Capacity Building for Municipal Zero-Net Energy

Governor's Office of Planning and Research
Best Practice Pilot Program

Benjamin Silverman, CivicSpark Fellow

CivicSpark Sponsor: City of Oakland's Environmental Services Division

August 2016

The Governor's Office of Planning and Research developed the Best Practice Pilot Program (BP3) to formalize the process of providing technical assistance to local and regional partners while capturing the design and implementation of best practices. The BP3 acts as a mechanism to institutionalize the production of case examples of piloted policies or programs recently recommended or required by the State. To learn more about the Best Practice Pilot Program, please visit the BP3 web page. This report is one of a series of case studies supported by CivicSpark, a Governor's Initiative AmeriCorps Program, administered by the Local Government Commission in partnership with the Governor's Office of Planning and Research.

Thank you to the City of Oakland's Public Works Department and the City of Oakland's Environmental Services Division for hosting the CivicSpark Fellow and his project. Thank you to the City of Oakland's Community and Economic Development Agency, the United States Energy Information Administration, and the Urban Sustainability Directors Network for providing information and assistance necessary for this project.

Executive Summary

The purpose of this report is to provide a case narrative of one municipality's project to explore the logistics and process for deep decarbonization of existing city buildings. This project consisted of a high level scoping of existing municipal buildings for their potential to be retrofitted to zero-net energy (ZNE) levels of efficiency and the updating of the City's standard operating procedure for municipal construction to conform to ZNE principals. While the actions taken in this project were largely preliminary, they indicate some of the first steps many cities can take in exploring ZNE as an option for their buildings.

This project in in-line with the California Energy Commission (CEC) and the California Public Utilities Commission's (CPUC) goals for all new residential buildings to be ZNE by 2020 and all new commercial by 2030. While the CEC and CPUC goals are at the cutting edge of climate action strategies in the United States, they will only impact new construction and major renovations. The majority of buildings that will exist in 2050 have already been constructed. Performing deep energy efficient retrofits on these buildings will thus be critically important to reducing our GHG emissions, and greater city capacity will be needed to be devoted to this task.

CivicSpark

CivicSpark is a Governor's Initiative AmeriCorps program that is administered by the Local Government Commission in partnership with the Office of Planning and Research (OPR). The program connects young, emerging sustainability professionals with local municipalities to help build capacity for climate change action. Nearly 50 CivicSpark Climate Fellows are partnered with local and regional governments across California working on a wide range of projects related to reducing greenhouse gas (GHG) emissions and building climate resiliency.

The CivicSpark Climate Fellow partnered with the City of Oakland's Environmental Services Division for 2015 through 2016 was Benjamin Silverman, who was tasked with exploring strategies for switching out natural gas consuming building equipment with equipment that runs on electricity. This task expanded and evolved into exploring zero-net energy (ZNE) retrofitting strategies for municipal buildings. The key outcomes from this CivicSpark Fellow's investigation included a high level scoping for municipal ZNE retrofitting and an updated standard operating procedure for new municipal construction incorporating ZNE language.

Initial Project Goals

The initial scope of the CivicSpark Fellow's project was exploring potential decarbonization strategies for ending natural gas consumption in buildings community-wide. With the anticipation that energy from the electrical grid will become less carbon intensive in the near future, GHG emissions from natural gas consuming equipment will become a more significant portion of the building stock's carbon footprint that will need to be addressed. However, eliminating natural gas consumption in buildings poses many significant hurdles in terms of technical, cost and institutional problems. Nearly all residential and commercial buildings utilize natural gas to provide space heating and hot water, as well as cooking and

some laundry drying. Generations of buildings have been constructed with natural gas infrastructure, representing a massive amount of sunk capital costs. This is further complicated, as the analysis showed, by the fact that there are few cost competitive alternative systems to natural gas presently on the market. This context has led to a lack of consensus from national, state, and regional stakeholders on the need to start envisioning how to phase out natural gas.

Despite political challenges, Oakland, California is a city that offers many ideal features for taking on natural gas consumption to reduce overall emission. Despite being resource constrained, Oakland has a political context open to climate action, a renewable heavy energy grid, and a seasonal climate requiring low heating loads year round, making Oakland an ideal place to experiment with natural gas phase out.

The initial tasks consisted of consolidating and categorizing available alternative technologies to natural gas equipment, specifically focusing on space and water heating. Utilizing efficiency data from an Energy Information Agency report and prevailing PG&E utility rates, energy demand and cost comparisons were made between natural gas and electrical consuming building equipment.

