Assessment of Program Options to Support Hybrid Systems with Solar, Storage and Combined Heat and Power (CHP)

Final Report

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Notice

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This is the second in a series of two whitepapers. This paper examines options for program administrators to consider when designing an incentive program for hybrid DER that encourages developer teams and spurs the market. ***The first paper*** *showed how "green resilience" tri-tech hybrid systems consisting of solar PV, battery energy storage, and CHP could work together to maximize energy resiliency for critical operations while minimizing fossil fuel requirements.*

Executive Summary

Observations[1,2] indicate that in just the past few years the confluence of technology, economic, and regulatory changes have bolstered the prospects for behind-the-meter hybrid systems consisting of multiple DER technologies. Expanding the fledgling market for resilient hybrid energy solutions consisting of on-site solar, battery storage, and CHP technologies will require a robust pool of competent solution providers. Some large conglomerates, via mergers and acquisitions, are positioning themselves[3] to be able to deploy hybrid solutions consisting of products and services pulled entirely from within their various divisions (i.e., the "all-under-one-roof" approach). Additionally, smaller companies have begun self-assembling into teams with a designated team leader[4] who provides assurance to the customer that the collection of components will function as an integrated system.

While many of the multi-building microgrid projects being deployed across the country leverage hybrid DER designs, those projects tend to be custom "one at a time, one of a kind" endeavors, which creates challenges for growing the market to scale. Fortunately, single-building projects serving smaller customers can be amenable to some degree of standardization, replication, or simplification, and the market traction that accrues may extend to the marketplace for larger-sized microgrids.

Energy efficiency program administrators can help drive hybrid system growth in microgrid markets by:

- vetting existing solution providers and/or teams to establish a list of those deemed capable,
- facilitating matchmaking to accelerate the formation of additional competent teams to add to the vetted list,
- educating and conducting outreach to introduce prospective customers to the vetted list, and
- incentivizing deployment projects conducted by those on the vetted list.

Ideally, the implementation of project-after-project in an iterative fashion will refine toward a suite of standardized solutions that ultimately can be deployed at scale in the absence of incentives.

The process for vetting solution providers will rely primarily on perceived capabilities, as opposed to actual track records due to the scarcity of existing Solar+Storage+CHP installations. Approaches to accomplish this vetting, while mitigating risk to customers and program administrators, will need to be considered.

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1 https://www.forbes.com/sites/pikeresearch/2018/07/11/der-and-the-role-of-aggregated-demand-management/#32b531853ad0
2 https://cleantechnica.com/2015/05/21/hybrid-rooftop-solar-chp-storage-model-has-potential-says-ge/
3 https://www.greentechmedia.com/articles/read/centrica-play-for-north-american-distributed-energy-dominance#gs.w7awie
4 https://www.habitatmag.com/Publication-Content/Bricks-Bucks/Resilient-Power-Hub

For every project, program administrators must ensure that the solution provider is capable and that quality equipment is chosen to meet the specific needs of the customer. Each proposed project to deploy a hybrid DER system at a specific customer's site will need to undergo a case-by-case technical merit review. Solution providers invest time and money speculatively while courting customers. Program administrators must provide a sufficient degree of transparency expressed via the rules of an incentive program (eligibility, incentive rate, etc.) so that solution providers can assess the likelihood of receiving incentive awards. Unavoidable uncertainty can be mitigated by establishing and publishing benchmarks for what would constitute an acceptable outcome of the case-by-case technical merit review.

Transparent criteria from program administrators will ensure that hybrid solutions are installed with quality components and integrated controls to provide resilient power and meet specific customer requirements. With encouragement from an incentive program, solution providers can assemble teams of CHP, PV, and energy storage developers to implement hybrid solutions and work towards standardized equipment packages. Ultimately, as hybrid DER solutions mature, commercial and industrial customers will have access to proven options for resilient multi-technology power solutions.

