# *Zero Net Energy Communities: Three Cities Leading the Way*

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**ABSTRACT**

From components to systems, and from buildings to communities, cities are increasingly playing a larger role in moving towards a clean energy future. This paper examines how three cities are leading the way in achieving zero net energy (ZNE) community goals. Using the cities of Palo Alto, California, Fort Collins, Colorado, and Cambridge, Massachusetts as case studies, we first examine the regulatory and contextual factors impacting and influencing each community's efforts to become zero net energy communities. Key questions include factors such as the role of the utility organization, energy mix, building characteristics and technology, community demographics, key stakeholders, and past sustainability programs and policies.

Secondly, the paper examines how sustainability and climate goals drive city ZNE goals and present an assessment of available community-level ZNE policies and programs, key challenges and opportunities for action. Furthermore, this paper analyzes how cities can work with their utility partners to leverage existing energy efficiency and renewable energy programs, and new opportunities to collaborate on ZNE programs and policies. Finally, the paper concludes with recommendations and best practices for approaches to ZNE communities that is scalable to other cities around the country.

## Introduction

The time for top-down environmental directives is changing and changing rapidly, and cities are becoming increasingly empowered to address energy use in buildings within their communities. In particular, cities are leveraging their unique jurisdiction over land use and implementation of building energy codes to reduce greenhouse gas emissions. In recent years, many cities have begun to establish zero net energy targets and action plans for new programs and policies for implementation.

## Background

Buildings are an essential component of local government sustainability and climate action planning, with ZNE building initiatives as an important next step for implementation. Cities across North America are taking action into their own hands. For example, the Urban Sustainability Directors Network (USDN) has convened 13 cities to advance ZNE communities with commitments to examine pathways, financing and economic impacts of moving their building sectors towards ZNE (USDN 2016). Table 1 provides a snapshot of a number of city ZNE targets and initiatives in this rapidly evolving area. The scope of these ZNE targets and plans varies – ranging from high level community-wide goals to specific goals focused on individual building sectors and measures, and includes many cities beyond those participating in the USDN initiative.

Table 1: Overview of City Zero Net Energy Building Targets

| Jurisdiction | Sustainability Goals | ZNE Approach | Utility Context |
|---|---|---|---|
| **Austin, TX** | Carbon neutral by 2050 (City of Austin 2015) | The city set a goal of making all new single-family homes net-zero-energy capable by 2015. | Austin Energy (municipal utility) – target 55% renewable energy generation by 2025 |
| **Bloomfield, IA** | Roadmap for energy [net zero] by 2030 (Labrador 2015) | Focus on solar initiatives | Bloomfield Utilities Department (municipal utility) |
| **Cambridge, MA** | Reduce greenhouse gas emissions 80% by 2050 (Cambridge 2015) | Energy efficiency in existing buildings, ZNE new buildings | Eversource - Massachusetts Renewable Portfolio Standard requirement of 15% renewable energy by 2020 and an additional 1% each year after |
| **Fort Collins, CO** | Reduce greenhouse gas emissions 20% by 2020, 80% by 2030 (FortZED 2016) | Downtown area zero net energy initiative | Fort Collins Utilities – renewable energy option |
| **Lancaster, CA** | Zero net energy community goal (Mead 2015) | Mandate solar on all new residential construction | Lancaster Choice Energy |
| **Montpelier, VT** | First zero net energy state capital (Noyes 2014) | Investing in biomass district heating and increase solar | Green Mountain Power. All energy consumed to be renewable by 2030 |
| **Palo Alto, CA** | Currently exploring carbon neutrality goals (Jacobson 2015) | Energy reach codes to exceed California minimum requirements | Palo Alto Utility (municipal utility) has achieved 100% renewable energy |
| **San Antonio, TX** | Tracking sustainability indicators for 2020 (San Antonio 2015) | All new construction to be zero carbon by 2030, IECC 2015 code adopted | CPS Energy and other retail energy providers |

Our research shows that most cities with ZNE objectives do so in the context of broader climate and sustainability objectives, but not all. Local government ZNE programs and policies represent a convergence of city sustainability goals that seek to drive deep energy efficiency in combination with cleaner, renewable energy supply. Developments in energy efficiency technology and distributed energy resources including solar photovoltaic (PV) and energy storage have enabled cities to act aggressively to use these opportunities to meet sustainability objectives that protect the environment and support robust local economies.

