beginning summer 2025. According to NYISO[4], some of the factors include "increased electrification of the transportation and building sectors, continued economic growth following the pandemic, and the unavailability or retirement of select generators under the New York State Department of Environmental Conservation's emissions limits". These challenges have shown that a progressive transition is needed to prevent power outages resulting in public safety risks.

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[1] NYC Department of Buildings, "Local Law 97", https://www.nyc.gov/site/buildings/codes/sustainability.page, 1.

[2] NYC Department of Buildings, "Local Law 84", https://www.nyc.gov/site/buildings/codes/benchmarking.page, 1.

[3] NYC Department of Buildings, "Local Law 154", https://www.nyc.gov/site/buildings/codes/building-electrification.page, 1.

[4] NYISO, "Study finds reliability need in 2025 for NYC region", https://www.nyiso.com/-/press-release-%7C-nyiso-study-finds-reliability-need-in-2025-for-new-york-city-region, 1.

Local Law 97: The real impact for CHP

[5]An unnoticed solution to transition towards a net zero grid is onsite power production. In more recent years, onsite power production has shown higher reliability, carbon emissions reduction and higher energy efficiency compared to traditional systems. A technology capable of producing power on site is Combined Heat and Power (CHP). [6]According to DOE by definition CHP is "*A suite of technologies that can use a variety of fuels to generate electricity or power at the point of use, allowing the heat that would normally be lost in the power generation process to be recovered to provide needed heating and/or cooling*." In other words, CHP offsets electricity purchased from the grid and increases the buildings plant efficiency by offsetting thermal energy (E.g. - Domestic Hot Water, Chilled Water, Steam, and so on) while decreasing the fuel usage of traditional systems (E.g. – Boilers, ….).

The capability provided by CHP can facilitate time for NYC's grid to transition towards renewable energy. However, this technology is not incentivized under NYC's climate change policies due to operating on fossil fuels. Consequently, NYC building owners are not considering CHP systems due to the urge on electrification.

It is clearly shown in DOE's CHP and Microgrid Installation Database[7] that NYC has an approximate of 500 CHP installations for a total approximate capacity of 1.8 GWs. In this scenario, a transition towards green power would require NYC's grid to increase their load 5 times the current projected deficit of 446 MWs. At the same time, these installations would require more thermal energy due to the phase out of the recovered thermal energy from CHP systems. NYC's grid will need a higher increase in their load to provide enough electricity to cover all electric & thermal energy usage in NYC buildings while reducing carbon emissions.

Supporting innovative technology is key to reduce the challenges and consequences that NYC is facing in the new clean energy economy. Under the CHP systems umbrella there are technologies that provide the same value of combined heat and power with a fraction of carbon emissions compared to other CHP technologies. A clear distinction are microturbines which are small gas combustion turbine that can use gaseous or liquid fuels. These units can be integrated to a modular package starting at 65 kW capacity and only produce 10-15% of the carbon emissions produced by their counterparts. Furthermore, microturbines can operate on net zero or low carbon fuels even though these fuels are not readily available in NYC due to the lack of research and review by the state[8].

Traditional systems provide a single energy commodity per energy source thus the direct emissions are calculated by ESPM as "emissions that occur at your building only"[9]. On the

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[5] DOE, "Combined Heat and Power basics", https://www.energy.gov/eere/iedo/combined-heat-and-power-basics, 1.
[6] DOE, "Combined Heat and Power basics", https://www.energy.gov/eere/iedo/combined-heat-and-power-basics, 2.
[7] DOE, "CHP and Microgrid Installation Database, https://doe.icfwebservices.com/chp, 2.
[8] NYSEDA, "Combined Heat and Power Systems", https://www.nyserda.ny.gov/CHP, 2.
[9] Energy Star, "Technical reference: Emissions", https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf, 2.

other hand, microturbines provide two energy commodities per energy source and penalized under LL97 in the same manner as traditional systems. In other words, LL97 does not give credit for the thermal energy recovered in the distributed power generation process. Even though microturbines are well integrated with heat recovery boilers, absorption chillers, heat recovery steam generators (HRSG), and/or drying processes due to their clean heat exhaust gas, thus the free energy produced is not considered a carbon offset asset.

