DISTRIBUTED ENERGY GENERATION AND GREEN INFRASTRUCTURE:

TRANSIT ORIENTED DEVELOPMENT FOR BRIDGEPORT, CONNECTICUT

Final Report

Master of Sustainability Management Capstone Thesis Project

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NEW YORK & CONNECTICUT SUSTAINABLE COMMUNITIES

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

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CAPSTONE THESIS PROJECT
MASTER OF SCIENCE IN SUSTAINABILITY MANAGEMENT
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Regional Plan Association – Transit Oriented Development
New York & Connecticut Sustainable Communities

Columbia University in the City of New York

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LIST OF ACRONYMS

CARE- Community Action for a Renewed Environment

CCAT- Connecticut Center for Advanced Technology

CHP- Combined Heat and Power

CSO- Combined Sewer Overflow

CSS- Combined Sewer System

CT- Connecticut

CWA- Clean Water Act

CWF- Clean Water Fund

DEEP- Department of Energy and Environmental Protection

DEG- Distributed Energy Generation

DEMHS- Department of Emergency Management & Homeland Security

DEP- Department of Energy & Environmental Protection

DOE- Department of Energy

DOT- Department of Transportation

DWSRF- Drinking Water State Revolving Fund

EPA- Environmental Protection Agency

ESF- Emergency Support Function

FEMA- Federal Emergency Management Agency

GHG- Greenhouse Gas

GI- Green Infrastructure

GW- Gigawatt

kWh- Kilowatt hour

LIS- Long Island Sound

MGD- Million gallon per day

MMBTU- Million Metric British Thermal Unit

MS4- Municipal Separate Storm Sewer System

MW- Megawatt

MWh- Megawatt hour

NARC- National Association of Regional Councils

NPDES- National Pollutant Discharge Elimination System

NPS- Non-Point Source

NREL- National Renewable Energy Laboratory NYSERDA-New York State Energy Research and Development Authority

O&M– Operations and Maintenance

PPP- Public Private Partnership

PS- Point Source

PUC- Public Utility Control

PV- Photovoltaic

RFS- Renewable Fuels Standard

RPA- Regional Plan Association

TMDL- Total Maximum Daily Load

TOD- Transit-Oriented Development

WPCA- Water Pollution and Control Authority

WWTF- Waste Water Treatment Facility

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EXECUTIVE SUMMARY

A sustainable city can be defined as premeditated hub that incorporates efficient and environmentally positive strategies such as green infrastructure and distributed energy generation. A sustainable city is also marked by the synergy between all three of its environments: physical, economic and social and it is the interplay amongst these three, partially or in totality, that determines the existence and continuity of the city.[1,2] Urban planners deem transit-oriented development projects such as the East Bridgeport Barnum Station project as one such possible synergistic opportunity.

Transit-oriented development (TOD) is a mix of housing, commercial development including retail, and amenities — referred to as "mixed-use development" — in a walkable neighborhood with high-quality public transportation.[3] A TOD project is especially relevant in present times because transportation has been found to be a major contributor (approximately 30 per cent) to greenhouse gas (GHG) emissions. According to a 2002 study by the California Department of Transportation, TOD has the potential to reduce annual greenhouse gas emissions by 2.5 to 3.7 tons per year for each household. In another study conducted by The Center for Transport-Oriented Development (CDOT) in 2010, it was found that in the Chicago metropolitan region, the transportation-related GHG emissions of households within one-half mile of public transportation are 43 percent lower than the regional average. The same study showed that for households located in central business districts that serve as a hub with the highest concentration of transit, jobs, housing and business, the emission levels are 78 percent lower than regional averages.

Bridgeport's citywide GHG emissions for 2007 were reported to be 1,019,544 metric tons of CO2 (equivalent). The city has a population of 141,627 people and low per capita emissions at 7.92 tons,[4] however, it scores much lower than the national average in air and water quality. According to the Bridgeport's Health Index, on a scale from 1 to 100, Bridgeport's water quality rates a score of 32, which is below the U.S. national average of 52. The Air Quality Index for Bridgeport is 30.0, which is also below the US national average of 32.0.

[1] Camagni, R., Towards sustainable city policy: an economy-environment technology nexus. Ecological Economics (1998).Volume: 24, Issue: 1, Pages: 103-118 ISSN: 09218009.DOI: 10.1016/S0921-8009(97)00032-3
[2] "TOD 204: Planning for TOD at the Regional Scale. *Center for Transit Oriented Development*.Web.Nov.2011. <http://reconnectingamerica.org/assets/Uploads/RA204REGIONS.pdf>.
[3] Ibid.
[4] "Greenhouse Gas Emissions Inventory Bridgeport, CT." Regional Plan Association, September 2008

On behalf of Regional Plan Association (RPA), this report analyzes sustainability strategies which would improve the water quality and enhance energy-efficiency of Bridgeport. This report will recommend promising strategies for distributed energy generation and green infrastructure to be implemented in the East Bridgeport Development Corridor. As a part of the evaluation process for suggesting promising strategies, the implementation of these technologies have been analyzed through the context of environmental justice, governance and funding options.

DISTRIBUTED ENERGY GENERATION

Distributed energy generation (DEG) is most commonly described as the generation of electricity from a localized smaller scale system that is in relatively close proximity to the end user. This reduces or eliminates the reliance on electricity from traditional large scale centralized power plants, which are often located far away from the end user.[5] As this report will show, the distributed energy generation strategies most beneficial to this TOD project in Bridgeport are solar PV panels, microturbines and fuel cells.

Findings from this report include that solar PV systems are capable of meeting the estimated ~1 kilowatt (kW) average need for residential development in Bridgeport. The report will also show that for large commercial projects in Bridgeport, microturbines and fuel cells have the capacity to meet the estimated average need ~24 kW for a typical commercial office building.

The proposed commercial development projects throughout the East Bridgeport Corridor will vary in size and energy demands. Possible fuel sources for these distributed energy generation technologies include natural gas and biogas. The natural gas distribution infrastructure already exists in Bridgeport, as it is a common fuel source for heating. The potential for local biogas production in Bridgeport at the wastewater treatment facilities has been explored recently through a study by GHD Inc., an environmental engineering company. This study also found that local production would be feasible; however, at present there are economic factors and site requirements that need to be addressed. This report will provide research and background analysis to support recommending residential solar PV systems, commercial microturbine CHP systems and commercial fuel cell CHP systems for implementation in Bridgeport.

[5] *California Energy Commission*. CA Govt. 2008. Web. Nov. 2011. <http://www.energy.ca.gov/title24/2008standards/>.

To further the feasibility of distributed energy generation and green infrastructure, this report recommends conducting energy consumption surveys for both residential and commercial sectors in Bridgeport. The estimated average usages contains in this report were calculated using information that was not specific to Bridgeport; but rather, by using data for the state of Connecticut and the North East region of the United States. By conducting Bridgeport-specific energy consumption surveys, officials will have a better baseline to benchmark and assess Bridgeport's energy needs. The baselines will also be useful for future studies regarding energy demands in Bridgeport.

GREEN INFRASTRUCTURE

Bridgeport is grappling with burdensome costs associated with updating antiquated, inefficient, and under sized infrastructure for managing stormwater runoff, like many cities across Connecticut and the nation. The 2009 Report Card published by the American Society of Civil Engineers awarded a "D" grade for the national water infrastructure citing an investment requirement of $255 billion compared to a projected $146.4 billion in spending outlay over a five-year period. This creates a $108.6 billion shortfall nationally. One potential solution to this shortfall is to implement alternative stormwater management strategies such as green infrastructure. Green infrastructure refers to strategies for handling storm precipitation at its source before it has entered the sewer system. Common green infrastructure strategies are vegetated swales, green roofs, permeable pavement and rainwater harvesting. These strategies have other environmental benefits such as improved air quality, reduced construction-related disruptions, enhanced aesthetics, and heat island effect mitigation.

The report recommends that the development corridor around the area of the East Bridgeport Barnum Station should be designated as a "green infrastructure zone" for utilization of green infrastructure strategies for existing and new developments. Another promising strategy is designing and conducting a monitoring and measurement program to collect site-specific data for combined sewer overflow. Additionally, this report recommends the use of GIS tools to provide area residents with accurate information about combined sewer overflow impacts in the East Bridgeport Development Corridor.

BACKGROUND

CHAPTER 1: BACKGROUND

1.1 PROJECT DESCRIPTION

The **New York & Connecticut (NYCT) Sustainable Communities** is a joint initiative funded by the **U.S. Department of Housing and Urban Development** (HUD), the **U.S. Department of Transportation** (DOT), and the U.S. **Environmental Protection Agency** (EPA). The Sustainable Communities Program supports metropolitan and multijurisdictional planning efforts that promote coordinated housing, land use, economic and workforce development, transportation and infrastructure investments. As recipients of a **Sustainable Communities Regional Planning** grant, the New York-Connecticut Sustainable Communities initiative will implement 16 interrelated projects that address the region's complex challenges at multiple scales—metropolitan, community, corridor and sub-region—to expand economic opportunity; foster new affordable, energy-efficient housing; provide more transportation choices; strengthen existing communities; and make the region more globally competitive.[11]

This report was provided on behalf of **Regional Plan Association** (RPA) who acts as one of the Consortium members overseeing the implementation of best sustainability practices into the program. RPA's research, advocacy, and demonstration projects have been working towards orienting the region's development around an enhanced transit network for decades – achieving Transit-Oriented Development (TOD) throughout the tri-state region before the economic, environmental, and social benefits of TOD were widely recognized.[12] TOD aims at reorienting urban development patterns around transit facilities by providing residents with easy accessibility, improving air quality, preserving open spaces, increasing ridership and revenue and most importantly reducing urban sprawl.