In this paper, we explore how three cities are leading the way to achieve zero net energy community goals, including ZNE definitions, programs and policies, utility energy mix and interactions with key stakeholders. The cities were selected for their leadership to date.

## City of Cambridge

With a population of 105,000 residents, City of Cambridge is the fifth largest city in Massachusetts. In 2002, the City of Cambridge adopted a Climate Protection and Action plan that set ambitious goals to reduce greenhouse gas (GHG) emissions by 80% by 2050. Since that time the city has become officially designated as a Green Community under the Massachusetts Green Communities program and adopted a net zero emissions goal. Close to 80% of the GHG emissions in Cambridge stem from buildings operations (Cambridge 2015). As such, the City of Cambridge chose to focus their net zero strategies on existing buildings and new construction. Should the city be successful in reaching net zero in the buildings sector, they'll have made significant progress towards making their city carbon neutral.

### Past Efforts

The building stock in Cambridge is primarily made up of residential, commercial (mainly office, labs, retail, and hotels), and university buildings. University buildings account for nearly 25% of the total building square footage in the City (Cambridge 2015).

To meet its greenhouse gas reduction goals, the city has enacted many initiatives related to reducing energy consumption in buildings. These include:

- Building Energy Use Disclosure Ordinance
- Net zero school projects
- Cambridge Energy Alliance to promote local energy efficiency programs

Local efforts include marketing and outreach for Massachusetts state-wide incentive programs, no-cost weatherization services for low-income residents, financing options for solar energy and energy upgrades. City of Cambridge also claims the title of having more LEED certified buildings than any other city in the United States. To monitor the success of its efforts to date, City of Cambridge is currently conducting an updated GHG inventory across building energy use, transportation, solid waste and other emissions sources.

### Net Zero Energy Goal Development

The idea for the net zero goals arose in 2013 when a group of residents brought forward a petition to the Cambridge City Council seeking amendments to the zoning ordinance that would require all new construction to achieve net zero annual GHG emissions. The petition, known as the "Connolly Petition," proposed to focus on energy efficient building design and renewable energy production, and if necessary, regional renewable energy certificates (Cambridge 2015).

While there was support for the amendments, there was also concern about how the proposed changes would affect the local economy. City council and members of the planning board were concerned that requiring zero net energy construction in new buildings would significantly impact real estate development in the city. To explore the issue more closely, the City Council formed the Getting to Net Zero Task Force consisting of residents, subject matter experts, business and property owners and two major universities.

The task force determined that a 25-year course of action was appropriate to achieve net zero targets by 2040. The task force defined net zero as: “A community of buildings for which, on an annual basis, all greenhouse gas emissions produced through building operations are offset by carbon-free energy production. Achieving the net zero objective relies on a combination of energy efficiency improvements, renewable energy production and, where necessary, purchase of carbon offsets or, potentially, credits (that meet specific criteria).”

The definition is similar to the ZNE definitions adopted by other cities, but differs in its requirement for carbon-free energy supply. To achieve its goals, the City of Cambridge “Getting to Net Zero Framework” is organized around five key action areas:

- Energy efficiency in existing buildings
- ZNE new construction
- Low carbon energy supply
- Local carbon fund
- Engagement and Capacity Building.

In the energy efficiency in existing buildings action area, the plan calls for continuing to work with the utilities to adapt current energy efficiency programs and focus more on performance-based incentives, wherein monetary incentives are based on measured GHG reductions. The City has enacted a Building Energy Use Disclosure Ordinance, as a step towards requiring building upgrades at the time of sale or renovation, and for building owners to submit operations and maintenance plans as a condition of occupancy.

