CITI2zero – Building Sustainable Communities Driven By Zero Energy at Scale

Mindy Craig, Principal and Dave Hewitt, Senior Consultant BluePoint Planning

"This one trend, climate change, affects all trends."
- U.S. President Barack Obama, 2015 Paris COP21

Abstract

Buildings and their energy use account for 41% of carbon emissions in the United States (DOE 2011). Building-by-building approaches are insufficient to achieve significant change. To make a real impact, district-scale approaches need to be employed. Net Zero Energy (NZE) Buildings are the leading demonstrators of advanced energy efficiency integrated with renewable energy, demand management and storage. While NZE Buildings are remarkable examples of how to reduce the carbon intensity of a building; NZE Districts can have much greater impact through larger scale, better economics, enhanced grid interfaces, and improved resiliency. District-scale approaches can consider new and existing buildings, as well as water, transportation, and waste. Implementing NZE at a district-scale provides multiple financial and economic benefits, particularly when leveraging the costs to upgrade and replace aging infrastructure in conjunction with the reductions in the cost of renewables and energy storage. NZE Districts also provide scale and locational value to benefit the grid. Achieving these multiple benefits is complex and requires broader thinking, planning, and understanding than is currently in practice. This paper provides a framework focused on developing leadership and strategies to encourage the adoption and implementation of NZE Districts. Specific attention is given to the soon to be updated California Long-Term Energy Efficiency Strategic Plan, which will incorporate specific strategies and approaches to develop and leverage NZE districts as a critical means to meeting the State's carbon goals.

Introduction

Energy is a driver - of economies, policy, government, development and climate change. This paper looks at a potential transformative solution that uses energy and climate drivers, in conjunction with dynamic changes to the electric grid, as a means for positive change embodying the promise of more sustainable communities. The solution is found by:

1. Leveraging the "infrastructure imperative" and our need to rebuild and re-envision our energy distribution infrastructure;
2. Recognizing that a community scale approach is critical to scaling energy efficiency and renewable energy to meet Climate goals; and,
3. Optimizing local government's interest, ability and need to make substantial investments to reduce carbon emissions, beyond building energy use.

In the simplest terms, the solution is the development of zero net energy and zero carbon districts as a part of community planning and development. The proposed solution is aligned with the challenge and opportunities of a changing electrical grid, specifically including the grid benefits and community resiliency attributes of distributed energy resources. The paper provides a broad look at non-technology specific solution sets, identifying the strategies needed to change markets including the development of new business models and the involvement of new market actors.

For the purposes of this paper, a district or community (used interchangeably) is defined as a campus (educational, municipal or corporate - frequently already served by a district energy system of some type); a commercial district (downtown, neighborhood mixed-use retail); a master planned development (such as a residential subdivision or an urban redevelopment area). Typically, the district referred to in this paper has a commonality that allows for ease of organization and financing, ranging from ownership of the land and buildings to a business improvement district, special tax district or redevelopment planning area. A district may include any mix of new and existing buildings and addresses integrating efficiency, distributed generation and energy storage along with water conservation, zero waste and alternative transportation systems. Renewable power sources are located within the community and are not imported.

Figure 1. Green Building Motivation

A sustainable community is defined in a number of ways, however nearly all definitions include a balance of multiple measures for success, including economics, transportation, resource conservation, equity and more. In this very broad picture of sustainability, energy is one element. However, it is a critical one and often a primary driver for sustainability.

Another important aspect of sustainability is how we create, manage and reuse our buildings. Buildings consume a tremendous amount of energy and costs, as discussed later in the paper, for operation as well as in construction. A survey of commercial business owners and green building firms indicates that energy costs are the number one motivator for clients to demand a green building (Figure 1). Importantly, the benefits owners take away from their green, energy efficient buildings are comfort, health, and employee retention to name a few. (McGraw Hill 2011) This dynamic indicates an opportunity to grasp distributed energy resources (including efficiency) as a tool to support more sustainable development overall.