Introduction

The New York State Energy Research and Development Authority (NYSERDA) has long supported efficient CHP systems with incentives and technical assistance. In early 2019, NYSERDA declared success with market transformation such that CHP projects are expected to be able to proceed in the absence of subsidies. A vital market-moving feature pioneered by NYSERDA -- the vetted list of quality packaged CHP systems and competent solution providers -- has been embraced by U.S. Department of Energy (DOE)[5] and expanded nationwide. NYSERDA has also established a vetted list of competent solution providers that specialize in solar PV, and as time progresses may establish a similar list regarding battery energy storage.

In our **previous paper**, we assessed the value proposition for hybrid systems using solar photovoltaics (PV), battery energy storage, and CHP. Compared to a single-technology CHP system sized for resilience, it was shown that a hybrid system with solar and storage can incorporate a smaller CHP system that uses less fossil fuel, while maintaining the same level of resilience for the host facility. NYSERDA perceives that to create projects with meaningful value to spur market growth, it will take more than merely tapping solution providers from each of these lists on an ad hoc basis; a well-structured incentive program can accelerate essential marketplace learning.

In this paper, ICF explores benefits and drawbacks associated with different program structures and discusses program design considerations for a new "green resilience" program that encourages efficient hybrid systems consisting of solar PV plus energy storage plus CHP.

Designing a Program Structure to Support Learning Regarding Hybrid Installations

The ability for markets to deliver Solar+Storage or single-technology CHP is relatively strong. However, there is currently minimal alignment of market actors positioned to deliver integrated Solar+Storage+CHP solutions. Today, programs to encourage both solar and storage (either discretely or

[5] U.S. DOE Packaged CHP eCatalog: https://chp.ecatalog.lbl.gov/

paired) are available in at least 9 states and of those, 5 states also separately encourage CHP: California, Maryland, New Jersey, New York, and Massachusetts.[6] Pioneering customers in these leading states can avail themselves of multiple programs to deploy a project with cobble-together Solar+Storage+CHP, but there are no programs that are currently streamlined to specifically encourage installation of a combined solution.

A program to promote a "systems" approach will need to attract all-under-one-roof solution providers and/or inspire the formation of teams with a team leader that can give system-level assurance to the customer. The program will also need to establish and conduct a vetting process to recognize those solution providers who appear to be competent (i.e. creation of a vetted list). Furthermore, the program design must resolve programmatic and project-specific technical factors such as application intake/selection procedures, eligible building types, technology sizing requirements, and resilience capability criteria. Key factors for initial program launch and long-term success are explored in detail below.

Application Intake/Selection Format

One of the main program design features that can affect participant uptake and involvement is the deadline format. Most programs fall under one of two categories: continuously open or deadline format.

A continuously open process would allow project teams to form at their own pace and bring potential projects to NYSERDA with detailed and well thought-out designs, as opposed to rushing to meet a deadline. This approach also gives greater certainty to the solution provider that they will be rewarded for the time and effort they speculatively invest in recruiting a customer and increases the likelihood that solution providers will devote attention to the program. The drawback of launching a new program based on a continuously open process is that the eligibility threshold and incentive rate must be specified in the absence of extensive benchmarks. A continuously open process will fund the conforming applications that are submitted first without regard to whether they may be the best submissions. This drawback is less-pronounced for a topical area where the marketplace is well-characterized with an abundance of benchmark examples.

A deadline format may initiate faster responses from a narrower field of applicants without necessarily driving participation of the most well-qualified applicants, and may also discourage applicants that require more time for complex projects. At this early stage in hybrid DER system development, this could be particularly problematic.

Decoupling key attributes (scrutiny of the team, scrutiny of the project) as two separate processes that can each be administered continuously has been shown to enhance program effectiveness. A continuously-open vetting process to recruit teams for enrollment on an expanding list of eligible solution providers can be complemented with a continuously-open program where eligible solution providers can request award of funds to specific projects. NYSERDA used this approach for its CHP program consisting of Request For Information RFI 2568 paired with Program Opportunity Notice PON 2568.

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[6] According to DSIRE, six states have statewide incentives for energy storage and an additional three states have utilities that offer direct incentives: http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2019/09/DSIRE_Storage_Incentives_September-20191.pdf. Of those 9 total states that encourage storage, five also have current programs or incentives for solar and for CHP.