In the ZNE new construction action area, the plan would seek to create target dates for ZNE new construction starting with municipal buildings in 2020, followed by residential in 2022, multi-family, commercial, and institutional in 2025, and labs in 2030. The city will also seek to provide incentives for ZNE construction, increase green building requirements, require ZNE performance improvements for existing buildings, and remove barriers that limit improved insulation in historic buildings.

For low carbon energy supply, the city will seek to develop a strategy to procure additional green power, increase building integrated solar by requiring solar ready rooftops at time of construction, and work on an agreement with the local utilities to continue to switch to lower carbon forms of energy supply.

Where it is exceptionally challenging for individual projects to achieve net zero emissions, the city will seek to develop an alternative approach wherein building owners are able to buy into a locally managed carbon fund. Through the Carbon Fund, payments would be made to offset building emissions and create vehicle that is easy to use as an alternative method to zero net emissions.

Finally, the task force suggested that the city develop a comprehensive long term communications strategy around the net zero goals. The communications plans will ensure that key stakeholders remain aware of the city’s progress towards the net zero goals, and are engaged when feedback is needed or desired.

**Challenges to Overcome**

There are several significant challenges that the city faces in reaching their goal of zero net emissions for the building sector in the next 25-years. These include:

- **Large existing buildings stock.** New construction only accounts for 1-3% of the total building square footage in the city each year. Therefore, the great majority of emissions reductions will need to come from the existing buildings stock
- **Split incentives related to owner-tenants.** A large percentage of occupants in both the residential and commercial sectors lease their space and the opportunities for energy efficiency in these spaces are severely hampered by split incentives. Approximately 60% of the housing units in Cambridge are rented according to the Cambridge Community Development Department as is the majority of office space (Cambridge 2015).
- **High energy use building types.** Many university, laboratory, and hospital spaces are highly energy intensive and therefor present a challenge in achieving ZNE without purchasing renewable energy certificates (RECs).

### Implementation

To manage and oversee the process, the city will continue to invest time and resources into monitoring industry trends and updating the action plan as needed. The Cambridge Net Zero Framework stipulates that the overall strategy is to be reviewed and updated every five years and that a Climate Protection Action Committee be charged with issuing an annual report on the city's progress towards its Net Zero Goals documenting what actions have been taken, and the trends in GHG emissions from building operations.

## City of Fort Collins

With a population of 161,000, Fort Collins is nestled in the foothills of the Rocky Mountains in northern Colorado and is home to Colorado State University. The city has a long history of leadership in climate action planning starting as early as 1997, when the city became a member of ICLEI – Local Governments for Sustainability. In 2015, the City of Fort Collins adopted aggressive climate action goals, including community carbon emissions reductions of 20% by 2020, 80% by 2030, and carbon neutrality by 2050 (FortZED 2016).

### Past Efforts

Unlike much of the state, Fort Collins operates its own municipal utility. The majority of Fort Collins Utilities' customers are residential (85%), although a significant portion of energy demand comes from small commercial and large commercial/industrial customers including Colorado State University, New Belgium Brewing and Woodward. In 1998, Fort Collins Utilities became the first utility in the state to offer customers the option to purchase renewable energy.

In 2003, Fort Collins adopted its first energy policy, partnering with the Platte River Power Authority to increase the amount of renewable energy and help homeowners improve efficiency. The policy laid the groundwork for Fort Collins residents and local businesses to have access to a full suite of energy efficiency resources as part of a regional "Efficiency Works" portfolio of programs. Most recently, to promote its zero emissions goals, Fort Collins Utilities also began implementing a feed-in-tariff to support solar PV, based on a fixed-price, 20-year power purchase agreement between the utility and commercial customers (FortZED 2016).