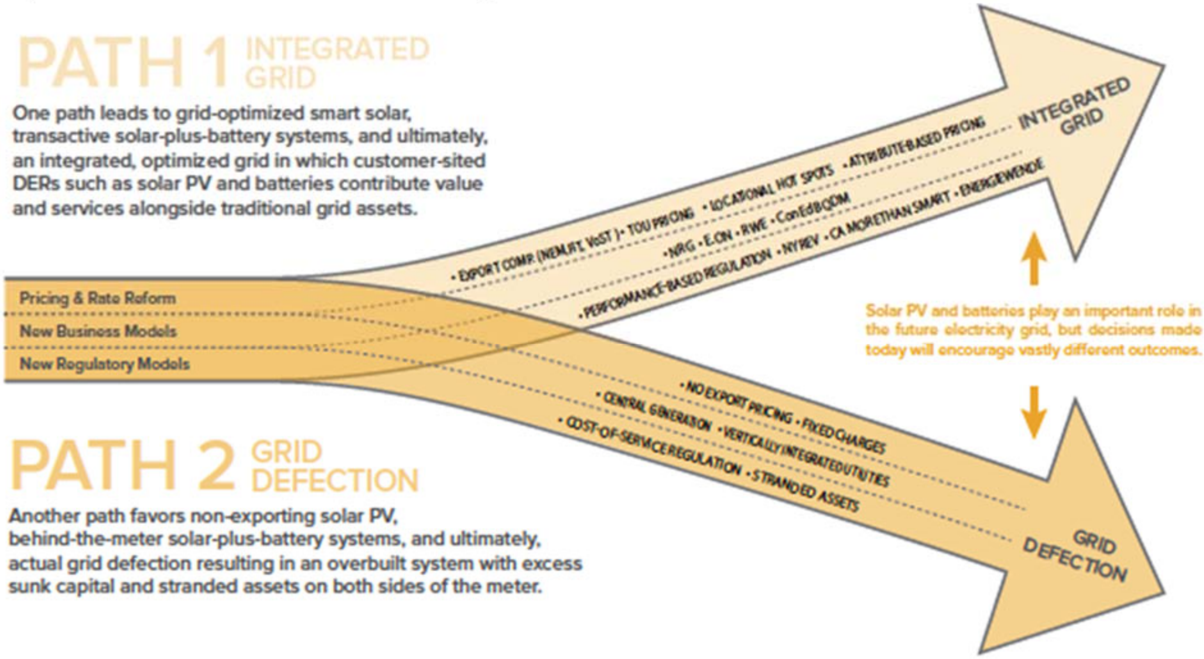
The Challenge and The Possibility

Infrastructure Imperative

The Association of America Society of Civil Engineers (ASCE) estimates that the United States needs to invest $3.6 trillion dollars in upgrading its massive and complex infrastructure system including the electricity grid, transit networks, roads, dams and much more. The continued delay in making these improvements and lack of political and economic will to upgrade this infrastructure threatens US economic vitality and quality of life. (ASCE 2013)

The electrical grid needs alone are estimated at approximately $11 billion per year or about $107 billion by 2020. The Rocky Mountain Institute (RMI) completed a study in 2015 on

Figure 2. Two Paths for the Grid: Integrated or Grid Defection



Source: RMI 2015

"The Economics of Load Defection" and in it estimates that the costs of grid infrastructure improvements to be $2 trillion dollars between now and 2030. More importantly, RMI indicates that these costs are to be paid by customers who have a better economic solution with solar-plus-battery options. This increasing viability of grid-connected, solar-plus-battery customers, has raised concerns with utilities about grid defection, stranded assets, as well as rising inequalities among customers who can purchase these systems and lower income customers who cannot. RMI posits two potential paths forward as illustrated in Figure 2, the evolution to an integrated grid with storage, demand response, and optimized placement of PV or a model that creates overproduction of assets and ultimately grid defection. (RMI 2015) Can NZE at a district and community scale leverage this challenge to transform it into a solution for aging infrastructure stability and sustainability?

Historically, NZE and onsite renewables have been considered a liability for the grid, pushing the limits of this one-way system. This concept is changing dramatically. The new idea is that NZE buildings and districts can be resources for grid management, if appropriately distributed. This idea of locational value can help utilities better assess and manage their distribution networks on a daily basis, as well as in emergencies or major events. For example, the CPUC in California is actively addressing this opportunity in current proceedings and is directing utilities "to identify optimal locations for the deployment of distributed energy resources". (CPUC 2015)

Community-scale: Moving beyond a Building to Building Approach

The Department of Energy (DOE) estimates that the Commercial and Residential Building Sector consumes 41% of all primary energy in the US, substantially more than the transportation or industrial sectors, and 10% of the water. (DOE 2011) Understanding the magnitude of this vast consumption of energy resources, states and cities are aggressively addressing the building sector energy use with strict codes and standards policies, programs like LEED and ENERGY STAR, and broad planning efforts such as California's goals to increase energy efficiency in existing buildings by 50% and transform all new residential buildings to ZNE by 2020 and all new commercial buildings to ZNE by 2030.