The project scope includes researching the sustainability practices of distributed energy generation and green infrastructure and determining the best opportunities to implement these sustainability strategies within East Bridgeport Barnum Station project. The East Bridgeport Barnum is a proposed new commuter rail station on its east side, acting as a central anchor to the city's east side redevelopment opportunities totaling over 700 acres. It will provide a regionally critical second Metro-North rail access point for Connecticut's largest city and promotes mixed-use,

[11] "Projects." *New York and Connecticut Sustainability Communities*. New York and Connecticut Sustainability Communities. Web. 6 Dec. 2011. <http://www.sustainablenyct.org/projects/>.
[12] "Transit-Oriented Development." *Regional Plan Association*. Web. 6 Dec. 2011. <http://www.rpa.org/tod.html>.

transit-oriented development and affordable housing around the distressed East End and East Side neighborhoods.[13]

Using case studies from similar sustainable development projects, this report will provide promising strategies for the following areas:

1. **Implementation of distributed energy generation and green infrastructure technologies**
2. **Funding for strategy implementation**
3. **Streamlining of the governance process to facilitate implementation**

1.2 TRANSIT-ORIENTED DEVELOPMENT

TOD is defined as a more compact development within easy walking distance of transit stations (typically a half mile) that contains a mix of uses such as housing, jobs, shops, restaurants and entertainment.[14] TOD is not simply an assembly of buildings around transit nodes but is partly about building social capital—strengthening the bond between people and the communities in which they live, work socialize, and recreate.[15]

There are four scales to transit and TOD investments:[16]

- **Station Area**: Focus on neighborhoods/districts within a half-mile radius of the station while promoting walkability, a good mix of development uses, and improved transit access and ridership.

- **Regional:** Results in improved connections between people and jobs, and help ensure that disadvantaged communities share the benefits of improved access to opportunity.
- **Corridor:** Ensures that development at one station complements development at other stations, resulting in a network of transit-oriented places, a strong real estate market, and local demand for retail and services offered in neighborhoods near stations.

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[13] "Projects." *New York and Connecticut Sustainability Communities*. Web. 6 Dec. 2011. <http://www.sustainablenyct.org/projects/>.
[14] "TOD 204: Planning for TOD at the Regional Scale." *Center for Transit Oriented Development*, Web Nov.2011. <http://reconnectingamerica.org/assets/Uploads/RA204REGIONS.pdf>.
[15] "TOD 201: Planning for TOD at the Regional Scale." *Center for Transit Oriented Development*, pg 4, 2009. Web. Nov.2011. <http://reconnectingamerica.org/assets/Uploads/RA204REGIONS.pdf>.
[16] "TOD 204: Planning for TOD at the Regional Scale."*Center for Transit Oriented Development*, pg 4, 2011. Web. Nov. 2011. <http://reconnectingamerica.org/assets/Uploads/RA204REGIONS.pdf>.

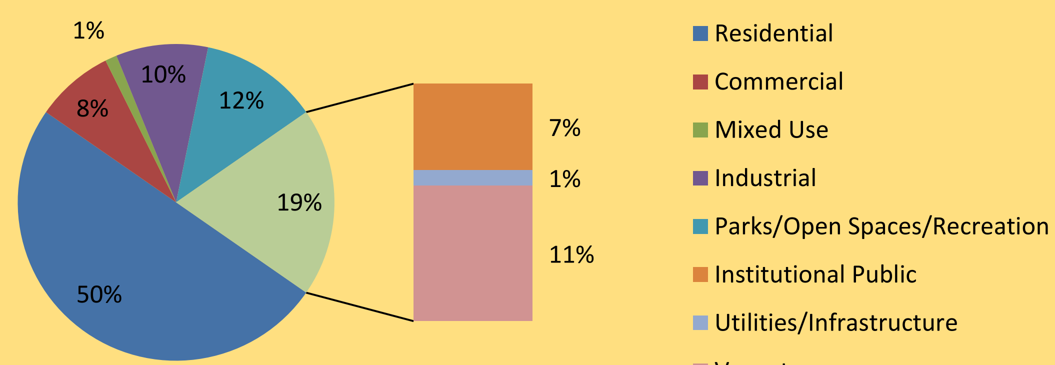
- **Project:** Includes planning for streets and public spaces, and can have a very big impact on whether people will walk, bike or drive to stations.

New York Connecticut Sustainable Communities program addresses all of these four scales. NYCT Sustainable Communities has also delineated six Livability principles that aim to align policy and investment at the local and regional scales. The promising strategies in this report align site-specific goals with Regional TOD planning guidelines.

1.3 BRIDGEPORT, CONNECTICUT

Situated on the southern coast of Connecticut on the Long Island Sound, approximately 60 miles northeast of New York City, Bridgeport is the most populous city in Connecticut with 144,229[17] people in 15.97 square miles.[18] Bridgeport is comprised of 13 defined neighborhoods with varying demographic compositions. Although it is situated in the affluent Fairfield County, Bridgeport is an anomaly with a median household income of $40,530[19] compared to the countywide average median household income of $79,892. As of October 2011, the non-seasonally adjusted employment rate for Bridgeport was 12.7 percent.[20] Connecticut has a non-adjusted employment rate of 8.2 percent and the United States has 8.5 percent unemployment for October 2011.[21]

FIGURE 1-1 PERCENT OF TOTAL LAND AREA



[17] *U.S. Census Bureau.* Web. Nov.2011.<http://www.census.gov/>.
[18] "State and Country Quick Facts." *U.S. Census Bureau*. Web. Oct. 2011. <http://quickfacts.census.gov/>
[19] "U.S. Census Quickfacts, Bridgeport2011". *U.S. Census Bureau*. Web. Oct. 2011 <http://quickfacts.census.gov/qfd/states/09/0908000.html>.
[20] "Connecticut Labor Market Information." *CT.GOV*. Web. Nov. 2011 <http://www1.ctdol.state.ct.us/lmi/LAUS/lmi123.asp>.
[21] "Connecticut Labor Market Information." *CT.GOV*. Web. Nov. 2011 <http://www1.ctdol.state.ct.us/lmi/LAUS/lmi123.asp>.

Over the past five years, Bridgeport has reassessed an array of development issues including land use, environmental impact, regional transportation planning, sustainable infrastructure, green jobs, and green development. Bridgeport's land-use is summarized in Figure 1-1. The approach to reforming and revitalizing Bridgeport is demonstrated in numerous studies and plans: Downtown Bridgeport (2007), Bridgeport 2020 (2008), BGreen 2020 (2009), and most recently Bridgeport Parks Master Plan (2011).

Figure 1-2 BRIDGEPORT

Many initiatives enumerated in the development plans have been executed such as citywide recycling, municipal building retrofits to reduce energy consumption, bicycle infrastructure enhancement, and streetscape enhancement.[23] In 2009, the Partnership for Sustainable Communities[24] gave Bridgeport the opportunity to pursue funding to develop a train station located in the East Side, a neighborhood with development potential.

The location of the East Bridgeport Barnum Station is one mile away from the current Metro-North and Amtrak station (See Figure 1-2). The adjacent East Bridgeport Development Corridor is an ideal location for transit-oriented development because an estimated 750 acres of available land.[25] This area can be utilized for both commercial and residential establishments.

The proposed East Barnum train station would facilitate greater public transit use. Building the station would help reduce the number of vehicles used, reduce traffic congestion on the I-95 in the eastern region of Bridgeport and increase transit usage. There are currently 10,000 residents[26] in an underserved region near the proposed

[23] "BGreen 2020: A Sustainability Plan for Bridgeport." *Regional Plan Association.* Regional Plan Association. Web. Nov.2011. <http://www.rpa.org/2010/03/bgreen-2020-a-sustainability-plan-for-bridgeport-connecticut.html>
[24] Partnership for Sustainable Communities is an interagency initiative under the Obama Administration jointly administered by the U.S. Department of Housing and Urban Development, U.S. Department of Transportation, and U.S. Environmental Protection Agency to provide funding for transit-oriented development projects (http://www.sustainablecommunities.gov/)
[25] New York-Connecticut Metropolitan Region Sustainable Communities Planning Program, Rating Factors Response, pg 13
[26] New York-Connecticut Metropolitan Region Sustainable Communities Planning Program, Rating Factors Response, pg 13

train station. The residents would able to have access to a variety of mobility options and greater employment opportunities it the train station is built.