## Net Zero Energy Goal Development

In 2012, the City of Fort Collins, Colorado State University, Colorado Clean Energy Cluster, and other key partners teamed to create Fort Zero Energy District (FortZED) with a goal of creating a 2.5 square mile downtown, mixed-use district into a Zero Net Energy (ZNE) pilot project. The area is estimated to include 45 MW of peak electricity demand, and approximately 10-15% of Fort Collins' distribution system. For the FortZED project, ZNE is measured as site energy usage; however ZNE has not been specifically adopted from a regulatory perspective. As such, a finalized definition has not been established. Initial efforts in FortZED have centered around four projects:

- Renewable and distributed system integration—Focused on distributed resources to reduce peak electricity demand;
- New Energy Communities Grant—Reduces energy demand in city buildings and installs renewable energy technologies;
- Community Energy Challenge—Grassroots outreach effort to reduce home energy use; and
- Green Restaurant Initiative—Encourages local restaurants to conserve energy.

One of the early successes of the FortZED project was the launch of the Renewable and Distributed Systems Integration (RDSI) project funded with a $6.3 million grant from the U.S. Department of Energy and $5 million in local community support. The project jump started FortZED by testing out a number of technologies that reduce peak energy use and integrate renewable energy (such as solar panels) onto the local energy system.

Through the RDSI project, FortZED also included a microgrid demonstration project to understand how to integrate solar energy sources into a microgrid and how to manage demand response on a microgrid. In total, through this project, FortZED demonstrated a potential 20-30% reduction in peak electric demand (FortZED 2016).

## Challenges to Overcome

After many early successes, Fort Collins Utilities and its partners are facing some big questions moving forward. These questions include uncertainty about the types of resources to invest in, where the financing will come from, and the ultimate effect on the city and the utility if efficiency and renewable plans are as successful as hoped. Challenges to accelerated action in the building sector include:

- Developing financing programs and business models that enable more cost-effective and broader uptake of efficiency measures without impacting affordability in Fort Collins
- Addressing issues unique to rental properties
- Finding solutions to address the unique needs of commercial and industrial facilities, and
- Successfully raising awareness and motivating citizens and businesses to understand the benefits of energy efficiency and invest in those solutions.

## Implementation

The FortZED effort is governed through a steering committee made up of members from the city, the utility, the Colorado Clean Energy Cluster, Colorado State University (CSU), and

the community. The utility, the city, CSU, and FortZED are working in close collaboration in order to ensure that efforts to increase the renewable portfolio of the utility are balanced with energy efficiency efforts. The utility has adopted a new purpose which guides the vision, "inspiring community leadership by reducing environmental impact while benefiting customers, the economy and society."

## City of Palo Alto

With a population of approximately 67,000 resident, Palo Alto is known as the heart of the Silicon Valley, and a hub of innovation. Since adoption of a Climate Protection Plan by the City Council in December 2007 and the adoption of updated goals in 2010, the City of Palo Alto has made considerable progress in reducing its greenhouse gas emissions and fostering sustainable practices.

### Past Efforts

Palo Alto has a long history of being a leader in the promotion of sustainable and high-performance building design and construction. Over the past three California building code cycles, the City has developed a green building code that is more aggressive than the State requirements. These efforts have been led largely by Palo Alto's Green Building Advisory Group – a collection of green building stakeholders that includes architects, engineers, contractors and other related parties.

The City's Green Building Program was initiated in 2003 with requirements for green building checklists at early stages (Architectural Review) of an application to ensure an integrated approach for projects. In 2007, zoning ordinance changes outlined voluntary compliance criteria, followed in 2008 by a Green Building ordinance requiring Green Point Rated (Build It Green) compliance for residential projects and Leadership in Energy and Environmental Design (LEED) Silver level compliance for non-residential projects meeting certain size thresholds. Following the 2008 ordinance, City staff has recommended updates to the ordinance to Council each year, including addition of Home Energy Rating System (HERS) requirements for existing homes (Jacobson 2015).

On the energy supply-side, Palo Alto Utilities has provided 100% renewable, carbon-free electricity since 2013. All electricity is now sourced from either large hydroelectric generation, long-term contracts for renewable energy or market purchases of renewable energy certificates (RECs).