Forming Project Teams

If left to its own devices, the marketplace may eventually bring forth all-under-one-roof solution providers, and likewise some disparate companies may eventually self-assemble into teams. However, a proactive effort to drive team formation can accelerate the availability of a cadre of solution providers. The formation of project teams is at the center of creating a successful hybrid DER program that delivers well-integrated solutions that the host site champion will find compelling. Given the complex nature of hybrid systems, highly proficient solution provider teams with expertise in solar, storage, CHP, and unifying controller system installation and operation are needed to create replicable and adaptable solutions.

One of the main issues with team formation is addressing the individual motivation of solar, storage and CHP developers and supporting alignment across the team. The unique motivations and considerations of each participant may require the program administrator to play a larger role in bringing teams together and fostering the development of team leaders. In some cases, it may be productive to introduce an additional member to the team who can serve as the team leader. Some potential challenges that may arise when forming teams, fostering partnerships, and developing team leaders may include:

- CHP developers are likely to be motivated to join a hybrid system team because it softens customers' discomfort with the fossil fuel aspect of CHP or because they need solar and storage technologies to receive an incentive. However, in many states, solar and storage developers can still receive other incentives without the inclusion of a CHP system. Some solar and storage developers may not see the additional value in partnering with CHP developers if they already have an established project pipeline and access to incentives through other programs.
- Solar+Storage+CHP systems will require more complex engineering than single-technology systems. CHP or solar developers (with single-technology expertise) may hesitate to take the lead on integrating multiple technologies and building control systems. Furthermore, CHP systems typically require a more involved engineering process than PV systems, especially with regard to thermal utilization. Solar and storage developers are unlikely to be familiar with the engineering requirements of CHP and may be less willing to take on the responsibility of a project lead.
- Project teams will likely need new strategies to overcome the perception of end-users that hybrid systems are too expensive. The additional costs and technical challenges that arise from combining technologies may cause some facility managers to shy away from pursuing these types of systems. From an end-user perspective, the decision to install a distributed generation system is driven primarily by economics and then secondarily for resiliency. Therefore, prime customers for a hybrid DER system may be a sliver of the marketplace where resiliency is paramount and sustainability is crucial and Solar+Storage without CHP is not large enough to meet the site's needs.

The Need for Team Leaders

Given the challenges that exist with individual developers, there is a strong need for capable team leaders to facilitate cooperation and take on tasks that other team members may not be equipped to handle. These team leaders need to be creditworthy and have prior experience developing large projects, preferably across multiple technology types. Some CHP developers with strong records of accomplishment in project development might opt to serve as team leader if adequately motivated by the prospect of a financial incentive. Elevation to the role of team leader may be feasible for CHP developers given that CHP projects are relatively complex compared to solar and storage installations and often already require the integration of additional technologies such as absorption chillers, gas cleanup devices, and remote monitoring and controls.

Microgrid developers or engineering companies that provide microgrid controls and automation software could also emerge as strong team leaders. These entities generally have a strong background in integrating multiple technologies, understand the challenges of integrating with existing building systems, and have experience working with many different types of end-users and utilities. Additionally, organizations that have the ability to provide financing above the program incentive levels could be beneficial team members for the success of the hybrid system.

Energy Service Companies (ESCOs) could also be interested in becoming team leaders and would likely have the necessary resources to do so. However, they are more likely to become interested after other companies – likely smaller project developers – have demonstrated the efficacy and positive economics of hybrid CHP solutions as a replicable service option.

Due to the complexity of designing and implementing hybrid systems, teams may initially be slow to form and team leaders may not emerge organically. Program administrators may need to play a large role in bringing solution provider teams together and driving the development of team leaders. It may be more effective to assemble a congenial crew of solar, storage and CHP developers and showcase them to potential team leads (e.g., ESCOs and microgrid developers), as opposed to ESCOs interviewing individual technology purveyors and assembling them into a crew that they hope will work together productively. Program administrators could organize events to facilitate structured meet-ups to foster team pairings among developers and bring together those that are most suitable for and interested in working on a hybrid system.