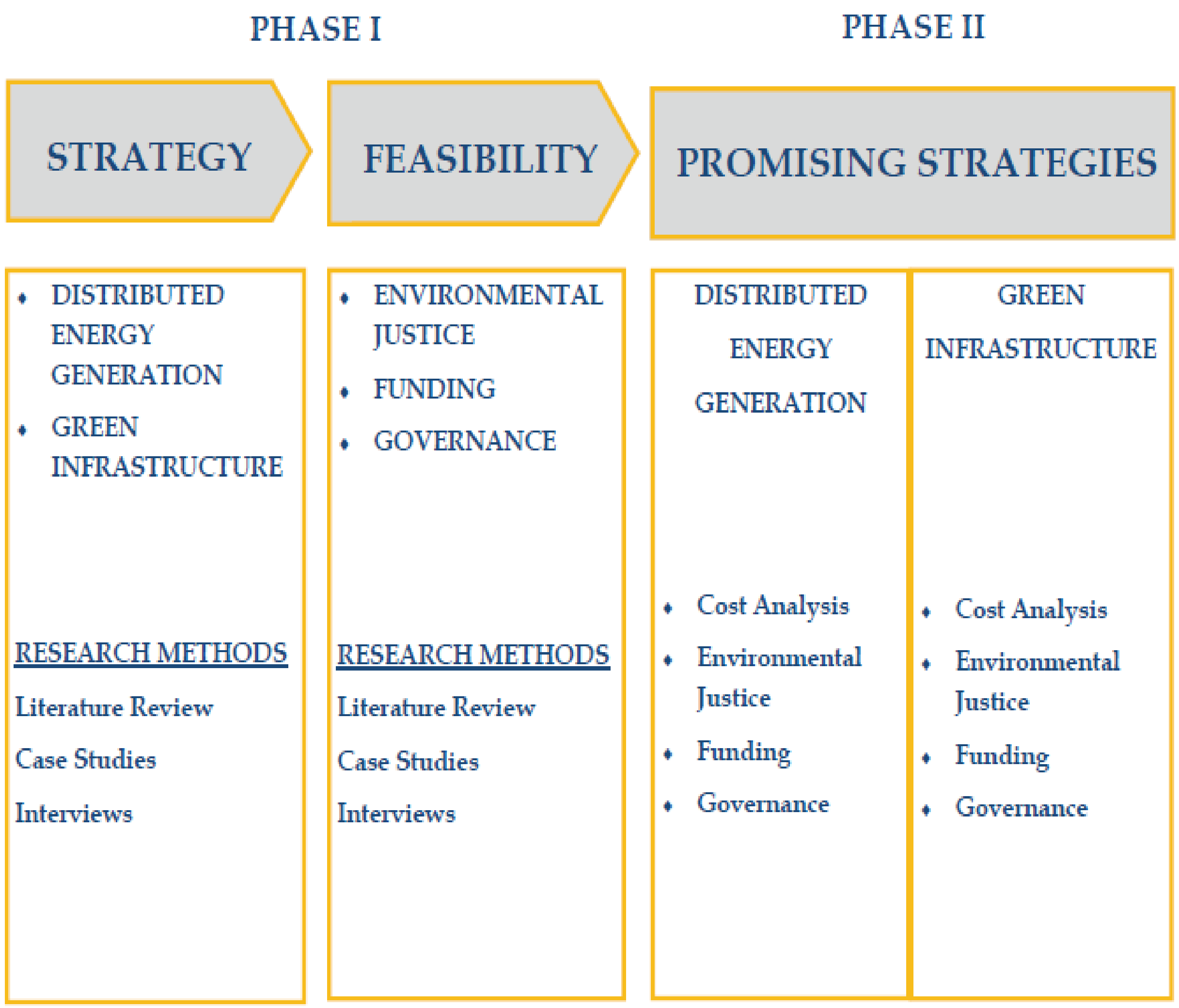
The proposed project also aims to provide affordable housing options in the vicinity. The New York and Connecticut Sustainable Communities Consortium evaluates the effectiveness of the East Bridgeport Barnum Station. The evaluation also includes costs, land-use, construction factors, parking rate and cost projections, travel time, traffic congestion mitigation and reduction and train operations. The PT Barnum Station aims to provide economic and social benefits to the public and the City of Bridgeport based on mobility, redevelopment, affordable housing and employment access.

1.4 METHODOLOGY

Research for this report was divided into the three phases and the following steps were taken to assess the potential implementation of distributed energy generation and green infrastructure. Research was conducted using various sources: online research, interviews with industry professionals and agencies, stakeholders, Columbia University faculty and resources. Additionally, feedback was provided by the Regional Plan Association (RPA).

This research project started with an in-depth look at the best practices for distributed energy generation and green infrastructure. This was followed by an analysis of the most appropriate distributed energy generation and green infrastructure technologies for implementation on the East Bridgeport Development Corridor.

Environmental justice issues associated with the strategy implementation were then addressed. Identification of appropriate funding mechanisms was the final phase of research.



1.5 DISTRIBUTED ENERGY GENERATION TECHNOLOGIES

Distributed energy generation is commonly described as the generation of electricity from a small scale system that is in relatively close proximity to the end user. This reduces or eliminates the reliance on electricity from traditional large scale centralized power plants, often located far away from the end user.[27]Additional benefits of distributed energy generation include lower energy bills, peak shaving, increased electric power reliability, and the use of green power.[28] By generating energy onsite, a facility reduces its need to pull power from the commercial grid, thus lowering its energy costs. Peak shaving occurs when a facility can generate its own electric power during times when commercial grids experience high demand,

[27] "California Distributed Energy Resource Guide." *The California Energy Commission*. The California Energy Commission. 07 Aug. 2008. Web. 28 Nov. 2011. <http://www.energy.ca.gov/distgen/>.

[28] "United States. U.S. Department of Energy." *Using Distributed Energy Resources*. 2002. p.2-3 Web. Nov. 2011.<http://www.nrel.gov/docs/fy02osti/31570.pdf>.

and therefore reducing demand on the energy grid. During these times, utility companies have higher rates so having the on-site power supply decreases energy costs during peak demand occurrences. Also, in the event of commercial grid failure, having the distributed energy generation onsite ensures continued power supply. Finally, using renewable technologies for distributed energy can lessen a facility's environmental impact.[29]

Common distributed energy generation resources include, but are not limited to, solar photovoltaic (PV) panels, microturbines and fuel cells. The benefits and challenges associated with each of these resources will be considered in this report. The type of fuel used in a microturbine or fuel cell will determine its classification as a renewable energy resource or not. Other technologies that are often associated with distributed energy generation resources are combined heat and power systems.

SOLAR PHOTOVOLTAIC (PV)

Solar PV panels are large flat panels that convert the sun's rays into electric power. They are classified as renewable energy resources and are among the most commonly used distributed energy generation resources. The panels are normally placed on the roofs of residential and commercial structures to supply power for the facility and help reduce demand for electricity from the larger grid.[30] Although PV panels are common, there are several challenges to implementation.

Foremost, the initial costs of installation are approximately $7,000-$10,000 per kilowatt (kW).[31] As a result, large-scale implementation requires significant capital costs. Secondly, solar PV technology is intermittent. Due to fluctuating climate, sun exposure for the panels is not guaranteed. For example, in Hartford CT, it has been calculated that the annual average amount of sunny hours a year between 1961 and 1990 was 2,585 out of the total 8,760 hours per year.[32] Hence, the reduction in sun exposure translates to a reduction in generation capacity. Finally, implementing this technology requires specific site conditions. For instance, in the northeastern United States, PV panels need to be oriented southward at a 45 degree angle to maximize sun exposure. This is not always possible due to existing building orientation and obstructions. To maximize utilization an alternative approach entails placing the

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[29] Ibid.
[30] "Using Distributed Energy Resources." *NREL*.U.S. Department of Energy. 2002. p.2-3 Web. Nov. 2011. <http://www.nrel.gov/docs/fy02osti/31570.pdf>.
[31] "Distributed Energy Resource Basics." *Federal Energy Management Program.* U.S. Department of Energy. U.S. Department Of Energy, 12 Oct 2011. Web. 28 Nov 2011. <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.
[32] "Amount of Sunshine Connecticut Gets each Month." *Current Results research news and science facts*. Current Results, 2011. Web. 28 Nov. 2011. <http://www.currentresults.com/Weather/Connecticut/sunshine-by-month.php>.

panels on a motorized mount that tracks the sun progression from east to west, throughout the day.[33]

MICROTURBINES

Microturbines function by burning fuel in a combustion chamber, which causes fan blades to turn. These rotating blades are connected to a crank that leads to a generator creating the electricity.[34] Microturbines use a variety of conventional fuels including petrol and kerosene. They can run on clean or renewable fuels such as natural gas, biogas and other waste gases.[35] The challenges for implementation of this technology are less when compared with solar PV systems, but still exist.

The first challenge is the cost of installation which varies depending upon size and intended utility of the microturbine. Sizes range from 15-60 kW and installation costs are estimated to range from $950-$1,700 per kW.[36] Another challenge associated with microturbines is reliability and cost of the fuel source. Using conventional fuels such as petrol and kerosene ensures reliability because they are inexpensive and produced in abundance. Natural gas is also reliable because of existing infrastructures throughout most of the urban and suburban areas in the United States which ensures the distribution of this fuel with ease. However, renewable fuels such as E85, biodiesel and biogas generally are costlier as they are not produced in abundance like traditional fuels. Thus using renewable fuels would amount to increased cost.