The results showed that even the most efficient electric equipment in the form of commercial rooftop heat pumps were 40% more expensive per quantity of heat delivered than their natural gas equivalents. Electric hot water systems faired even worst, averaging between 2 and 6 times more expensive than natural gas systems.

Barring a method for putting a price on carbon, in present market condition electrical heating equipment cannot yet compete on a purely cost basis with natural gas. With this insight in hand, the project's core focus was shifted. Taken in isolation, replacing natural gas with electrical building equipment is not a viable solution. Combing such a heating retrofit though with simultaneous improvements to overall building efficiency and installation of renewable energy generation, offers an alternative strategy. This led us to consider zero-net energy as a better framework by which natural gas phase-out could be pursued.

Redefined Project Scope and Execution

A zero-net energy (ZNE) building is one that produces the amount of energy from on-site renewable sources equal to the amount of energy used by the building. Such buildings typically achieve this standard through a combination of using passive heating designs, high efficiency building equipment, improved building insulation, and installation of large quantity of solar photovoltaic panels. Through this improved insulation and presence of renewables in newly constructed or recently retrofitted buildings, natural gas consuming equipment can be more easily replaced with electrical alternatives. Less energy is required to heat the same space or quantity of hot water, and that energy can be generated with photovoltaic systems, allowing for alternative systems like an air-source heat pumps to be more cost competitive with natural gas equipment.

While any ZNE building is a triumph, ZNE retrofits pose a number of hurdles that new ZNE construction do not face. The vast diversity of existing buildings in terms of building type, age, condition, standards built to, and systems installed make any one-size-fits-all approach to ZNE retrofits difficult. As shown by the sparse number of demonstrated case examples of ZNE retrofits, there is need for further

study into ZNE retrofits to achieve deep decarbonization of the building stock. This context led to the evolution of the CivicSpark Fellow's project area from natural gas phase-out strategies broadly, to ZNE more specifically.

The better cost savings, the larger climate mitigation impact, the State policy environment moving towards ZNE, and the need for more demonstration models of ZNE retrofits, all lent their weight to ZNE as the preferred vehicle for achieving deep decarbonization in buildings. Furthermore, the lack of reliable data on Oakland community-wide building characteristics and equipment types necessitated a more focused approach. As the City has more authority to effect change in its own building, and has far more reliable data on the energy consumption and equipment installed therein, municipal buildings were decided to be the main focus for this project.

The project developed into two main deliverables looking at the potential and process of implementation for ZNE retrofits for municipal buildings. The first project was updating the standard operating procedure for new municipal construction and renovation to include explicitly ZNE principals and language. The second was a high level project cost scoping and energy savings potential for ZNE projects at 117 municipal buildings. Combined, these two projects present a holistic approach to aligning the process for and goals of future municipal renovations can be in-line with ZNE at their foundations.

Standard Operating Procedure for Municipal Construction and Renovation

The City of Oakland Public Work's Standard Operating Procedure (SOP) regulates the process for all municipal facility renovation and construction projects. The document covers all requirements for a project from the initial contract negotiations, though budgeting, planning, design development, and construction phases. This check-list of project considerations is something that all construction contractors must sign as part of their contract to work with the City.

The SOP was due for updating prior to the CivicSpark Fellow's starting with the City of Oakland in order to be ready for future projects. With the Fellow's assistance, the SOP update was reframed to include ZNE design principals and procedures. The SOP was restructured to ensure that any future municipal new construction or renovation project would be scoped for full ZNE from its earliest stages. Such procedural considerations included discussing ZNE in the initial budgeting phase, establishing target energy use intensity for the project prior to hiring a consultant, the holding of workshops on integrated design approaches prior to the start of the design phase, and the inclusion of a whole host of energy efficient consideration as part of the design phase.

To ensure clarity of the document's purpose, the SOP was split into two documents, one covering project procedural aspects and a second document establishing energy-related standards for municipal buildings. While the procedural document contained the step-by-step project phases previously mentioned, the standards document went into greater detail of establishing baseline sustainable design requirements. Such minimum requirements include prioritizing light emitting diode lamps, orienting the building to maximize potential natural light and passive heating, maximizing solar renewable energy installation, setting minimum standards for wall and window installation, providing plug-in electric vehicle infrastructure, and utilizing electrical instead of natural gas building equipment wherever possible. The energy standards document further establish baseline energy use intensity requirements for each building type the City manages, for which the final building must either achieve or do better.

In this way, the procedural document and the energy-related municipal facility standard are cross-referenced with each to provide a holistic process of achieving ZNE. These two documents will provide future project teams an excellent resource in planning and implementing high performance municipal buildings.