Vetting of Solution Providers and their Major Pieces of Equipment

Ideally, a vetting process for solution providers should scrutinize the track record of a multiple hybrid DER projects using the same type of equipment that a given team has installed. However, for a fledgling market such as this, it's likely there will not be a sufficient number of example projects to assess. Furthermore, newly-formed teams may adjust their membership over time as they gain in-field experience with teammates. Favored equipment combinations may also change over time. Therefore, the vetting process should include provisions that conveniently enable swap-outs with "or equal" designations.

As an alternative, a vetting process regarding the competency of the team could consider the following:

- Capability of the team leader to supervise subcontractors.
- Capability of the team leader to offer an assurance plan covering the "system" to the customer[7]
- Capability of a member of the team to perform analytics to size each technology-based sub-system to sum to an overall system size that is appropriate relative to a given customer's loads (e.g., proficiency with a hybrid-capable modeling tool).

[7] Conversely, this could be achieved by the team leader taking the performance risk via Energy Services Agreements (ESAs) or other similar contracts.

- Capability of a team member to furnish and design the controller system that binds each technology-based sub-system into a holistic overall system.
- Capability of each purveyor of a technology-based sub-system (i.e., furnisher of solar, furnisher of storage, furnisher of CHP). Admittance onto a single-technology vetted list of solution providers regarding their particular technology could serve as the basis.
- Simplified review of a request to swap-out a team member furnishing solar, storage, or CHP equipment based on vetted lists of single-technology solution providers.

A vetting process regarding the quality of the major pieces of equipment could consider the following:

- Quality of each technology-based sub-system (i.e., the solar equipment, the storage equipment, the CHP equipment). Admittance onto a single-technology vetted list of equipment regarding their particular technology could serve as the basis.
- Quality of the unifying controller system that binds each technology-based sub-system into a holistic overall system. Conformance to IEEE Standard 2030.7 could serve as the basis.[8]
- Simplified review of a request for swap-out with an "or equal" major piece of equipment could be streamlined based on the replacement piece of equipment having been admitted onto a single-technology vetted list of equipment regarding their particular technology.

Building Types and Template Designs

To encourage the development of highly replicable projects, program administrators may choose to focus on a set of prototypical buildings as primary candidates for implementing hybrid systems and require submission of a "basis for design template" for these buildings (e.g., types of loads to be served for resiliency purposes during a utility grid outage, dispatch configuration to maximize value of the given components during normal days when running in parallel with the utility grid). Buildings types may be defined by the end-user sectors (such as hospitals or colleges) that are motivated by resiliency, are likely to have footprint space for on-site solar PV, and have thermal and electric loads that make them good candidates for CHP. Programs may also identify a focus on building shapes and sizes that can support both CHP and rooftop solar installations.

Initial candidates for hybrid system templates may include hotels, multifamily buildings, and assisted living centers, as well as hospitals and colleges. These particular sectors house vulnerable populations needing to shelter-in-place because they are substantially unable to evacuate or self-rescue during an emergency or grid outage. Use of public funds to incentivize fossil fuel technology in these sectors may be justifiable if it is the option of last resort.

While certain building types and sectors can be ideal for replicable hybrid systems, if program administrators are too prescriptive, these criteria could discourage design teams from bringing forth template designs in other sectors that may be a good fit. For example, certain mid-sized industrial manufacturing facilities may have a strong need for resilience (either for ride-through or for graceful shut-down) and a desire to implement CHP with PV and energy storage. Although these facilities may not tend towards replicable installations, it could be useful to include them as eligible for a hybrid CHP program in order to foster the broadest development of teams and hybrid CHP offerings. Then, as teams

[8] IEEE 2030.7-2017 - IEEE Standard for the Specification of Microgrid Controllers: https://standards.ieee.org/standard/2030_7-2017.html

begin to develop standardized hybrid solutions, the program could move toward supporting only replicable models.