Building energy efficiency has made commendable, yet somewhat uneven, incremental progress in carbon reduction. The amount of estimated investment for energy efficiency upgrades for existing buildings is tremendous for both commercial and residential buildings. "Commercial building owners and managers will invest close to $960 billion globally between now and 2023 to retrofit existing facilities with more energy-efficient heating, ventilation and air conditioning, windows, lighting, plumbing fixtures, and other key technologies." (Clancy 2014)

The move towards NZE buildings promises to harvest even more of these savings. The California Energy Commission estimates that new NZE commercial buildings will help to avoid the development of up to eight 500 MW power plants. The potential savings in the existing buildings sector, if we are able to achieve NZE, is even more substantial. However, at the current pace, these savings are not happening rapidly enough to achieve aggressive climate change goals.

Energy efficiency programs have largely been directed at the building and/or individual customer scale, providing services to individual structures, often ignoring any loads outside of the building shell. Adopting community scale efforts for renewable energy is becoming more and more attractive and is clearly a more economically viable approach than building by building. NZE buildings have demonstrated how to link deep efficiency with renewables and advanced building operation to achieve remarkable energy performance. Community scale efforts have the ability to address and encompass existing buildings in a NZE District by sharing renewable power, storage, enhanced controls and other elements, enabling a more sustainable approach to development. However, full integration of NZE lessons into sustainable urban planning will stretch both project boundaries and planning skills to achieve an integrated district-scale technical approach.

The approaches used in NZE buildings can be applied to the district scale more holistically and it is usually more cost effective to place solar PV or other renewable sources in larger district scale installations. In addition, the larger scale makes NZE resources more valuable to the grid. The local renewable power that is part of NZE can be shared among multiple buildings, creating a wires-based "district energy system" rather than the more traditional pipe-based warm and/or cold water system used in some communities today. The renewable energy system can be enhanced through storage of electricity, and possibly through ice or hot water storage either at the shared community solar site or connected to the systems in individual buildings. This kind of integrated system can provide a level of resiliency or back-up power during outages. The system also serves to help manage energy loads to flatten power requirements and reduce peak demand. The system can also serve transportation needs through supplying power to charge electric vehicles either during off-peak hours or when renewables are plentiful.

Given the grid impacts, where such a system is placed relative to grid requirements can vary substantially, and properly located, could be very valuable to utilities in reducing peak power and transmission/distribution needs. A community scale system could also benefit from direct control by the utility to better match distribution needs throughout the day. Clearly, leading edge buildings are no longer passive users of energy, but can also generate, store and interact with the grid at a very sophisticated level. Expanded to the community scale, costs can be reduced; financing, development and management options expanded; grid connectivity and locational value enhanced, and the energy and carbon benefits can reach a broader array of buildings and into transportation energy.

Major Markets for Community Scale

Local Government

The Carbon Neutral Cities Alliance is a new collaboration of seventeen international cities committed to achieving aggressive long-term carbon reduction goals and supported by the Urban Sustainability Directors Network. The Alliance aims to address what it will take for leading international cities to achieve deep emissions reductions including implementing best practices for achieving "transformative" deep carbon reduction strategies in urban transportation, energy use, and waste systems.

Nationwide, 34 states have adopted climate action plans, and hundreds of cities have adopted their own local plans, with more everyday. In California, the Public Utilities Commission (CPUC) has authorized ratepayer funding for energy efficiency for two Regional Energy Networks managed by local governments in Northern California and Southern California, representing nearly two-thirds of the state's population. In addition, the CPUC has authorized the development of Community Choice Aggregators (CCA) who can both purchase power for customers and manage energy efficiency programs. It is expected that in the next year dozens of cities and counties will become CCAs. The CPUC has made this change in light of understanding that investor owned utilities have limits to their effectiveness and flexibility to address the increasingly complicated and integrated energy landscape.