FUEL CELLS

Fuel cells are systems that use chemical reactions to generate electricity. These reactions occur when the fuel, which can include hydrogen and ethanol, is paired with an oxidizing agent, usually air, to produce electricity.[37] While fuel cells can provide a reliable power source, their implementation is not without challenges. Fuel cell technology is still relatively in the infancy stage and is extremely costly to

[33] Murty, Dr. Nagavolu. "Enabling Optimal Utilization of Solar Photovoltaic Power." *IQ Magazine Online*.Web. 28 Nov 2011. <http://www.iqmagazineonline.com/current/pdf/Pg20-25_IQ_32-Enabling_Optimal_Utilization_of_Solar_Photovoltaic_Power.pdf>.
[34] "California Distributed Energy Resources Guide: Microturbines." *The California Energy Commission*. The California Energy Commission, 18 Jan 2002. Web. 28 Nov. 2011. <http://www.energy.ca.gov/distgen/equipment/microturbines/microturbines.html>.
[35] "Technology Characterization: Microturbines." *U.S. Environmental Protection Agency*. Energy and Environmental Analysis, Dec 2008. Web. 28 Nov. 2011. <http://www.epa.gov/chp/documents/catalog_chptech_microturbines.pdf>.
[36] "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program*. U.S. Department of Energy. 12 Oct. 2011. Web. 28 Nov 2011. <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.
[37] "Fuel Cells." *Energy Fool*. Energy Fool , 2011. Web. 28 Nov 2011. <http://www.energyfool.com/site/?q=renewable-energy/fuel-cells-subcat>.

implement. Currently, estimated costs are over $5,500 per kW,[38] and sizes range from 1 kW to 10 megawatts (MW).[39] While fuel cells can run continuously as long there is a fuel source, frequent maintenance is needed to replace the membranes that are exposed to the reactions between the fuel and the oxidizing agent.

COMBINED HEAT AND POWER

Combined heat and power (CHP) systems are often associated with microturbines and fuel cells. Commonly referred to as "cogeneration," these systems capture the waste heat produced from microturbines or fuel cells when generating electricity.[40] This waste heat is then used for a facility's heating needs. The challenges for implementation begin with cost. Installation cost of this system varies depending on size and generation capacity, with the average cost being approximately $1,500 per kW.[41] Another challenge for implementation is the interface with demand on the system. Often there are times when electricity is needed but heating is not. This can be mitigated by storing this heat or by using this captured heat in air conditioning.

1.6 GREEN INFRASTRUCTURE TECHNOLOGIES

Green infrastructure is a term that commonly refers to strategies for handling stormwater at its source before it enters the sewer system. A broad definition of green infrastructure is a strategically planned and managed network of natural land, working landscape and other open space that conserve ecosystem values and functions and provide associated benefits to human populations.[42] Green infrastructure therefore entails designed systems that mimic the pre-developed landscape's hydrologic characteristics. Green infrastructure can also be referred to as Low Impact Development (LID).

Green infrastructure can have a multitude of meanings depending on the context and individual. "For example, some people refer to trees in urban areas as green infrastructure because of the 'green' benefits they provide, while others use green infrastructure to refer to engineered structures (such as water treatment facilities or

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38 "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program*. U.S. Department Of Energy, 12 Oct 2011. Web. 28 Nov 2011. <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.

39 "California Distributed Energy Resource Guide: Fuel Cells." *California Energy Commission*. California Energy Commission, 19 Aug 2003. Web. 28 Nov. 2011. <http://www.energy.ca.gov/distgen/equipment/fuel_cells/fuel_cells.html>.

40 "California Distributed Energy Resource Guide: Combined Heat and Power." *California Energy Commission*. California Energy Commission, 18 Oct 2004. Web. 28 Nov 2011. <http://www.energy.ca.gov/distgen/equipment/chp/chp.html>.

41 "Co-ops, Condos, and Co-Generation." *CALFINDER*. Calfinder Contractors, 2011. Web. 28 Nov 2011. <http://solar.calfinder.com/blog/solar-politics/co-ops-condos-and-co-generation/>.

42 "What is Green Infrastructure?" *Green Infrastructure The Conservation Fund*. Web. Nov. 2011. <http://www.greeninfrastructure.net/content/definition-green-infrastructure>.

green roofs) that are designed to be environmentally friendly."[43] For the purpose of this report, green infrastructure is considered to be an alternative to conventional stormwater infrastructure approaches, which are typically retention and treatment facilities for collecting and cleaning stormwater prior to discharging it into natural waterways.[44] Green infrastructure provides benefits such as reduced runoff volume, decreased pollutant concentration, recharged groundwater, improved air quality, mitigated heat island effect, increase in open space and wildlife habitat. The following four selected green infrastructure strategies; permeable pavements, vegetated swales, green roofs, and rain harvesting are highlighted to show the common purpose and limitations of green infrastructure design.

PERMEABLE PAVEMENTS

Permeable pavements refer to materials that can be used for a variety of hardscape applications such as sidewalks, streets, parking lots, bicycle paths, and driveways. The materials of pervious concrete, porous asphalts and permeable interlocking concrete pavers are substitutes for the commonly used asphalt and concrete. The various pavements have a similar composition; a surface pavement layer, underlying stone aggregate reservoir layer and filter layer.[45] The benefits of permeable pavements are increased infiltration and reduced runoff volume and pollutant concentration. The limitations of permeable pavements are the extensive implementation process and the regular maintenance needed to vacuum particles to ensure effectiveness. Porous pavement has design limitations due to the lack of fine aggregate. However, this can be accounted for with a complementary base material. Porous pavement is not suitable for areas with heavy loads, high traffic, deep slopes, and areas requiring snow removal. Permeable pavements can be scaled for commercial, industrial and residential settings.

VEGETATED SWALES

Vegetated swales are indented and sloped areas of vegetation and grass capable of absorbing, treating, and slowing down runoff from common areas such as roofs, streets, and parking spaces.[46] Vegetated swales also increase infiltration and reduce runoff volume and pollutants concentration. Depending on the region and climate it is advantageous to use plants native to the area. Vegetated swales are limited in that

[43] Green Infrastructure: Smart Conservation for the 21st Century, The Conservation Fund, Sprawl Watch Clearinghouse Monograph Series, pg 7

[44] Managing Urban Stormwater with Green Infrastructure: Case Studies of Five U.S. Local Governments, Lisa Valentine, July 2007, pg 7 & 9

[45] Virginia DCR Stormwater Design Specification No. 7, Permeable Pavement Version 1.7 2010, pg 1

[46] City of Portland Oregon, Environmental Services, Stormwater Solutions Handbook, Vegetated Swales, 2011, pg 1

it needs consistent maintenance including mowing, weeding, reseeding and watering as needed. Additional factors that contribute to the potential ineffectiveness of vegetated swales are compacted soils, frozen ground, short grass heights, and steep slopes.[47] Vegetated swales can be scaled for commercial, industrial and residential settings.

GREEN ROOFS

Green roofs are engineered systems that provide multi-benefits such as insulation, pollutants absorption, stormwater retention, and urban heat island reduction. Green roofs typically drain vertically through the design and then horizontally with waterproofing layer towards the outlet.[48] The incorporated plant species do not require irrigation or fertilization. Stormwater is evaporated or absorbed by plants and reduces reduce runoff volume and pollutants concentration specifically on development sites. Green roof vegetation also reduces the amount of air pollutants such as carbon dioxide (CO_2). The insulation provided by green roofs leads to a decrease in energy consumption since less energy is needed for cooling especially during summer months. The limitations of green roofs are the high installation and O&M costs, deep slopes, pitched roofs, and heavy loads. Green roofs can be scaled for commercial, industrial settings.

RAIN HARVESTING

Rain harvesting is a green infrastructure mechanism that collects and retains stormwater. Water is conserved and salvaged for a variety of needs such as gardening, irrigation, and landscaping needs. Rainwater harvesting can also be used for non-potable uses such as flushing of toilets and urinals inside buildings, exterior washing, fire suppression (sprinkler) systems, supply for chilled water cooling towers, replenishing and operation of water features and water fountains, and laundry, if approved by the local authority.[49] Harvesting infrastructure generally includes four main components: catchment, conveyance, storage, and distribution. Catchment areas are most usually roofs. Water is conveyed through gutters, roof leaders, downspouts and standpipes to a storage location. Rainwater is commonly stored in rain barrels or cisterns when installed at the end of downspouts to capture runoff from the roof. Cisterns are larger structures that capture and store water runoff from the roof. The limitations of rain harvesting are consistent maintenance

[47] EPA Storm Water Technology Fact Sheet, Vegetated Swales, September 1999, pg 3
[48] Virginia DCR Stormwater Design Specification No. 5, Vegetated Roof Version 2.1 2010, pg 2
[49] Virginia DCR Stormwater Design Specification No. 6, Rainwater Harvesting Version 1.7 2010, pg 1

requirements such as blockage supervision and particles removal. Rain harvesting can be scaled for commercial, industrial and residential settings. Rain barrels are often applied in a residential setting and cisterns are often applied in a commercial, residential setting due to the higher capacity demand.