For a better visualization, let's take for example a NYC building with a CHP installation and its impact on LL97 for the next 10 years[10]. See below building's profile:

NYC existing building			
Building Characteristics: - Gross Floor Area = 233,759 sq. ft[11]. [+ 4,900 Parking] - Building Property Type: Mixed Used (Residential & Commercial)			
LL97			
Multifamily Housing (224,082 sq. ft)	Restaurant (2,430 sq.ft)	Other-Education (7,247 sq. ft)	Parking-Completely Enclosed (4,900 sq. ft.)
Total Carbon Budget (2024-2029) = 1,620.83 tCO2e[12].			
Total Carbon Budget (2030 -2034) =780.98 tCO2e.			
LL84 Data (2022)			
Site Energy Usage = 14,296,018 kBtu	Electricity Use (Grid Purchase) = 1,248,833 kWh	Natural Gas Use (Onsite) = 100,350 Therms	Net Emissions (with Locality Factors) = 893.824 tCO2e

CHP Performance

In 2022, this building operated a microturbine with a capacity of 65kW and used the clean exhaust gas to produce hot water with an air to water heat exchanger to offset domestic hot water loads. The performance of the microturbine equipment during the year reported (2022) is as follows:

Metric	With microturbine	Without microturbine
Electricity (Grid Purchase) – kWh	1,248,832.6	1,647,059.1
Microturbine Output Power – kWh	398,226.5	0
Natural Gas Use – Therms	100,350	66,406.44

[10] NYC Open Data, "Energy and Water Data Disclosure for Benchmarking (2022)", https://data.cityofnewyork.us/Environment/NYC-Building-Energy-and-Water-Data-Disclosure-for-/5zyy-y8am/about_data, 3.
[11] Square footage, 3.
[12] Metric Tons CO2 equivalent number [Co2 + Ch4 + N2O], 3.

Recovered Thermal Energy – Therms	30,324.19	0

Loading both energy usage profiles to ESPM, the total GHG Emissions (Metric Tons CO2e) increases by 65.2 metric Tons CO2e with the microturbine equipment.

Metric	With microturbine	Without microturbine
Site Energy Use – kBtu/sq.ft.	61.2	52.4
Net Emissions (With Locality Factors) - tCO2e	893.824	828.623

The initial thought is that microturbines are not providing a positive value to reach net zero. However, there are 2 variables to consider:

1) The amount of carbon increased is not significant enough to cross the threshold of the building's LL97 carbon budget (1,620.83 Metric TCO2e). Meanwhile, the microturbines are providing energy costs savings that can be utilized to implement other carbon mitigation strategies and/or prevent hefty rent increases to residential and commercial tenants.

   For the years 2030-2034 the threshold of the building's LL97 carbon (780.98 tCO2e) will reduce significantly, and the building will have to pay penalties if the current energy profile stays consistent. The penalties could amount to $268/tCO2e * [893.82-780.98] tCO2e = $30,241.12. On the other hand, microturbines can generate significant yearly savings that can be utilized to retrofit the building.

   Using the previous example, we can calculate the yearly savings produced by the microturbine installed:

   In this facility, the CHP system generated 398,226.5 kWh, utilized 64,267.74 therms for fuel & offset 30,324.19 therms of domestic hot water load. Assuming the average utility cost provided by the U.S Bureau of labor statistics (NY)[13] for electricity and gas, the savings are as follows:

Average NY Rates	Cost with microturbine	Cost without microturbine
23.1 cents/kWh	$288,480.19	$380,470.65
1.429 $/Therms	$51,561.89	$94,894.89

[13] U.S. Bureau of labor statistics (NY), "Average energy prices in New York", https://www.bls.gov/regions/northeast/news-release/averageenergyprices_newyork.htm#:~:text=New%20York%20area%20households%20paid,per%20kWh%20in%20December%202022., 4.

1.215 $/Therms (Discounted)[14]	$78,066.04	$0
Total Cost ($/year)	$418,108.12	$475,365.3
Savings ($/year)	$57,257.18	

The majority of microturbines installed in NYC have been paid with the generated savings, thus these installations are generating extra savings that can be used to implement further carbon reduction strategies. This building can accrue $57,257.18 per year for a total of $286,285.9 before paying penalties by 2030. After 2030, the building will save 27,016.06 per year for a total of $135,080.3 by 2035. Simultaneously, NYC's utility companies are shifting towards net zero energy, thus this building can potentially be under the carbon budget threshold consistently in the next 10 years.

2) Utility companies are currently implementing low carbon electricity production while building owners are rushed to electrify their buildings. In other words, the utilities have to lower their carbon emissions for the current electricity demand and provide more low carbon electricity for the new demand created by electrification which can lead to a shortage in electricity. Meanwhile, building owners are responsible to pay the fines for the pollution produced by the utilities. These fines can be mitigated with the savings produced by microturbines and later minimized with low carbon fuel implementations.