Local governments see energy efficiency and other sustainability measures that address climate change, as part of their mission to meet constituent needs, local economic development interests and their overarching sustainability needs. Local governments play a critical role in the development of their communities through general plans, urban design guidelines, and building permit and code management and compliance, as well as influencing transit and transportation policy. Local governments also oversee a broad range of public buildings, including city administration buildings, park facilities and schools and institutional buildings. Together, all of these roles and demands make local governments take an integrated approach to their planning framework and are positioned to be a major part of the solution for more complex integrated ZNE Districts.

Two examples of this are the City of Cambridge, Massachusetts and Fort Collins Colorado. Cambridge has recently adopted a ZNE Action Plan to transform the entire city to an aggregated Zero Net Carbon Community. Specifically, "A community of buildings for which, annually, all greenhouse gas emissions produced through building operations are offset by carbon-free energy production." (Integral Group 2015) They are leveraging their existing policies, including a Climate Action Plan, relationships with building owners in the City, particularly the large universities such as Harvard and MIT who represent the highest energy demand, and other stakeholder processes leading development in the City.

In Fort Collins, the city and its municipal utility have worked with the Colorado State University and a variety of private businesses (Colorado Clean Energy Cluster) to develop FortZED. FortZED is a zero energy district planned for the university and the downtown business district. Building off this initial project, the city recently adopted a plan to achieve 80% reductions in carbon emissions by 2030. (RMI Outlet, March 4, 2015)

Campuses

Another major audience for district scale solutions is corporate and campus planners, such as business parks, multi-building corporate headquarters, colleges and universities, school districts, government building complexes and hospital/medical complexes among others. A key advantage of these audiences is that decision-making structures are already in place to handle administrative, land use, financing and construction and operation, and many of these audiences already have some version of a micro grid or central power plant or at least back-up generation.

Table 2. US District Energy Systems

System Type	No.
Colleges & Universities	400
Community Utilities	119
Healthcare Installations	251
Military/Gov Installations	41
Airports	10
Industrial	13
Other	3
Total	**837**

Source: IDEA 2009

The International District Energy Association (IDEA) has quantified the number of district energy systems in the United States, as well as what kind of owners managed them. In 2009, there were 837 district systems (Table 2) nationwide and colleges and universities were the largest owner with 400 systems, followed by healthcare installations and community utilities (IDEA 2009).

Stanford University has just completed a $430 million dollar project to reconstruct its campus district energy system from a traditional gas fired heat and power with steam distribution to electrically powered combined heat and cooling with hot water distribution. The project was initiated to replace aging and obsolete infrastructure, and then designed with sustainability as a primary driver. Part of the investment was replacing heating and cooling equipment in a variety of existing buildings to be compatible with the new system. The project is estimated to cut Stanford's GHG emissions by 50%, save 18% of drinking water, and save nearly $300 million over the next 35 years. (Stanford 2015)

Master Planned Developments

Planned residential developments are another audience for community scale. A variety of subdivisions have featured individual houses with some solar or even NZE. In most cases, it will be more economical to develop renewable energy at the community scale rather than on individual homes. Subdivisions are planned new loads from a utility perspective, so understanding the benefits beyond just the residential community, e.g. to include adjoining or incorporated community facilities schools or retail businesses, can assist load diversification.

Other master planned developments, such as urban brownfield redevelopment, are also opportunities to consider NZE at the district scale. While such projects are not common, they are typically significant in scale with major economic impacts. Again, control of the project is typically in the hands of one developer, who can make critical administrative, financial and land use decisions in close collaboration with city planners and regulatory agencies. Long-term management options could be placed in community control, or financing, development and long-term management could be provided by the local utility or a third party.

Developing an Integrated Framework – Citi2Zero

Moving to district-scale approaches driven by integrated infrastructure systems that involve efficiency, renewables, storage, transportation and controls will dramatically change the relationship between buildings and the grid. Building on successful models and approaches discussed above and others, this approach offers an opportunity to streamline and standardize, to an extent, how to establish and manage NZE Districts. What's more, by leveraging the economics around this essential infrastructure, there is an opportunity to create a truly integrated solution that can drive deeper sustainability. We propose a framework – CITI2zero (Community-Scale Integrative & Transformative Infrastructure for Zero Energy) – to inform and direct the creation of community-Scale projects in all markets. There are 5 major components to this framework:

1. **People** –local government, the building owners, building operators, utility and the tenants who will drive the flavor of the District and have the ability to influence policy, behavior and investment

2. **Renewable Infrastructure** – A renewable power system that optimizes the grid and integrates storage, electric vehicle charging, advanced controls and distribution