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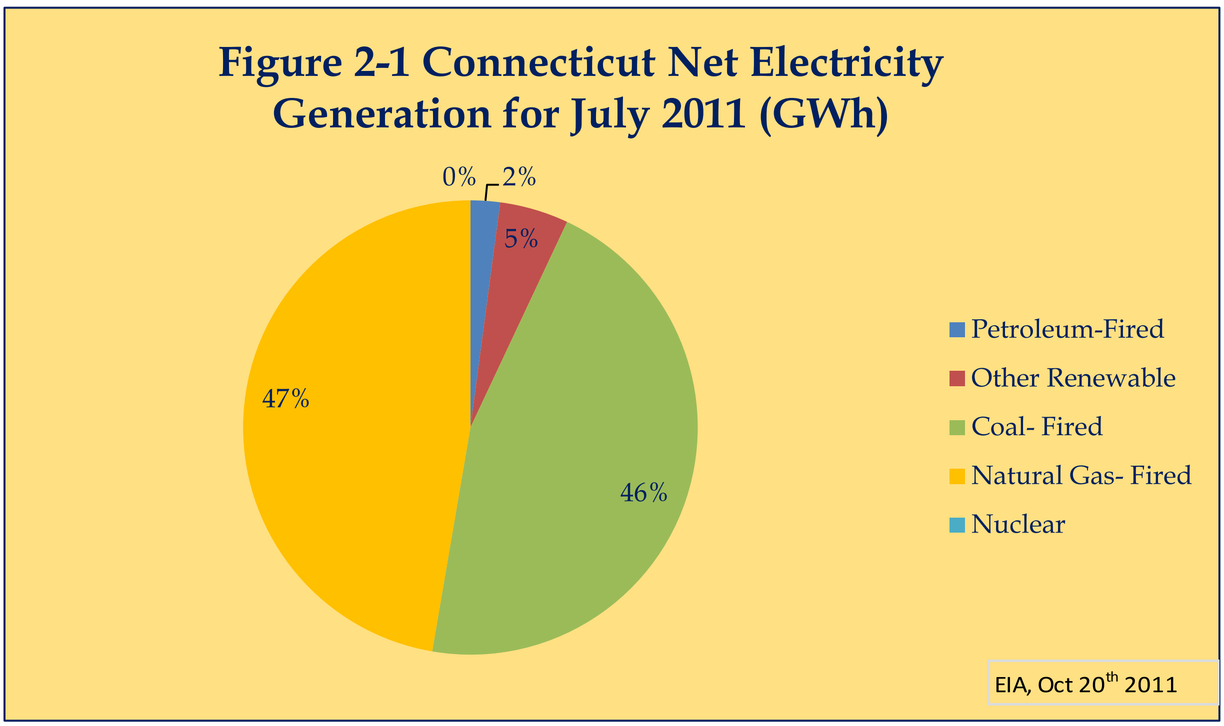
DISTRIBUTED ENERGY GENERATION

CHAPTER 2: DISTRIBUTED ENERGY GENERATION

2.1 ENERGY-USE IN BRIDGEPORT

The proposed development plan for East Bridgeport, Connecticut contain multiple opportunities to improve the area's energy landscape and ensure a more sustainable future. Located around the proposed East Barnum railroad station there are 30 acres of developable land within a quarter mile of the site. Within three quarters of a mile there are 100 acres of developable land.[50] The proposed East Barnum Station is a part of the much larger East Side Development Corridor with over 700 acres of developable land.[51] The abundance of developable land also offers East Bridgeport the opportunity to augment its methods for meeting its energy needs. See Figure 2-1 for Connecticut's net electricity generation during July 2011.[52]

Traditional sources of electrical generation such as petroleum, natural gas and coal combustion, produce significant carbon dioxide emissions and are leading contributors to greenhouse gases and climate change. A study done by RPA



50 "BGreen 2020: A Sustainability Plan for Bridgeport, Connecticut", 2008. p.29

51 "New York-Connecticut Sustainable Communities Consortium." *New York-Connecticut Sustainable Communities Consortium Projects*. New York-Connecticut Sustainable Communities Consortium, 2011. Web. 8 Nov. 2011. <http://www.sustainablenyct.org/projects/>.

52 "Connecticut Data." *U.S. Energy Information Administration*. U.S. Department of Energy, 20 Oct. 2011. Web. 10 Nov 2011. <http://38.96.246.204/state/state-energy-profiles-data.cfm?sid=CT>.

quantified Bridgeport emissions to be 1,019,544 metric tons in 2007. Electricity as an energy source accounted for 32.2 percent of the city's 2007 emissions.[53] Broken down by sector with electricity as an energy source, residential contributes 13.5 percent, commercial 14.8 percent and industrial 2.8 percent of the citywide emissions total.[54]

As part of the BGreen 2020 plan, Bridgeport outlines several strategies to increase the city's usage of renewable energy sources and promote energy efficiency. The strategies start at the municipal level and encourage the private sector to follow. Select strategies include Bridgeport's establishment as an energy improvement district; the creation of a green energy park on a closed landfill; benchmarking and retrofitting municipal and educational facilities; the promotion of energy audits and energy efficiency programs in the commercial and industrial sectors; and the endorsement of solar development and leasing programs.[55]

Beyond BGreen 2020, United Illuminating (UI), the local electricity distributor, provides energy efficiency initiatives for its customers as well as helps to administer the Connecticut Energy Efficiency Fund (CEEF). The CCEF is a state wide initiative for assisting residential, commercial and industrial electric users to manage their energy usage and cost. The fund is supported by the utility rate payers and seen as a conservation charge on electric bills.[56] Some of UI's other energy efficiency efforts include in-home residential and multi-family residential weatherization services, incentives and solutions for commercial customers, promotion of the Department of Energy's (DOE) Energy Star program, and providing information on financial resources available through the CCEF.[57]

While these strategies offer a path to Bridgeport's stated energy goals, another strategy that can be increasingly utilized is distributed energy generation. Distributed energy generation offers several advantages that can be realized in Bridgeport when properly implemented. According to Patrick McDonnell, Director

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[53] "Greenhouse Gas Emissions Inventory Bridgeport, CT" p.15, Regional Plan Association, September 2008
[54] "Greenhouse Gas Emissions Inventory Bridgeport, CT," Regional Plan Association, p.16, September 2008
[55] "BGreen 2020: A Sustainability Plan for Bridgeport, Connecticut", p.23-25, 2008
[56] "Connecticut Energy Efficiency Fund." *The United Illuminating Company*. The United Illuminating Company, 2010. Web. 28 Nov 2011. <http://www.uinet.com/wps/portal/uinet/business/!ut/p/c5/vY7JcqMwGISfxQ8QS2KR4IjBYGEQZgl2uLjAG2A2k7CYpw-VXGYOM6dUum_d1f_3gwjMruI-u8UfWV3FBTiACB8thxq2SqhCQ1eEVKCc63gqggYBe3CAwtHPnw2d7pOXwwGx-2ixxB1sTbeDQKd2rttsLXHB6zCx1oYsOc1daKOTjELdXSura1-ZdDHfiv6m-ViYaWuFBJRBA3HfPfyHFAjeQET-2DuyNu8Dl7oSQZDwIPjBb__LYvAXWdyPskwQZUm5HE7lEi5lRGQsylgSRcwjXgD7_DSMqmQqGk3SXqSOcUHFuXAfHb3dbtW-jcN6xxVTI-4nQp58JnYWJ121sfvYhgFhaSa4MAh33Ybnnfr1Er9AIYe5ahiPsmsts1irrhM_rJI00liS9_TwJlX2OVWMM6Xd6Mt-PV69vvGc7ZGNqySl3c56x0-s4VYV83ukq03eQc1jJpa3qjz4enuUeP1ccmF_f3bTSlksANvU5QU0Zd9spsOXL3P8CUxarvw!/dl3/d3/L2dBISEvZ0FBIS9nQSEh/?pcid=e31fe18041ed0b41a7c5af369578051e>.
[57] Virginia DCR Stormwater Design Specifications No. 6, Rainwater Harvesting,Version 1.7, Pg 1,2010,

of Conservation and Load Management at UI, Connecticut is one of the leading states in distributed energy generation on a per capita basis. There are no large (5-30MW) distributed energy generation systems in Bridgeport. The primary distributed energy generation technologies utilized in Bridgeport are solar PV on residential rooftops and small engine generators on commercial sites.[58]

In addition to helping the city meet its local and state energy goals distributed energy generation offers many other advantages. Along with the East Barnum Ttrain station are proposals to develop on the land adjacent to the station. These developments will add further stress on already congested transmission lines in Southwestern Connecticut.[59] If properly applied, distributed energy generation technologies can help offset the load demand from the proposed new developments. Furthermore, distributed energy generation offers a method for reducing Bridgeport's emissions. As a renewable resource, solar (PV) systems produce no emissions. Microturbines and fuel cells produce significantly less emissions when compared to centralized power generation plants.[60] For instance, the emissions from burning non-renewable fossil fuels for electric generation at conventional plants are 1.392 lb/kWh for CO_2 and 0.00296 lbs/kWh.[61] Table 2-1 summarizes these emissions: [62]

TABLE 2-1		
TECHNOLOGY	EMISSIONS(lb/kWh)	
	NO_x	CO_2
Photovoltaics	0	0
Microturbine	0.00049	1.19
Fuel Cell	0.000015	0.85

Department of Energy, 10/12/2011

Lastly, distributed energy generation offers Bridgeport's electricity customers an opportunity to reduce their energy costs. Distributed energy generation systems cannot provide the entire energy load demanded by a facility alone, and still has to interconnect to the electric grid to rely on its power. Utility customers that use distributed energy generation systems can reduce their monthly costs because they would reduce the amount of power needed to be pulled from the grid.[63]

[58] McDonnell, Patrick. "RE:RE: Columbia University Sustainability Project on Bridgeport." Message to Nicholas Walker. 10 Nov 2011. E-mail.