### Net Zero Energy Goal Development

Palo Alto has recently increased its efforts to expand ZNE buildings at the community level. In 2015, Palo Alto implemented both an Energy Reach Code Ordinance and Green Building Ordinance that go beyond the minimum requirements outlined by the State of California. The Energy Reach Code requires all new single- and multi-family residential and non-residential construction to be designed to exceed the minimum 2013 California Building Energy Efficiency Standards, Title 24, Part 6 by 15%. Additionally, the Energy Reach Code Ordinance requires new single-family residential construction to be built with a dedicated solar

zone of at least 500 square feet and empty conduit from the building's electrical panel to the roofline - setting up new residential construction to easily accommodate the installation of solar PV.

The Energy Reach Code Ordinance also places stricter energy requirements on existing building renovations, alterations and additions. Existing buildings undergoing renovations have two paths to compliance: "Performance" or "Prescriptive." The Performance compliance path requires buildings to be designed to exceed the state energy code by 5-10% depending on building type. The Prescriptive compliance path requires the building to meet the minimum California requirements for energy performance and install additional measures such as cool roofs, exterior walls with low U-factors, or efficient indoor lighting.

The California Public Utilities Commission has established a goal of all new residential construction in the state to be built ZNE by 2020 and all new commercial construction to be built ZNE by 2030. Palo Alto is looking to implement a ZNE ordinance that would accelerate this timeline. City staff has presented a preliminary timeline requiring larger residential new construction to achieve ZNE by 2017 and some commercial new construction to achieve ZNE by 2025. Guidelines related to specific thresholds for "larger" residential and commercial remain to be finalized.

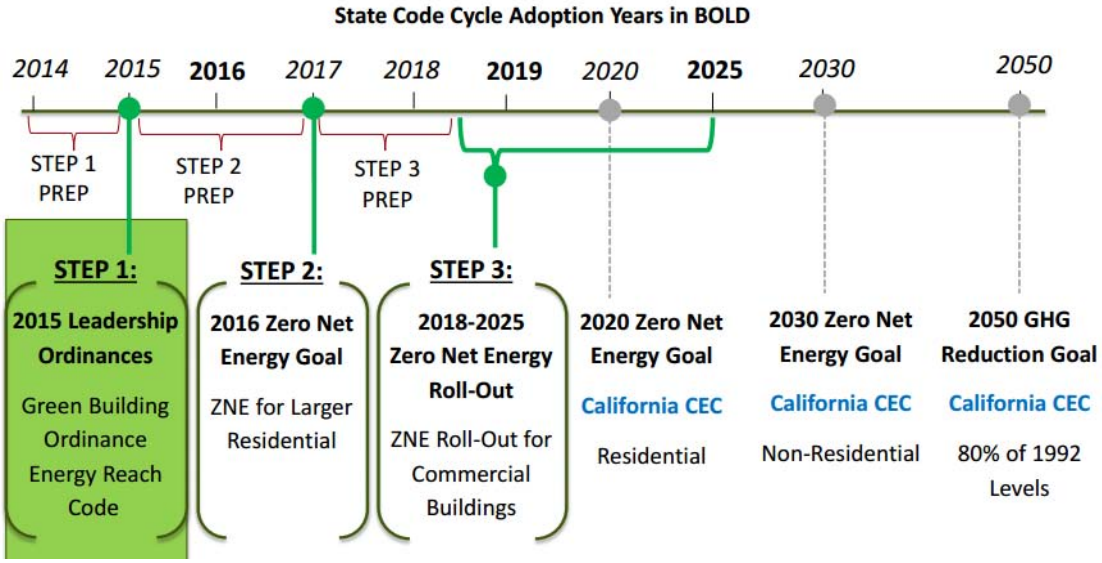


Figure 1. Palo Alto Green Building and Zero Net Energy Ordinance Goals. *Source*: Jacobson 2015.

Palo Alto is still refining their definition of ZNE, but the City's Green Building Advisory Group has emphasized the importance of incorporating zero net carbon into the definition. As California moves towards the "time-dependent value" (TDV) as the metric for defining ZNE – a methodology that places a higher value of kWh consumption avoided during peak times than non-peak times – the Green Building Advisory Board feels the TDV definition of ZNE may be less applicable to Palo Alto since its electricity is already 100% carbon neutral.