3. **Buildings** – a dynamic mix of new and existing buildings that in aggregate achieve zero energy and increasingly zero carbon

4. **District Fabric** – the back bone of the district with the integration of all the other key infrastructure systems including water/sewer, waste, transportation and landscaping informed by land planning and urban design for sustainability

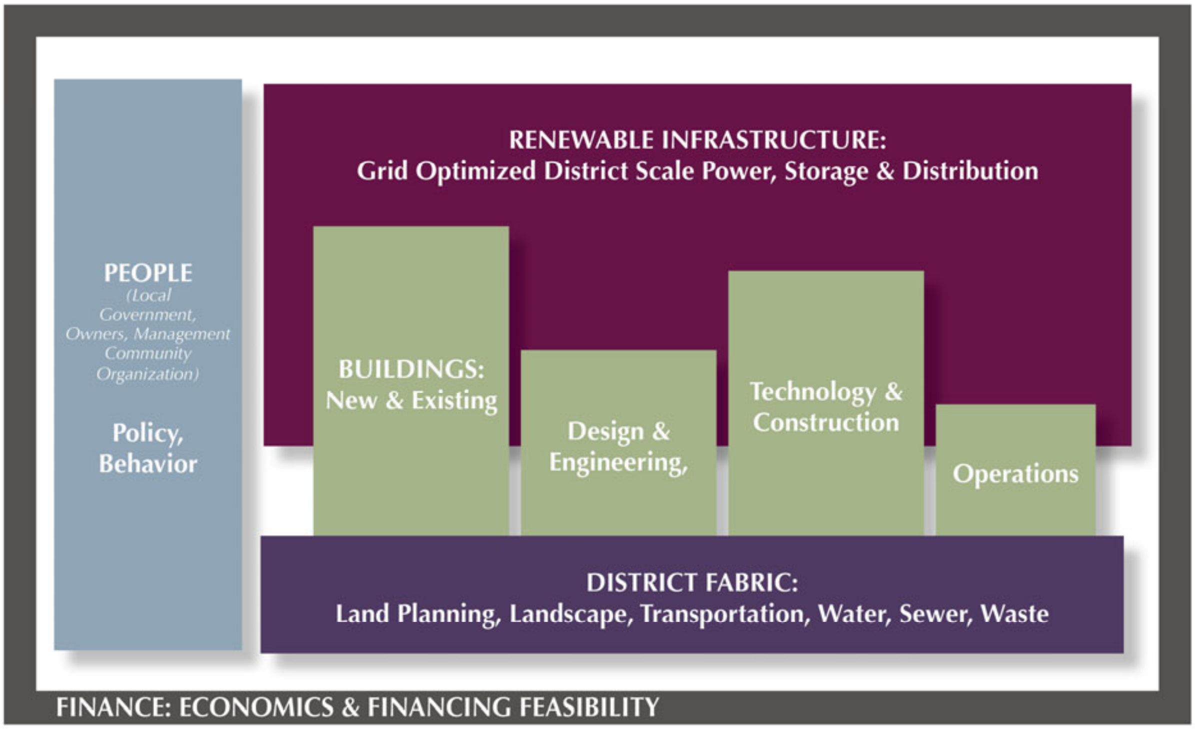
5. **Finance** – at each level, economics and financing is considered and maximized and the organization of the District enables district-wide finance tools

Within the CITI2zero framework, efficiency has a different value well beyond the energy savings and/or demand savings, as the locational value in the grid will likely be a primary component of the value. Within the district-scale system, efficiency will be used as a way to optimize the value of the onsite generation, storage and demand control. The scale of the district system should be sufficient so that ongoing maintenance and operations clearly can be monitored and acted on to optimize overall system performance over time. As loads within the community change, for example due to changes in tenancy, there will be a capacity at the site to monitor, adjust and optimize.

The CITI2zero framework clearly moves electricity use in buildings into the hands of another set of planners and implementers, primarily at the city, campus or community level. It also changes how utilities deal with the customer, as there is now another element to the system. There will need to be a new set of tools to assess, exploit and manage the best opportunities.

Another critical aspect of the CITI2zero framework is the tenet that each community start by evaluating and understanding its particular strengths and assets and build a sustainable community on those. While best practices will still be important, the existing infrastructure of the

Figure 3. CITI2Zero Framework



community should be the first layer to influence and drive strategies to achieve Zero. Some of the elements that might be a driver would include, but not limited to, an existing district level energy system, a major new redevelopment opportunity (i.e. a Military Base closure), or critical infrastructure improvements to roads, sewer pipes, gas lines or similar.