Zero-Net Energy Scoping for Municipal Building

Simultaneously to the work on updating the Standard Operating Procedure, work was carried out to perform a high-level scoping for ZNE retrofits of municipal buildings. The impetus for this work came from a finance coordination initiative launched by the Urban Sustainability Directors Network (USDN). Though this initiative, USDN aimed to connect investors and grant makers with municipalities to help finance local sustainability projects. Municipalities provided factsheets detailing hypothetical sustainability projects that would require outside investors to help fund, the project cost of these initiatives, as well as potential returns on investment from the project. These financing factsheet would be later used to help build better communication between those in the municipal sustainability and financial sectors. The City of Oakland prepared three factsheets for the USDN finance initiative, one of which was looking into ZNE retrofits for municipal buildings.

The ZNE retrofit factsheet covered 117 major facilities to determine rough averages of estimated project costs and energy savings. The primary data used for each building was electricity and natural gas consumption for the last 12 months, type of heating equipment installed, building size, and available roof space. Roof space information was used to calculate potential yearly solar energy yields and cost of panel installation. Building size was used to calculate cost of a menu of typical energy conservation measures utilizing going industry costs on a square footage basis. The yearly natural gas consumption data was utilized to learn the quantity of delivered space and water heating that would need to be offset by electrical air-sourced heat pumps, and the data on present heating system equipment was used to determine the type of heat pumps to be installed. Insulation improvements to windows and exterior walls, while critical for most ZNE projects, weren't able to be factored for due to lack of reliable data on municipal building envelope conditions.

This initial high-level scoping found an average ZNE retrofit cost of between $500 thousand and $1.125 Million per building. Average yearly energy cost savings were estimated to be between $19,500 and $30,000 per building at present utility rates. The wide range in potential project costs and energy savings was a product of the multiple unknowns that came with the analysis. Further in-depth field analysis will be necessary to determine more precisely potential ZNE project scope, costs, and impact.

By preparing the USDN finance factsheet, the City was able to identify a list of top ten to twenty candidate buildings for ZNE retrofits was determined. Those buildings with the smallest baseline electricity and natural gas consumption relative to the most amount of roof space for solar panels were included in this short-list. These buildings comprised several recreational and community centers, libraries, firehouses, and other municipal facilities. This analysis will help to determine which buildings should be prioritized first for in-depth, on-site auditing and scoping for ZNE retrofit in the future. This high-level scoping project will be one of the first steps in eventual deep decarbonization efforts that the City may want to pursue.

Outcomes and Conclusions

Achieving the next generation of leading edge efficiency gains in buildings will likely take the form zero-net energy and Cities can use their position to be at the vanguard of such work. By restructuring the way it approaches future construction projects so that ZNE is a core element of the process from the beginning and establishing a preliminary list of potential ZNE retrofit projects, Oakland can be at the forefront of the market transformations to come.

Equally important to these project outcomes were the lessons learned relative to the difficulties encountered. The lack of city wide detailed data on building specific characteristics and energy consumption proved to be a large hurdle in designing initiatives targeting the private sector and led to the focus on municipal buildings instead. The lack of expert literature and resources on ZNE retrofits in the non-residential sector necessitated a far more preliminary scoping scan than needed to properly inform future projects. In both of these areas, future collaboration with the Office of Planning and Research may be able to provide much in resources and know-how to address these knowledge gaps. A strong focus by OPR on the technical knowledge for implementing ZNE retrofits in municipal facilities will be a great aid to many cities like Oakland interested in being at the vanguard of climate change mitigation. Such technical assistance in the scoping of ideal sites, designing ZNE buildings, and implementing the retrofits would be highly valuable for cities and the wider market.

Replicability

As ZNE technical assistance is developed, other cities may wish to pursue a similar approach of the CivicSpark Fellow's to better engage with that discussion. Such an approach would include restructuring the baseline standards for municipal construction projects, whether in the form of that city's green building policy or internal procedural documents. ZNE doesn't necessarily have to be the sole metric written into these updated standards, but an eye to pushing the envelope on efficiency in the way best for that city should be pursued. Simultaneously, a high-level scoping can be carried out on existing municipal facilities to determine which are best candidates for deep energy efficiency retrofitting and renewable installations. Such an analysis, no matter how preliminary or high-level, can help to inform long-term strategic planning and distribution of future resources.

In the future, the goal of deep decarbonization of the State's existing building stock can be greatly aided by cities, OPR, and industry stakeholders actively collaborating to build up the collective knowledge base of ZNE retrofits. Such knowledge will help to inform future policy changes and financing initiatives to promote ZNE in existing buildings.