Resiliency Guidelines and Considerations

In regions of the country where the utility grid is still fossil fuel heavy, single-technology CHP as well as hybridized CHP may be embraced for emission reduction benefits, whereas in other parts of the country the justification for continued deployment of fossil fuel fired CHP is based on increased resiliency. Either way, enhanced resiliency is one of the primary benefits of a hybrid DER program, and programs will likely need to specify a minimum essential suite of amenities to be powered during a grid outage in order to maintain critical operations and allow building occupants to shelter in place. This list could include building sanitation services, the heating/cooling of occupied spaces, lighting in common spaces and stairwells, a facility-controlled centralized refrigerator for temporary storage of sensitive medicines, a centralized location for charging of cell phones, and the operation of at least one elevator if present. Program guidelines should effectively establish a targeted resiliency need or critical load, and support projects that install an amount of capacity capable of maintaining these critical functions.

This prescriptive approach is advantageous when designing complex hybrid systems because it sets a threshold that all sites must adhere to. Exceptions could be provided for special cases, or in situations where opinions differ on what the resiliency needs are for a given site. An end-user or hybrid system team may value resiliency differently based on past experience or have a different definition of critical loads than the program defines. The program administrator could develop a process for addressing these differences in critical load definitions and resiliency criteria when they occur between the end-user, hybrid team, and program administrator.

Another important aspect of the resiliency guidelines is the sizing of technologies involved. One of the main goals of a hybrid program is to limit fossil fuel use and maximize solar+storage deployment. Pairing some of the storage to match with the solar may "firm" the solar output, and also pairing some of the storage to match with the CHP system may enable a downsized CHP system that can still handle the inrush current from certain loads (motors, pumps, elevators) on critical circuits during utility grid outages.[9] These resiliency considerations will impact sizing strategies and dispatch techniques for all technologies in a hybrid system.

Technology Sizing Considerations

Sizing strategies can play a significant role in determining an adequate incentive structure for hybrid DER systems. Programs may specify a sizing combination that maximizes solar capacity based on available rooftop space and size the storage and the CHP components to supplement the solar for meeting minimum resiliency requirements. While this strategy would be effective at achieving resiliency and emissions reductions goals, it may not necessarily yield the most economical system. This raises an issue that should be at the core of the program's mission and affects how the program should seek to influence customer actions. Does the program seek to address resiliency at lowest carbon footprint and on this basis lock-in the size of the components, and then determine the optimum dispatch for that fixed set of components? Or, does the program allow an economically-optimized system with fossil fuel

[9] Furthermore, pairing some amount of storage with CHP is expected to improve the dispatchability and therefore the value proposition of the overall system despite the relatively high cost of the storage portion, as indicated by modeling performed by GridMarket. This modeling showed that such pairing yields hybrid projects that would be cost-effective at sites where the single technology CHP option would not have been cost-effective otherwise: https://www.nyserda.ny.gov/-/media/Files/EERP/Combined-Heat-and-Power/2016-Conference/Scale-Potential-Growth-Davis-OBrien-GridMarket.pdf

generation that may be larger than required to deliver resiliency for critical loads? Either way, sizing challenges for each technology will likely arise.

CHP developers have historically expressed their intentions to size CHP to match the baseload thermal requirements of a site to maximize fuel conversion efficiency, but in reality have often up-sized their CHP systems (and as a result they discard thermal energy at times) because it can be economically advantageous to minimize electric purchases from the utility. Whether baseload thermal sized or up-sized, historic sizing of CHP may be higher than the "resiliency need" level. For solar, sizing may be constrained by available roof and ground space on-site, which may also be difficult to account for in development of replicable template design strategies put forward by teams.

Given these potential challenges, program administrators could develop flexible sizing guidelines for all three technologies to account for differences among sites and avoid limiting participation from one or more technologies. Flexible sizing considerations for each technology are highlighted below.