   On the other hand, gas utility companies in NYC cannot provide new gas services to new construction buildings. In this situation gas companies have to shift their commodity from gas to low carbon fuels, however the city's main focus is electrifying our grid and using electricity as the new fuel. Relying on one source of energy can increase unreliably due to constrains or emergencies caused by storms or other factors.

The untold difference between generating your own power and buying power from the grid is the significant reduction in distribution. With onsite power, a good portion of carbon emissions rely more on distributed generation equipment compared to the grid and add an incentive to decarbonize the power distribution equipment. Loading both building usage profiles to the "Building Emissions Calculator"[15] in ESPM, we can see the difference of indirect and direct emissions.

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[14] "NYC gas utility companies provide a discounted gas rate of 15% the building's gas rate for distributed generation technologies.",4.

[15] Energy Star, "Building Emissions Calculator", https://portfoliomanager.energystar.gov/buildingEmissionsCalculator/, 5.

☐	Building Name	Annual Period Ending Date	Total (with Locality Factors) (kg CO_2e)	Direct (with Locality Factors)(kg CO_2e)	Indirect (with Locality Factors)(kg CO_2e)
☑	With CHP	12/31/2022	893,824	532,959	360,866
☑	With no CHP	12/31/2022	828,623	352,685	475,938

For the same example if there is no CHP equipment installed, the utility produced 475.94 Metric Tons CO2e compared to the current scenario with CHP equipment installed of 360.87 Metric Tons CO2e. More specific, 115.07 Metric Tons CO2e were not produced to distribute energy to this building rather produced onsite. The first thought to decarbonize the CHP system is usually shutting down the equipment due to the minimal potential increase in carbon. However, the shutdown will halt processes at existing sites and create a redundant need for more power from the grid resulting in a bigger constraint for the utility. The extra power removed from the grid can be used to support electrification at a rhythm that can be sustained by the grid infrastructure.

A short-term solution provided by the city could be the accurate calculation of CHP gas utilization compared to traditional systems. Both (CHP & traditional systems) utilize the same energy commodity (natural gas or others) but differ in efficiency with CHP having a higher efficiency and providing 2 energy commodities. With an accurate comparison, the CHP system would have a lower carbon intensity if both commodities were taken into account. This can incentivize building owners to not shut down their equipment which indirectly assists the utility's constraint issue during the infrastructure transition towards net zero electricity.

A long-term solution provided by the city could be the prioritization of the low carbon fuel market to reduce the carbon utilized by microturbines. Since microturbines are clean engines with low carbon emissions, reducing the carbon content from its fuel will automatically convert this equipment into a net zero carbon technology.

Even though the example facility is only operating the smallest microturbine equipment available (65kW) there are almost 500 CHP installations in NYC of different capacity. As mentioned before, the 1.8GWs produced by all CHP systems installed in NYC would require the grid to increase its supply on top of:

- Current electricity demand.
- Upcoming electricity demand increase due to the electrification promotion through LL97.

Incentivizing building owners with CHP installations through a deduction from report annual building emissions for Renewable Energy Credits (RECs) could be the fastest transition towards a net zero grid while reducing the utilities' energy constraint. Or at least, provide low carbon fuels for building owners that have the technology to utilize them. For example, there are facilities using available Renewable Natural Gas (RNG) produced from manure and organic waste in Wastewater Treatment Plants turning this technology into a net zero carbon electricity production plant. However, RNG is not available outside of WWTP installations nor being provided by gas companies.

Another low carbon fuel that can be utilized to make CHP greener is hydrogen blended natural gas. In this case, Microturbines are already capable of up to 30% hydrogen blended gas to minimize carbon emissions, but this fuel is not available due to the change of infrastructure needed and the cost associated with this fuel in the market. In the near future, this technology will be capable of using up to 100% hydrogen fuel even if it is not available in the market. The current infrastructure of NYC does not allow for the usage of hydrogen blended fuels which puts this energy strategy ahead of the scheme to further carbon emissions reductions.

There are available methods for different low carbon fuel implementation in NYC:

- [16]Renewable Natural Gas (RNG): A microturbine installation paired with an anaerobic system. The microturbine system can offset the electricity consumption of the facility managing the waste and the recovered heat can be used to reheat the anaerobic digester to reduce carbon. In buildings, if RNG becomes a commodity that gas companies can provide to building owners, microturbines can utilize this commodity to provide 100% zero caron electricity and thermal energy

- [17]Green Hydrogen: An electrolysis process with solar panels or wind turbines can generate green hydrogen. This hydrogen could be blended with RNG for a 100% net zero carbon fuel or natural gas for a low carbon fuel. As mentioned before, if the technologies are capable to use 100% hydrogen, then there is no need to blend. However, the infrastructure to transport hydrogen is very delicate and complicated so, an option to produce hydrogen on site can eliminate this challenge.