The following is a brief summary of the key strategies and considerations to implement the CITI2zero framework and is not designed to be exhaustive in this limited paper.

People: The New Players

Connecting and engaging all the potential players in a District project is essential to success. Models such as developed by Architecture 2030 and the 2030 Districts initiative is a good example. Each District 2030, led by the City, focuses on engaging building owners and essential stakeholders within a geographic area to commit to and ultimately reduce their carbon footprint through sustainable operations and construction of their buildings. A number of major cities such as Dallas, San Francisco, Seattle and Los Angeles have joined the program and are using it to get substantial commitments for energy reduction. (Architecture 2016) Building on this model of commitment and engagement is an important first step that can be expanded to further integrate city planning and finance into the effort.

In addition, there is an opportunity for substantial utility involvement in community scale systems. Municipal utilities have been the primary drivers of community scale solar system to date, and utilities offer a wide variety of technical expertise, especially including how to best integrate with the grid, as well as financing, construction management and operation. It is likely that different states will make different regulations regarding the appropriate role for utilities, and speculating on the politics of utility involvement is beyond the scope of this paper.

In many cases, utilities are probably best positioned to act as partners, rather than directly as the developers, due to the complex nature of the community engagement. City governments, college administrators, corporate Vice President's of Finance and other key players will likely both need and want to be an essential part of the development process. The deep engagement of the community surrounding the distributed energy resource is a critical aspect of orchestrating the deal, and likely will require significant participation from institutional or corporate leadership.

Renewable Infrastructure

Establishing a feasible renewable power source is a key component to a NZE District. PV is an increasingly cost effective approach, especially when implemented at a District scale. The challenge with PV is locating it to optimize the generation potential and ensuring there is enough reliable power for a district year around. There is an opportunity to integrate Direct Current (DC) to DC connections to allow for Electric Vehicle (EV) charging and for the future of potential DC appliances to maximize solar production. Shading, small building footprints, and viewsheds are all potential issues that need to be addressed.

Integrating storage with a renewable energy system is critical to ensure reliability. While the rapidly dropping price of battery storage is making them more attractive, providing lower cost storage such as ice and hot water, and optimizing the grid benefits of electric vehicles, are additional ways to increase utilization of renewable resources. New technologies in storage, such as District Scale flywheel storage, are moving quickly and will need to be evaluated as potential solutions.

Other renewable power sources are being developed and refined to work more effectively at the community scale. This includes new approaches and improvements to wind power, geothermal and others. Depending on the building mix, scale, existing infrastructure and other variables of each district, one or another power generation approaches may be appropriate, and as technologies advance, considering broader options for renewable or a suite of options is important.

Buildings

NZE buildings are technically feasible for nearly every building type (hospitals and high rise buildings are more challenging). Current NZE buildings include careful and comprehensive design/construction combined with some less common technologies (ground source heat pumps, ductless heat pumps, LED lighting, daylighting technologies, radiant cooling and direct outdoor air systems, for example), all technologies that are currently available to the design and construction industry.

Cost is a complex issue for NZE building projects. However, a variety of NZEs have been designed and built within normal cost parameters and the largest identifiable incremental cost – the PV system – has dropped dramatically in price over the last few years. NZE buildings that are part of a community system may well move the incremental costs of the solar, storage and perhaps some HVAC elements into the community system, thereby moving these costs out of the building's capital budget and into operating costs. There may also be additional space available in the building available for occupancy rather than mechanical systems, creating an additional benefit.

For single family residential, community scale renewables and storage makes NZE more practical. A recent Market Characterization Study from TRC Energy Services for the California utilities states that the Zero Energy Ready Home is making an impressive entry into the California housing market. The study identified only sixteen NZE homes in California, but over one thousand ZE-ready and near ZE homes. The study states that "the diversity of builders and locations of ZE-ready, near ZE, and NZE homes indicates that this type of construction is feasible under different contractor business models and in different climates." (TRC 2015) Combining single family develops with nearby businesses and schools into a ZNE district could help balance daily electric loads and may be beneficial to project economics.