[59] "FuelCell Energy Development Partner, Bridgeport Fuel Cell Park, LLC Wins Pre-Development Financing for 10-Megawatt Fuel Cell Power Plant." *FuelCell Energy*. FuelCell Energy, Inc. 31 May 2006. Web. 30 Nov. 2011. <http://files.shareholder.com/downloads/FCEL/1506894568x0x101714/e3f2a744-ec8f-49a6-bfa7-00796df85ee8/FCEL_News_2006_5_31_General.pdf>.

[60] "Benefits of Distributed Generation." *Distributed Generation Education Modules*. Consortium on Energy Restructuring, Virginia Tech , 2007. <http://www.dg.history.vt.edu/ch1/benefits.html>.Web accessed on November 29 , 2011

[61] Coal Combustion figures from: "100% Wind Powered Hosting." *Invisible Gold*. Invisible Gold, LLC., 2009. Web. 30 Nov. 2011 <http://www.invisiblegold.com/about/environment>.

[62] "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program*. U.S. Department Of Energy, 12 Oct 2011. Web. 28 Nov. 2011 <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.

ESTIMATED ENERGY NEEDS

To better understand how Bridgeport can increase its utilization of distributed energy generation, an understanding of the typical energy needs for residential and commercial buildings in Bridgeport is necessary. The development area surrounding the proposed East Barnum Railroad Station includes both residential units and commercial space. The following estimates are reached with the most recent data provided by the Energy Information Administration (EIA). These estimates will be used to analyze the proposed distributed energy generation strategies.

A part of the Department of Energy, the Energy Information Administration (EIA) reported that in 2009 the average residential electricity consumption in Connecticut was 724 kilowatt hours (kWh) per month.[64] ***This is approximately ~1 kilowatt (kW) per month for Connecticut households. (See Box 2.1 Energy Assumptions)***

In 2010, the Energy Information Administration (EIA) released their findings for their 2003 Commercial Buildings Energy Consumption Survey (CBECS). The survey reported that there were 47,000 office buildings in the New England region, totaling 578 million square feet (ft^2).[65] ***Therefore, the estimated average area of an office building in New England, Connecticut is assumed to be 12,298 square feet. (See Box 2.1 Energy Assumptions)***

In 2003, all U.S. office buildings had an electricity consumption of 256,000 kilowatt hours (kWh) per building which averaged to a consumption of 17.3 kWh/ft^2.[66] The average electricity consumption per square foot along with the estimated average area of an office building in New England (~12,298 ft^2) allows for estimated electricity consumption for office buildings of ~212,755 kWh**. *This is approximately ~24kW of electricity consumption per office building in New England (See Box 2.1 Energy Assumptions)***

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[63] United States. U.S. Department of Energy. *Using Distributed Energy Resources*. 2002. p.2-3 Web. Nov. 2011. <http://www.nrel.gov/docs/fy02osti/31570.pdf>.

[64] "Table 5A. Residential Average Monthly Bill by Census Division, and State 2009." *U.S. Energy Information Administration*. Energy Information Administration, 2009.Web.28 Nov. 2011. <http://www.eia.gov/cneaf/electricity/esr/table5_a.xls>.

[65] "Types of Office Buildings." *U.S. Energy Information Administration*. U.S. Department of Energy, Sep 2010. Web 16 Nov. 2011. <http://www.eia.gov/emeu/cbecs/cbecs2003/officereport/office1.html>

[66] "Office Building Energy Consumption." *U.S. Energy Information Administration*. U. S. Department of Energy, Sep 2010. Web. 16 Nov. 2011. <http://www.eia.gov/emeu/cbecs/cbecs2003/officereport/office2.html>.

BOX 2.1 ENERGY ASSUMPTIONS

According to the Energy Information Administration (EIA) of the DOE, the average Connecticut residential consumption was 724 kilowatt hours (kWh) per month,[1] which equals ~1 kilowatt (kW):

24 hours a day x 30 days a month = 720 hours a month

724 kWh / 720 hours = 1.006 kW ≈ **1 kW**

According to the CBECS given by the EIA, in 2003, there were 47,000 office buildings totaling 578 million square feet (ft^2) in New England region.[2] Hence, this averages ~12,298 ft^2 per office building:

578 million ft^2 / 47,000 buildings = 12,297.87 ft^2 OR **~12,298 ft^2 per building**

In 2003, U.S. office buildings averaged a consumption of 256,000 kilowatt hours (kWh) of electricity per office building,[3] which averages to an electricity consumption of 17.3 kWh/ ft^2. Combining the average electricity consumption per square footage with the average square footage per building gives:

12,298 ft2 x 17.3 kW/ft2 = 212755.4 kWh OR **~212,755 kWh per year**

This is equals approximately ~**24 kW average electricity consumption per office building:**

24 hours a day x 365 days a year = 8760 hours a year

212,755 kWh / 8760 hours = 24.29 kW OR **~24 kW**

* Because 2003 was the last year the EIA has this information available for, we must make some key assumptions. First, that the average office building size in New England has not changed significantly since 2003. Second, the average electricity consumption of office buildings across the country has not changed dramatically. With these key assumptions we can estimate that the average office building will consume an average of ~24 kW. This amount will vary depending on specific office building type as well as time of year. In the summer the average will typically increase due to air conditioning usage.

[1] "Table 5A. Residential Average Monthly Bill by Census Division, and State 2009." *U.S. Energy Information Administration*. Energy Information Administration, 2009.Web. 28 Nov. 2011 <http://www.eia.gov/cneaf/electricity/esr/table5_a.xls>.

[2] United States. U.S. Department of Energy. *Using Distributed Energy Resources*. 2002. p.2-3. Web. 28. Nov 2011 <http://www.nrel.gov/docs/fy02osti/31570.pdf>.

[3] "Types of Office Buildings." *U.S. Energy Information Administration*. U.S. Department of Energy, Sep 2010. Web. 16 Nov. 2011 <http://www.eia.gov/emeu/cbecs/cbecs2003/officereport/office1.html> .

Residential units and commercial buildings vary in size and occupancy. A one-size-fits all approach is unrealistic, but this average aggregate approximation will be useful in providing a starting point for determining demand loads for distributed energy generation requirements.

Distributed energy generation systems often cannot provide the entire load demand by a facility and in most cases interconnections to a commercial grid to ensure a reliable flow of electricity. Furthermore, depending on the electrical load demand, a combination of distributed energy generation technologies must be installed together to maximize the efficiency of the system. There is no "silver bullet" to the implementation of distributed energy generation resources, thus a case-by-case approach should be undertaken. The estimated average consumptions for residential units (~1 kW) and office commercial units (~24 kW), while only estimates; do provide a useful baseline for average demand needed. In the following section, promising distributed energy generation strategies will be identified based on these estimated consumption baselines.

2.2 DISTRIBUTED ENERGY GENERATION PROMISING STRATEGIES

The distributed energy generation strategies most beneficial to the East Bridgeport Development Corridor project are solar PV panels, microturbines and fuel cells. At the residential level, PV systems afford residents the opportunity to generate the ~1 kW average needed. For larger commercial projects, microturbines and fuel cells offer the capacity to meet the ~24 kW average calculated for commercial office buildings. Microturbines and fuel cells also provide flexibility in generation capacity and fuel source usage. Scalability in generation capacity is essential as the commercial development projects throughout the East Bridgeport Corridor will vary in size and energy demands.

The fuel source for microturbine and fuel cells include natural gas and biogas. An infrastructure already exists for natural gas distribution as it is a common fuel used for heating. A study by GHD Inc. found that local biogas production at wastewater treatment facilities is feasible. There are site-specific size requirements and economic factors that need to be addressed before such a strategy could be implemented.[67] Microturbine and fuel cell coupled with CHP systems offer greater fuel efficiency. Therefore, residential solar PV systems, commercial microturbine CHP systems and

[67] "Biosolids to Energy Feasibility Study City of Bridgeport, Connecticut." GHD INC. February 2011

commercial fuel cell CHP systems are promising strategies for implementation in East Bridgeport Corridor.

The estimated average usages calculated above were obtained using information available from the state of Connecticut and the North East region of the United States, not Bridgeport per se. Conducting energy consumption surveys specific to Bridgeport allows the opportunity to obtain quantifiable metrics. These metrics can help determine a better baseline to benchmark and assess Bridgeport's energy needs. They will also be useful for future studies regarding energy demands in Bridgeport.