- Blue hydrogen: This hydrogen is produced by combining gas and steamed water to produce hydrogen and CO_2 that is later captured. The CO_2 can be sold to different facilities in need of CO_2 for beverages, plants, and other products. The same situation as green hydrogen would apply for transport, infrastructure, and utilization.

Within these solutions the factor of public safety should always be taken into account. As a benefit, CHP systems are capable of working independent of the grid and providing both electric and thermal energy to a facility in the middle of a storm. The U.S has experienced an

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[16] National Grid, "What is renewable natural gas (RNG)?", https://www.nationalgrid.com/stories/energy-explained/what-is-renewable-natural-gas-rng

[17] National Grid, "The hydrogen colour spectrum", https://www.nationalgrid.com/stories/energy-explained/hydrogen-colour-spectrum

increased in numerous natural disasters such as Superstorm Sandy that have caused damages to our grid resulting in electricity outages that can put at risk vulnerable occupants. With the electrification of heat, having a storm can cause a higher risk if the grid's security is not increased.

During a disastrous situation, green power or the transmission of electricity to customers can easily become unavailable. Sky can be too cloudy to harvest solar energy, wind turbines are locked down to protect their blades from high winds, and transmission or distribution lines can be destroyed due to the storm. With a CHP system installed in a building, electricity and thermal energy can be uninterrupted as long as fuel gets delivered to the system. In other words, during a power outage caused by a storm, occupants can still have enough electricity and/or thermal energy for domestic hot water, heating or cooling when a CHP system has been installed with a proper design. Gas is less likely to be interrupted during a storm compared to electricity.

The assistance to offset the carbon produced in the distribution of electricity, the energy savings created, the thermal energy offset as a byproduct, the availability of using low carbon fuels, and the reliability during natural disasters are great benefits to assist NYC in its program to reduce Carbon footprint, encourage building owners to take action in retrofits, increase grid resiliency, and public safety in the energy sector.

Conclusion

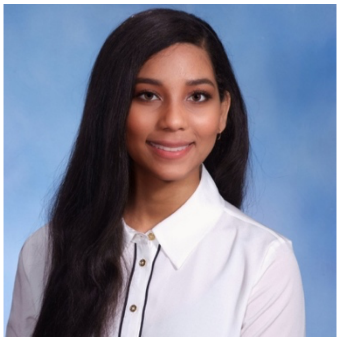
Collaborators between NYC's leading building and energy stakeholder (The 80x50 Buildings Partnership) have recommended climate change policies to reduce building energy use in NYC. However, is very challenging to reduce building energy usage with the current building occupation rate in NYC. The initial incentive through LL97 is relying on more efficient technologies to reduce the unnecessary energy consumption due to old or less efficient solutions.

The transition towards a net zero grid is an enormous gap to bridge. Flexible technologies can make the process easier without reducing the grid's reliability and increasing economic challenges. Microturbines are very flexible due to the higher reliability, carbon emissions reduction, higher energy efficiency, extra energy commodities, energy savings, easy integration to existing buildings and fast design-to-installation process. Supporting this technology will provide more flexibility to building owners and developers for a transition towards a net zero grid.

Understanding the current economic challenges of implementing these solutions in NYC's grid infrastructure, there are long term federal incentives for CHP technology, carbon sequestration and production of low or net zero carbon fuels through the [18]Inflation Reduction Act of 2022 that can support this energy transition. Corporations, institutions, local governments, utilities, and tax-exempt entities are eligible to receive this incentive to

[18] Internal Revenue Service, "Inflation Reduction Act of 2022", https://www.irs.gov/inflation-reduction-act-of-2022

support green energy technologies and decarbonization strategies. With further support from local government agencies, this technology can play a significant part in decarbonization, grid resiliency and public safety in the energy sector.



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During her career, Mariel Gonzalez has obtained experience with microturbine technology including equipment sizing & feasibility studies. Previously, Mariel was with the Sustainability Help Center, a sub-contractor of NYC Dept. of Buildings, assisting building owners with LL84 benchmarking, LL95 energy building grades & LL87 energy efficiency reports.

Miss Gonzalez received her B.S degree in mechanical engineering from The City College of New York. She is a Certified LEED Green Associate by the U.S. Green Building Council and an active member of the Association of Energy Engineers (AEE).