District Fabric

Once we broaden our scope from a building-by-building approach, the opportunities and promise of leveraging other important areas of sustainability is much larger. By taking an integrated perspective, the potential ROI and benefits become larger and appeal to a broader audience. At the district scale, considering transportation and alternative transportation networks (bikes, transit), integrated gray water and black water systems, sustainable storm water management and landscapes becomes feasible. The EcoDistricts initiative, which has a deep and important focus on equity, urban planning and integration of transit-oriented development with a vision to create "Just, resilient and sustainable cities, from the neighborhood up" is doing just that. Participants include Austin, Atlanta, Washington DC, Los Angeles and Denver. Each city is focusing on a smaller district within their city for the EcoDistrict. Their model incorporates the entire ecology of place. (EcoDistrict 2016)

Finance

Establishing an effective financing mechanism that can be sustained for initial development and through operation of the District is a crucial requirement. There are multiple strategies and opportunities including the utility development, third party development, and local government options to finance a broad spectrum of components at the ZNE District. The ownership strategy and financing mechanisms will differ from project to project and will sometimes require creative arrangements and partnership development. Typical approaches may include private-public partnerships, bond financing, developer led funding and others.

Public financing elements may require the careful designation of what is considered part of the District, similar to establishing a special tax district. This can be done in concert with community leaders, building owners, tenants and other essential stakeholders. In certain cases, existing designations may exist such as a business improvement district (BID) or Downtown/Main Street Association, or may fall within an existing planning construct such as a specific plan area, streetscape plan or master plan. Depending on the type and mix of the district buildings, multiple forms of financing will need to be assessed and considered.

California has developed a mechanism that is well suited to this type of development – an Enhanced Infrastructure Financing District (EIFD) that values infrastructure improvements and establishes a clear stream of funding that can be used for public infrastructure projects (except for schools), as well as some private projects. “EIFDs rely on the principle that, if you build something, it creates value. If you zone something, it creates value. Infrastructure also creates value. That value—because of the way the financing instruments have been arranged—can be captured.” (Pisana and Silva 2015)

A Path Forward

“But when we want to shake things up and instigate change, it’s necessary to break free of familiar thought patterns and easy assumptions. We have to veer off the beaten neural path. And we do this, in large part, by questioning.” *A More Beautiful Question* - Warren Berger

The promise of NZE Districts is substantial. It requires all of us – practitioners, policy makers, and decision makers – to rethink how we achieve sustainability goals and become more holistic and integrated. Sustainability requires us to be aspirational, yet history and experience tells us that it is hard to achieve if the economics are not in line with the vision. The infrastructure crisis provides an opportunity we cannot miss. By reshaping the issue and leveraging its funding into a driver for major change to how we use energy in communities, we can make major advances in achieving our climate goals, while establishing a new paradigm for sustainable communities.

References

ASCE (American Society of Civil Engineers), "Infrastructure Report Card", 2013, http://www.infrastructurereportcard.org, accessed March 3, 2016.

Architecture 2030, "District 2030", 2016, http://www.2030districts.org/, accessed March 8, 2016.

CPUC (California Public Utilities Commission), Code Section 769, Article 3. Equipment, Practices, and Facilities, January 1, 2015.

Clancy, Heather, "In California, At Least, The Case For Energy Efficiency Is Building", Forbes, December 30, 2014.

DOE (U.S. Department of Energy), Buildings Energy Data Book, "Chapter 1 Intro", 2011, accessed March 1, 2016, http://buildingsdatabook.eren.doe.gov/.

EcoDistricts, 2016, http://ecodistricts.org/about/vision-mission-values.

Integral Group, "The Getting to Net Zero Action Plan", Cambridge Getting to Net Zero Action Plan, April 29, 2015.

IDEA (International District Energy Association), District Energy Systems Map, 2009, http://www.districtenergy.org/u-s-district-energy-systems-map, accessed March 10, 2016.

M. Pisano and F. Silva, "A New Tool for Urban Economic Development: EIFDs Demystified", Planning Report, June 2015.

McGrawHill, "Green Outlook 2011: Green Trends Driving Growth", 2011.

RMI (Rocky Mountain Institute), "The Economics of Load Defection", April 2015.

Stanford University, "SESI General Information Brochure", 2015, http://sustainable.stanford.edu/sites/default/files/documents/Stanford_SESI_General_Information_Brochure.pdf, accessed March 12, 2016,

TRC (TRC Energy Services), "ZNE Residential Market Characterization", February 2015.