The City, in collaboration with the Clean Coalition, is also undertaking the Downtown Palo Alto Net Zero Energy (dpaNZE) Initiative. Launched in 2014, the dpaNZE is targeting 100 existing commercial buildings in downtown Palo Alto for Net Zero Energy by the end of 2017 and is designed to serve as a retrofit example for the rest of Palo Alto and beyond. The initiative is also focused on heavily promoting fuel switching to electrify natural gas applications and

accelerating the transition to electric vehicles. The electrification efforts associated with the dpaNZE will enable renewable energy to power a larger share of building energy through renewable energy generation.

Palo Alto, in collaboration with DNV GL, also launched its new Sustainability and Climate Action Plan (S/CAP) initiative in August of 2014 to chart a path to dramatically reducing their carbon footprint. One major strategy being explored in the S/CAP is focused on achieving ZNE in new residential and commercial construction ahead of California's state-level goals surrounding ZNE. A major point of emphasis in this strategy is working to dramatically lower the number of new natural gas hookups and increasing electrification of new construction through heat pumps for both domestic hot water and space conditioning.

### Challenges to Overcome

One key challenge identified in Palo Alto is related to conflicts between the extensive tree canopy in Palo Alto and solar PV electricity generation. In developing the City's "solar ready" mandates for new construction and ZNE, the City spent substantial time balancing competing priorities in this area. The City's Development Services department has coordinated with the Building Division, Public Works Department and Urban Forestry division to address conditions in which shading from protective tree may impact a solar ready zone. In the event of a conflict between the Green Building Ordinance, the Solar Shade Act, and the Palo Alto Tree Ordinance, the requirement most protective of existing tree canopies will prevail.

As part of the S/CAP development, the city has identified the need to further explore and evaluate cost-effectiveness of ZNE and electrification strategies to support new reach codes and possible requirements for all-electric ZNE new construction and retrofit packages.

### Implementation

The Sustainability and Climate Action Plan (S/CAP) currently under development seeks to provide a holistic frame for sustainability which includes energy use in buildings. Implementation of ZNE strategies city-wide will require collaboration amongst city departments. These include Development Services (building permitting and building code development), Community Planning (land use, floor-to-area ratios), and Utilities (distributed energy resource policies and programs, and electricity and natural gas tariffs). The S/CAP will identify responsible departments and key community partners for implementation, including next steps associated with specific work plans.

## Policy Analysis, Opportunities and Challenges

The cities studied in this paper have differing approaches to ZNE, but all rely on on-site renewable energy generation equal to or greater than the energy consumed. Like climate planning and sustainability, ZNE provides another way for cities to leverage a whole suite of traditional energy efficiency approaches for reducing use, including energy use disclosure, energy efficiency programs and incentives, streamline permitting, education and outreach. Figure 2 provides an overview of the spectrum of policies and programs being utilized by cities striving towards ZNE buildings and community goals.

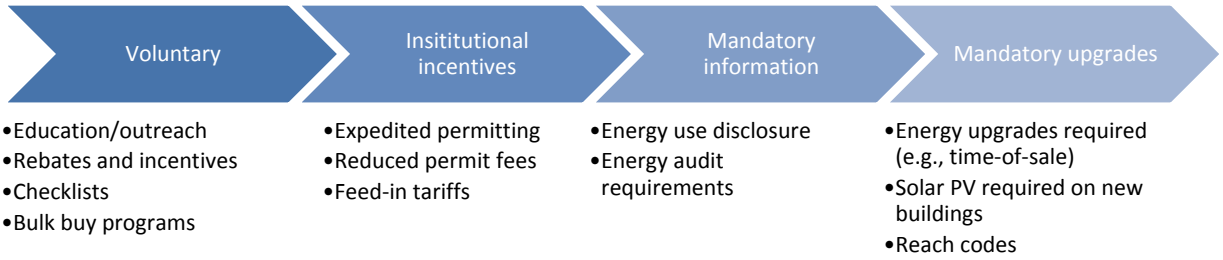


Figure 2: Overview of City Policies and Programs for Zero Net Energy. *Source:* DNV GL