Promising Strategy: ***Conduct energy consumption surveys for residential and commercial sectors in Bridgeport.***

SOLAR PHOTOVOLTAIC (PV)

Solar PV systems offer many benefits and has been successfully implemented in other Connecticut towns. In 1999, a New England resident installed one of the first interconnections to a local utility for a residential 3 kW solar PV.[69] Initially, the customer faced many barriers to interconnection imposed by the local utility company such as; having to enlist the utility company on its homeowner's insurance policy, a large interconnection fee and a lengthy process.[70] Since then the utility company has streamlined the interconnection process to be much easier.

The 3 kW solar PV system installed in this case study generates almost twice as much electricity needed ~1.6 kW (See Box 2.2 *Considering Peak Load Efficiencies for Solar PV*) during summer peak hours to supply a household. As previously mentioned, solar PV is an intermittent resource and needs to be connected to the commercial grid to ensure it as a reliable electricity source. This connection was successful in New England, and Bridgeport can see similar results. However, a baseline is needed to determine the amount of space needed to generate ~1 kW of average usage.

[69] Alderfer, R. Brent; Starrs, Thomas J; Eldridge PE, M. Monika. United States. National Renewable Energy Laboratory Department of energy. *Making Connections Case Studies of Interconnection Barriers and their impact on Distributed Power Projects*. p.73-74. National Renewable Energy Laboratory, 2000. Web. Nov. 2011 <http://www.doe.gov/bridge>.
[70] Ibid.

BOX 2.2 CONSIDERING PEAK LOAD EFFICIENCIES FOR SOLAR PV

Daily power demand varies, typically with higher demand during the day and lower demand at night. According to EIA, the peak demand for New England during October 2010 was approximately 60 percent higher than the lowest demand point in the daily cycle.[1] Additionally, the peak demand occurred at six in the evening consuming 16 gigawatts (GW) of electricity, with the lowest demand at three in the morning consuming 10GW.

Using the estimated residential consumption average of ~1 kW and the approximate energy spread in New England of 60 percent, the peak demand changes incrementally to ~1.3 kW, with a minimum demand of ~0.8 kW. The daily peak is higher during the warmer summer months because of increased use of air conditioners. If the incremental peak demand of ~.3 is increased by a factor of two, the average Connecticut residential peak demand would be ~1.6 kW during the summer season.

* It is important to note that this is an estimated average aggregate given the data available from the Energy Information Administration.

[1] "Today in Energy." *U.S. Energy Information Administration*. U.S. Department of Energy, 06 Apr 2011. Web. 28 Nov 2011. <http://www.eia.gov/todayinenergy/detail.cfm?id=830>.

The National Renewable Energy Laboratory's (NREL) PV Watts calculator estimates Bridgeport's yearly solar radiation as 4.44 kWh/m^2/day. This is approximately 185 watts per meter squared (W/m^2).[71] Common solar panel efficiency is 12 percent.[72] Utilizing the estimated residential average of ~1 kW for Connecticut's residential sector it can be determined that 495 ft^2 of space will be needed to generate ~1 kW of electricity. See Box 2.3 "National Renewable Energy Laboratory Bridgeport Output Calculator," for a detailed analysis.

[71] "PV Watts AC Energy and Cost Savings." *PVWATTS A Performance Calculator for Grid Connected PV Systems* (2009): n.pag. *National Renewable Energy LabrartoryPVWATTS Calculator*. Web. 12 Nov 2011. <http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/US/code/pvwattsv1.cgi>.

[72] "History of Solar Power." *Ameco Solar*. Ameco, 2011. Web. 2 Dec. 2011. <http://solarexpert.com/pvbasics2.html>.

BOX 2.3 NATIONAL RENEWABLE ENERGY LABORATORY BRIDGEPORT OUTPUT CALCULATOR

Bridgeport's solar radiation based on the NREL calculator is 4.44 kWh/m^2/day needs to be converted:[1]

> 4.44 (kWh/m^2/day) / 24 hours/day = .185 kW/m^2 OR **<u>185 W/m^2</u>** of solar radiation

According to SolarExpert.com the average efficiency for PV modules are 12%.[2] Using this efficiency with the solar radiation equals 22 W/m^2.

> 185 W/m^2 x .12 = 22.2 W/m^2 OR **<u>22 W/m^2</u>**

Using the estimated residential average of ~1 kW, the amount of space needed to generate 22 W/ m^2 of electricity is approximately 495 ft^2.

> 1000 W (1kW) / 22 (W/m^2) = 45.45 m^2 OR **<u>46 m^2</u>**
>
> 46 m^2 x 10.7639 ft^2/m^2 = 495.13ft^2 OR **<u>495 ft^2</u>**

Therefore, the average residential household in Bridgeport will need **495 ft^2** of space for installation of solar PV modules with 12% efficiency in order to generate the needed ~1 kW average residential usage.

[1] "PV Watts AC Energy and Cost Savings." *PVWATTS A Performance Calculator for Grid Connected PV Systems* (2009): *National Renewable Energy LabrartoryPVWATTS Calculator*. Web. 12 Nov. 2011 <http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/US/code/pvwattsv1.cgi>.
[2] "History of Solar Power." *Ameco Solar*. Ameco, 2011. Web. 2 Dec 2011. <http://solarexpert.com/pvbasics2.html>.

Cost Analysis for Implementation: The DOE's Federal Energy Management program (FEMP), summarizes some of the installation costs and emissions information for PV systems as shown in Table 2-2. [73]

TABLE 2-2 SOLAR PV COSTS

TECHNOLOGY	SIZE RANGE (kW)	INSTALLATION COSTS ($/kW)b	HEAT RATE (BTU/ kWhe)	EFFICIENCY (%)	VARIABLE O&M ($/kWh)	EMISSIONS (lb/kWh)	
						NO_x	CO_2
Photovoltaics	Limited by Space	7,000-10,000	--	N/A	0.002	0	0

[73] "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program*. U.S. Department of Energy. 12 Oct. 2011. Web. 28 Nov 2011. <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html >

PV systems are being produced with lifetime of at least 25 years.[74] Using Table 2-2 and the average generation of ~1 kW, the installed cost would be $7,000. The variable operations and maintenance costs (O&M) would be approximately $7,400. According to United Illuminating (UI) the electricity distributor in Bridgeport the current rate per month for the basic residential customers with standard generation service from UI is 10.6155 cents/kWh, the distribution charge is 4.9113 cents/kWh. Therefore, basic residential customers with standard generation and distribution service pay

BOX 2.4 SOLAR COST ANALYSIS FOR OVER 25 YEARS

Using the Solar PV Cost Table and the estimated residential average of ~1 kW, the installation costs are $7,000. Considering the lifetime warranty of a solar PV module is 25 years,[1] the operations and maintenance costs for a solar PV module is $434.40.

724 kWh (monthly CT household average used previously)

724 kWh/month x (12 months/year) x 25 years = 217,200 kWh

(.002 $/kWh) x 217,200 kWh = **$434.40 for 25 years**

Thus, the variable operations and maintenance costs (O&M) are $7,434.40.

$7,000 + $434.40 = **$7,434.40**

According to UI, the electricity distributer in Bridgeport, the current rate per month for the basic residential customers with standard generation service is 10.6155 cents/kWh and the distribution charge is 4.9113 cents/kWh. Basic residential customers with standard generation and distribution service pay $33,413.67.

.155268 $/kWh[#] x 215,200 kWh (for 25 years) = **$33,413.67** (for 25 years)

Customers that install a PV system with 12 percent efficiency they would experience a savings of $25,979.27 over the 25 year life time of the model PV system.

$33,413.67 - $7,434.4 = **$25,979.27 over 25 years**

*Key assumptions are that the electricity rates do not significantly change and the average CT household kWh usage per month does not significantly change. Calculations reflect continuous PV use, although there is intermittency associated with PV technology not calculated here.

[1] Solar Generation 6 Solar Photovoltatic Electricity Empowering the World." *Green Peace*. Green Peace, 2011. Web. 9 Nov 2011. <http://www.greenpeace.org/international/Global/international/publications/climate/2011/Final SolarGeneration VI full report lr.pdf>.

[#] "The United Illuminating Company Residential Rate R." *The United Illuminating Company*. The United Illuminating Company. 23 Jun. 2011. Web. 8 Nov 2011. <http://www.uinet.com/wps/wcm/connect/5928018040d8629ea840bbd2ce51850f/Rate R.pdf?MOD=AJPERES&CACHEID=5928018040d8629ea840bbd2ce51850f>.

[74] "Solar Generation 6 Solar Photovoltatic Electricity Empowering the World." *Green Peace*. Green Peace,2011. Web. Nov. 2011. <http://www.greenpeace.org/international/Global/international/publications/climate/2011/Final SolarGeneration VI full report lr.pdf>.

15.5268 cents/kWh.[82] For energy produced standard generation, these customers will be paying $33,413.67 for the kWh's needed over the next 25 years. Please see Box 2.4 "Solar Cost Analysis for Over 25 Years" for further details.