- **Solar**
    - Sized to completely utilize the available on-site, sky-facing space – assumed to be unoccupied rooftop space minus setbacks/corridors, but could include appropriate ground space that is not shaded
- **Storage**
    - Sized to provide firming of the typical daily on-site solar output
    - Sized to enable the CHP system to handle in-rush currents during islanded mode
    - Sized and configured to provide firming and to also address in-rush currents (and thereby enable facilities to ride through a utility outage)
    - Sized to provide for the resiliency need for a chosen duration either with or without the CHP component (in case the CHP system not operational while undergoing maintenance) -- e.g., twelve-hours, three-days, etc.
- **CHP**
    - Size based on resiliency electric load after the maximum potential solar capacity has been determined
    - Size based on requiring the CHP system to have greater than 60% average capacity factor and greater than 70% annualized fuel conversion efficiency
    - As an option, a program could also allow sizing larger than the minimum resiliency need, but the program would only incentivize the portion of CHP capacity needed to meet critical loads
    - Evaluate each project for installing a pair of CHP prime movers (each half the size of the recommended CHP system) to enhance resiliency and expand the turn-down ratio of the CHP system, as well as facilitate the ability to run only one at any given time while bidding the capacity of the other into a demand response program

The sizing guidelines developed by the program administrator may have to balance the ability to provide the greatest amount of fossil fuel reductions with the ability to foster program participation. If sizing guidelines limit the willingness of developers, there may be a lack of quality teams and potential projects would not move forward. Administrators should place a high priority on guiding teams to incorporate within their hybrid DER designs the smallest and highest-efficiency CHP systems.

Technology Integration Issues

On a technical level, the unifying controller systems will need to have the ability to integrate solar, storage, and CHP in various ways. For example, all components may be behind a single utility meter all of the time, or each component might be behind a different utility meter during grid-parallel operation but may become integrated via "private wire" during a utility grid outage. Or, certain hybrid system components may be tied to specific facility loads under different utility meters, allowing generation from solar and CHP to be metered separately while serving critical facility loads.

On a regulatory level, there may be a different set of regulations and standards that apply to each technology. For example, in New York City, the interconnection standards governing the installation of solar versus CHP are different. Solar is allowed to export surplus power to the utility grid whereas CHP typically is not, and it is unclear if solar bundled with CHP behind a single utility meter will retain permission to export surplus power. Differences in standards and processes across technology and jurisdiction create uncertainty for developers and end-users, which adds to project costs and delays project timelines. Lessons learned via a program that supports pioneering hybrid DER projects can clarify these issues and thereby help markets subsequently grow to scale.

Maximizing GHG Emissions Reductions

An important aspect of a hybrid DER program is ensuring that GHG emissions remain minimal, and that all systems funded by the program either represent a cost-effective reduction in GHG emissions compared to the business-as-usual case or represent a tolerable minimized increase in GHG emissions (e.g., as an option of last resort for the sake of resiliency serving vulnerable populations). Motivation for such a program, and program impacts, will vary across the country -- meaningful reductions of GHG emissions might be possible in regions of the country where fossil fuel remains a significant portion of the utility grid mix and is likely to remain so throughout a substantial term of the life of a newly-installed hybrid DER system.

Incentive Structure and Value

For NYSERDA, given that there are existing incentives for both solar PV and battery energy storage, and that NYSERDA's long history of supporting CHP has enabled that technology to achieve cost-effectiveness in the absence of incentives, any incentive "adder" for a hybrid Solar+Storage+CHP system (i.e., an incentive above and beyond the incentives tagged to the solar and the storage aspects) should be intended to address the integration challenge associated with entry into this fledgling market. For simplicity and transparency, the size of the CHP sub-system could be used as a surrogate for degree of complexity, and therefore the "integration challenge" incentive could be scaled to the nameplate capacity of the CHP sub-system.

Eventually, periodic step-downs of the various portions of an overall incentive (e.g., through a megawatt-block format and/or incentive rate declines that occur on certain dates) could ease the financial burden on ratepayers in lockstep with cost declines that accrue via market maturation and internalization of lessons learned. In order to show sufficient consistency and stability to attract market actors who will need to invest sweat-equity on speculation while pursuing customer acquisition, such step-downs should be transparent and should not occur too early in the program. To spur the market, the program administrator might consider taking a measured amount of risk by awarding funds to projects that aren't fully shovel-ready in order to drive initial program traction (such projects could be subjected to periodic check-ins to shepherd them along).