In their ZNE planning, cities are identifying pathways that begin with voluntary and incentive programs, move to disclosure and ultimately to mandatory retrofits and reach codes. In many ways, cities are grappling with the same challenges faced by traditional utility energy efficiency programs including:

- New construction being the easiest to address through mandates because of technology, political, and cost-effectiveness reasons, but it is the smallest portion of the built environment
- Existing buildings are the largest portion of the built environment, but the most difficult to address due to issues such as:
    - Split incentives associate with owner-tenant responsibilities
    - Limited intervention points which are primarily related to time-of-sale, or permitting for other types of building upgrades or remodel
- Market awareness and education for high efficiency systems, electrification and fragmented solar market

On the energy supply side, it is notable that two of the three case study cities have their own municipal utilities. Several municipal utilities across the country have already achieved carbon neutral electricity including the cities of Palo Alto, Alameda Municipal Power and Georgetown, Texas. With the rapidly decreasing costs of renewable energy, the electricity mix in the United States is resulting in lower emissions factors every year. Therefore, cities are increasingly looking to electrification strategies to reduce community greenhouse gas emissions and move away from petroleum fuel sources including natural gas, fuel oil and propane. However, the three cities studied are all grappling with new challenges associated with how to increase renewable energy supply to meet aggressive GHG reduction climate goals, including limited options to displace natural gas GHG emissions with renewable biogas, and community concerns about the aesthetics with locally sited renewable energy systems.

Fundamentally, cities and their utility partners realize that ZNE initiatives are a framework by which cities can articulate a holistic vision for energy in buildings that includes both the demand-side and supply-side components to energy footprint in the community. The cost of distributed renewable energy and other energy resources such as energy storage are falling rapidly, and the urgency related to climate change and reducing greenhouse gas emissions is increasing. Cities are seeing and leveraging a suite of cost-effective tools available to them to address these issues head-on to support sustainable communities and transform energy use in buildings.

## Best Practice Recommendations

The approach taken by cities examined in this paper have shown that local governments understand the importance of prioritizing energy efficiency as the most cost-effective approach to reducing GHG emissions associated with building energy use, followed by renewable energy resources. The energy sector today is characterized by significant potential for disruption and growth with technological changes opening the market for innovative programs at the city level.

City staff, elected officials and community stakeholders are not only aware of the available range of cleaner energy technologies associated with becoming a greener community, but are acting to use these strategies for their benefit. The three cities examined have shown that successful ZNE activities:

- Frame the initiative within a broader set of sustainability and climate principles that involve diverse stakeholders in the planning process.
- Leverage funding from utility, state and federal sources including the U.S. DOE which just announced Smart Cities initiative that includes many renewable energy technologies, microgrid, etc.
- Focus on “quick wins” and achievements that leverage the complementary efforts related to energy use disclosure, utility energy efficiency incentive programs and energy reach codes

Moving forward, cities are grappling with the development of metrics to measure progress, GHG emissions, and energy use which are important areas that require coordination with utility partners. Even cities with municipal utilities recognize the silos in place and the limited access to energy data that city planners and sustainability staff need for effective community programs, policies and outreach. Cities and their utility counterparts have a mutual interest in sustainability goals and clean energy, but bring different resources to the table and unique tools to achieve community ZNE objectives. Local government staff need information on energy consumption in the community to plan citizen engagement strategies and offer services, as well as facilitate energy use disclosure programs, but they don’t have access to such data. For their part, utilities don’t have the same ability to adopt building reach codes, or require new buildings or existing buildings to complete energy upgrades. The benefits of collaboration are apparent, and more work is needed to align city sustainability and ZNE objectives with utility objectives for efficiency, reliability and new utility business models.

## Conclusion

From individual buildings to neighborhoods to entire communities, cities are increasingly driven by sustainability and climate goals to move towards a clean energy future that reduces energy use in buildings and increases renewable energy generation. While the case studies showed that each city is unique, the approaches and lessons learned will help other communities to engage its residents and businesses in implementing zero net energy goals that chart a path to a more sustainable future that improves quality of life and promotes economic prosperity.

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