Catalog of Solar+Storage+CHP Kits

As developer teams are formed and hybrid systems are installed, the combinations of solar, storage, and CHP equipment may potentially become standardized in the same way as packaged CHP systems have. If that does eventually occur, program administrators could collaborate (or US DOE could lead an effort) to develop a unified catalog of standard Solar+Storage+CHP kits and solutions providers. The kits could be module-based, enabling the combination of multiple modules so as to configure different size systems depending on available space for PV and facility energy requirements. This standardization will encourage more facilities to install hybrid systems, just as NYSERDA's catalog of packaged CHP systems helped to encourage installations and grow the New York CHP market.

Special Considerations for New York City Climate Mobilization Act

To curb greenhouse gas emissions and to meet larger city and state-wide environment and energy targets, New York City passed the Climate Mobilization Act (Local Law 97) on April 18, 2019. This law is a package of legislation that targets emissions from buildings larger than 25,000 square feet in size, aiming to reduce emissions and increase energy efficiency. The law establishes a cap for emissions attributable to an affected building, including off-site emissions occurring at central power plants from where the building's grid-supplied electricity is sourced summed together with on-site emissions, such as from CHP and boilers at a building. The law establishes an initial assigned emission factor regarding grid-supplied electricity with intention to refine the factor periodically to match the grid's decarbonization progress.

Affected buildings will be required to reduce all such emissions to below a certain cap, with different caps depending on the end-use sector of the building. These targets take effect in 2024, with increasingly stringent targets in 2030, 2035, and 2050. Buildings that do not comply with the new law are required to pay a fine, to be determined by the City.

The enacted limits for different building types are shown in Figure 1, expressed as an emissions intensity in units of annual tons of CO2-equivalent per square-foot of building. ICF analyzed the potential impact of this new law for multifamily buildings and hospitals to assess whether the law would be likely to (a) have no influence on single-technology CHP projects, (b) encourage a pivot from single-technology CHP projects to down-sized CHP incorporated into Solar+Storage+CHP hybrids, or (c) impede the deployment of CHP under any configuration.[10] Based on known examples, this analysis presumed a certain size CHP system relative to the size of a building, a certain capacity factor for the operation of the CHP system, and a certain emissions profile for the CHP system.

[10] Note that the law provides an alternative compliance pathway for certain hospitals.

Figure 1. Emissions Limits enacted by the New York City Climate Mobilization Act

	Building		Emissions Limits (ton CO2e/sf)			
	Code	Occupancy Group	2022-2023	2024-2029	2030-2049	>2050
	A	Assembly	0.008886	0.004439	TBD	TBD
	E	Educational	0.008886	0.004439		
	H	High Hazard	0.008886	0.004439		
	U	Utility and Misc.	0.008886	0.004439		
	B	Business	0.008552	0.004850		
Hospitals →	I	Institutional	0.008552	0.004850		
	M	Mercantile	0.008552	0.004850		
	F	Factory and Industrial	0.005170	0.001374		
	S	Storage	0.005170	0.001374		
Multifamily →	R	Residential	0.007010	0.004339		

For multifamily buildings, the emissions produced by a CHP system are estimated to be on the order of 0.001 tons per square foot, and this leaves considerable headroom under the cap through 2029 for the other emissions that must be accounted for (such as attributable to grid-supplied electricity and/or on-site boilers etc.). Therefore, single-technology CHP may still be a reasonable pursuit for some multifamily buildings. However, hospitals are significantly more energy-intensive and CHP systems are typically sized much larger on a per-square-foot basis. Emissions from a hospital CHP installation are estimated to reach 0.009 tons per square foot, likely making single-technology CHP inappropriate for those certain hospitals that haven't been afforded an alternative compliance pathway under the law. The inclusion in this law of an alternative compliance pathway for certain hospitals can be seen as an appreciation for the importance of resiliency and proven role of CHP at hospitals.

In our **previous paper**, we showed that hybridizing unlocks the ability to meaningfully downsize the CHP system by up to 33 percent, substantially reducing emissions while still maintaining the same level of resilience for the host facility. A hybrid Solar+Storage+CHP system would allow more headroom under the cap compared to a single-technology CHP system.

Summary of Program Considerations

A hybrid DER program as outlined above could encourage solar, storage, and CHP developers to work together to develop hybrid solutions that maximize resilience while minimizing fossil fuel use. Over time, these developer partnerships and equipment configurations could lead to a suite of standardized hybrid system solutions that can be replicated at critical facilities across the state and ultimately can be deployed at scale in the absence of incentives. Hybrid DER seems like a feasible pathway for compliance with NYC Local Law 97 of 2019 for some end-use sectors in NYC and may also expand markets elsewhere throughout New York. Considerations for the design of a successful program to incentivize hybrid DER systems are summarized in Table 1.

Table 1. Hybrid System Program Considerations

Program Features and Descriptions	Potential Strategies to Strengthen Program Features
Application Intake/Selection Format	A pair of a continuously open items (one for of vetting teams, the other for inviting project proposals from eligible teams) may assist in soliciting quality projects from a range of qualified applicants.
Forming Project Teams	The program administrator could play a large role in bringing individual developers together to form teams, and develop strategies that drive the development of team leaders, such as organizing events to facilitate structured meet-ups among engaged developers.
Need for Team Leaders	Team leadership is crucial to the success of hybrid system teams, and program administrators may need to facilitate the recruitment of capable solution provider team leaders, including microgrid developers and ESCOs.
Vetting of Solution Providers and their Major Pieces of Equipment	Key items include capability of the team leader to supervise subcontractors and offer an assurance plan covering the “system” to the customer; team’s capability to perform analytics, furnish and design the controller system consisting of high-quality components; team composition featuring purveyors of the technology-based sub-systems having achieved recognition via prior vetting of their capability and the quality of their equipment; procedure for request for swap-out with an “or equal” team member or major piece of equipment.
Building Types and Template Designs	To encourage the development of highly replicable projects, program administrators may choose to focus on a set of prototypical buildings as primary candidates for implementing hybrid systems and require submission of “basis of design templates” for these buildings.
Resiliency Guidelines and Considerations	In order to develop a baseline that all teams and end-user sites can adhere to, the program should have a straightforward and reproducible way to determine the resiliency need of each prototypical building category, including a way to handle exceptions for individual sites.
Technology Sizing Considerations	Given potential challenges in maintaining strict technology sizing criteria, the program could allow for flexible sizes for each of the three technologies to account for differences among sites and avoid limiting participation.
Technology Integration Issues	The unifying controller system may need to be robust enough to address various configurations when the site has multiple utility service feeds (multiple utility meters). Projects will need to understand the regulatory implications of installing bundled DER technologies on the customer’s side of a single utility meter (e.g., interconnection, export of power, etc.).
Maximizing GHG Emissions Reductions	Require the solar portion of the system to be sized at maximum site capacity, with a size limit for CHP based on covering remaining resilient power requirements.
Incentive Structure and Value	Incentives could be scaled to each individual sub-technology’s need for support to achieve cost-effectiveness and could be boosted by an incentive specific for addressing the “integration challenge” that arises due to the learning curve associated with bundling of Solar+Storage+CHP. Explore periodically stepping-down incentives to ease the financial burden on ratepayers in lockstep with cost declines that accrue via market maturation and internalization of lessons learned.
Catalog of Solar+Storage+CHP Kits	As template designs are successfully installed, programs can encourage solution providers to develop standardized kits of solar, storage, and CHP options for a hybrid system catalog.
Special Considerations for NYC Climate Mobilization Act	Certain building types, like those hospitals that have not been afforded an alternative compliance pathway, may exceed emission limits set by the NYC Climate Mobilization Act when CHP is installed. The program may need to exclude installations for these building within the city’s limits. Hybrid DER may also find markets elsewhere throughout New York State.