Despite large upfront installation costs and variable O&M costs associated with solar PV systems, they offer Bridgeport residents the opportunity for financial savings. Based on the available data, the assumptions made in this scenario, and the calculations made in Box 2.4 the savings would amount to approximately $1,039.17 per household per year. The East Bridgeport Development Corridor will include new residential structures. The exact number of new residential units in the corridor is unknown. However, Bridgeport 2020 estimates that the East Side Neighborhood contains seven percent of single family units.[86] If the new East Bridgeport Development Corridor is comprised of the same neighborhood composition it could be estimated that approximately 4,312 kW's of new residential demand could be offset if all of the single family units were able to install the appropriate solar PV systems.[87] Please see Box 2.5 "East Bridgeport Development Corridor for Solar" for detailed analysis.

It is important to note that the variable O&M costs may be too low for Bridgeport. Given Bridgeport's population density compared to other parts of the U.S., the O&M costs will probably be higher. Elements such as increased dust deposits from precipitation, exposure to animal waste, and even vandalism and theft all will drive the O&M costs higher. However, even if the O&M costs were 10 times bigger, they are still small when compared against a 25 year period.

While this scenario contains several assumptions, there is potential to offset at least 4,312 kW of new residential demand in the East Bridgeport Development Corridor if solar PV systems are implemented. Therefore solar PV systems are a promising strategy for Bridgeport.

Promising Strategy: ***The proposed single family residences located on the East Side Development Corridor should install solar PV systems and interconnect to the commercial grid.***

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[82] "The United Illuminating Company Residential Rate R." *The United Illuminating Company*. The United Illuminating Company, 23 Jun 2011.Web. 8 Nov. 2011. <http://www.uinet.com/wps/wcm/connect/5928018040d8629ea840bbd2ce51850f/Rate R.pdf?MOD=AJPERES&CACHEID=5928018040d8629ea840bbd2ce51850f>.

[86] "Bridgeport 2020: A Vision for the Future," BJF Planning, p.147, March 2008

BOX 2.5 EAST BRIDGEPORT DEVELOPMENT CORRIDOR FOR SOLAR

Using Bridgeport 2020s even percent estimation for single family residential in Bridgeport's Eastside Neighborhood as a basis for the East Bridgeport Development Corridor (700 acres):

700 acres x .07 = 49 acres

1 acre = 43.560 ft^2

49 acres x 43,560 ft^2 = 2,134,440 ft^2

Using the estimate of ~495 ft^2 needed to generate the ~ 1 kW estimated average residential demand.

2,134,440 ft^2 / 495 (ft^2/kW) = 4,312 kW

*A key assumption must be made. All of the new single family residential units in the East Bridgeport Development Corridor are willing and have the optimal site conditions to install the solar PV systems.

Given the estimated ~1 kW average needed for Connecticut residential units, solar PV systems are promising strategies for implementation to meet the demand for these new residences.

Solar PV systems are promising strategies for meeting the ~1 kW estimated residential demand while producing zero emissions, it is important to note certain challenges. Solar PV systems are not able to generate electricity all of the time. Therefore it is also suggested that these residences connect to the commercial grid to ensure electricity demands can be met at night and during impaired sun exposure.

MICROTURBINES

In 2003, the Aquarion Water Company, the premier water provider in Bridgeport, piloted the use of small microturbine systems in the water piping infrastructure.[88] Their goal was to utilize excess pressure in the water pipes and convert it to electricity using "Flow-to-Wire" devices produced by Rentricity Inc.[89] The "Flow-to

[88] "Aquarion Water Installing New Clean Energy Recovery Devices Supplied by Rentricity Inc.." *Water Industry News*. Water Industry, 23 Nov 2003. Web. 10 Nov. 2011.<http://waterindustry.org/New Projects/aquarion-5.htm>.
[89] Ibid.

Wire" devices consisted of a microturbine and other components[90] and had the ability to connect to the grid to deliver electricity to customers. "A single device was expected to produce enough electricity to meet the energy needs of between 20 and 100 average homes."[91] This application of a microturbine highlights a small portion of the flexibility these distributed energy resources have. The proposed building types situated throughout the East Bridgeport Development Corridor include residential, commercial, schools and community centers and vary in energy demand. Microturbines can be made to accommodate energy ranges of 30 kW, 65 kW and 200 kW sizes.[92]

In addition to kW size, microturbines have the flexibility to meet facilities heating needs when installed with CHP systems. These systems capture and use the thermal energy being produced during the electricity generating process that would have otherwise been wasted. The DOE states that CHP systems in general have fuel utilization efficiencies between 70 to 85 percent.[93] Installations of microturbine CHP systems utilizing natural gas are at the East Hartford High School and Branford High School in Connecticut.[94]

The fuel type used in microturbine CHP systems is usually natural gas but they have the flexibility to operate on a variety of fuels. These include biogases from landfills, wastewater treatment centers and anaerobic digestion.[95] In February 2011, GHD Inc. published a biosolids to energy feasibility study for Bridgeport Connecticut. The study researched the feasibility of using the biosolids produced from the city's wastewater treatment plants in alternative methods.[96] One alternative the study explored was the production of biogas through anaerobic digestion. The study stated that approximately 162,000 cubic feet per day of biogas could be produced by anaerobic digestion.[97] This biogas could then be used as a fuel for a microturbine. The study reported that microturbine CHP biogas-to-electricity production had efficiencies between approximately 70 to 75 percent[98] and that potential gross energy

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[90] "Aquarion Water Installing New Clean Energy Recovery Devices Supplied by Rentricity Inc.." *Water Industry News*. Water Industry, 23 Nov 2003. Web. 10 Nov. 2011.<http://waterindustry.org/New Projects/aquarion-5.htm>.
[91] "Aquarion Water Installing New Clean Energy Recovery Devices Supplied by Rentricity Inc." *Water Industry News*. Water Industry, 23 Nov 2003. Web. 10 Nov. 2011. <http://waterindustry.org/New Projects/aquarion-5.htm>.
[92] "Products." *Capstone Turbine Corporation*. Capstone Turbine Corporation, 2011.Web. 9 Nov. 2011.<http://www.microturbine.com/prodsol/products/index.asp>.
[93] "Combined Heat and Power Basics." *Department of Energy Federal Energy Management Program*. Department of Energy, 12 Oct 2011. Web. 13 Nov. 2011.<http://www1.eere.energy.gov/femp/technologies/derchp_chpbasics.html>.
[94] "Combined Heat and Power Units located in Connecticut." *Energy and Environmental Analysis INC.*. Energy and Enviromental Analysis INC., n.d. Web. 10 Nov. 2011.<http://www.eea-inc.com/chpdata/States/CT.html>.
[95] "Products." *Capstone Turbine Corporation*. Capstone Turbine Corporation, 2011. Web. 9 Nov 2011. <http://www.microturbine.com/prodsol/products/index.asp>.
[96] "Biosolids to Energy Feasibility Study City of Bridgeport, Connecticut." p. 8, GHD INC. February 2011
[97] Ibid. p. 53
[98] Ibid. p. 59

produced an approximate equivalent of 1,200 kW.[99] The study concluded that factors like site space availability and alternative net annual costs presented barriers to implementation. On the other hand, the study highlighted that biogas fueled microturbine CHP systems could potentially be utilized at the municipal level in Bridgeport.

Commercial applications of microturbines are more common. In Hauppauge, New York a 60 kW natural gas-fired microturbine was implemented at a typical full-sized supermarket (57,000 sq ft). The peak electricity load for a supermarket like this is 300 kW.[100] In addition to the microturbine, a heat recovery unit and HVAC unit were also installed. The combination of equipment was selected because of the complex electrical, heating and cooling energy demands typical full-sized supermarkets experience.[101] The supermarket was able to achieve electricity savings of $48,565, heat recovery savings of $13,368 and a net savings of $8,312 per year.[102]

Additional savings were realized because implementing this strategy was financially supported in part (65%) by grants and loans from various partners. [103] The partners were brought together by the National Accounts Energy Alliance (NAEA), "a consortium that offers assistance to energy managers that offer to use their facilities as test sites for distributed energy resources (DER). "[104] Some of the parties that the NAEA were able to get involved were New York State Energy Research and Development Authority (NYSERDA), The National Renewable Energy Laboratory (NREL), and the Oak Ridge National Laboratory (ORNL) amongst others.[105] The financial support from these partners helped mitigate the overall implementation costs. The net savings amounted to $8,312 a year with a payback period of six years.[106]

This case study demonstrates how a commercial space with complex energy demands can implement distributed energy generation technologies. This strategy can be replicated on the East Bridgeport Development Corridor.

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[99] "Biosolids to Energy Feasibility Study City of Bridgeport, Connecticut." p. 53, GHD INC. February 2011

[100] Bailey, Owen; Creighton, Charles; Firestone, Ryan; Marnay, Chris; Stadler, Michael. United States. Lawerence Berkely National Labrartory, Department of Energy. *Distributed Energy Resources in Practice: A Case Study Analysis and Validation of LBNL's Customer Adoption Model*. p. 38. 2003.Web. Nov.2011. <http://eetd.lbl.gov/EA/EMP>.

[101] Ibid.p.33

[102] Ibid.p. 36.

[103] Ibid. p. 56.

[104] Ibid. p. 35.

[105] Ibid. p. 35.

[106] Bailey, Owen; Creighton, Charles; Firestone, Ryan; Marnay, Chris; Stadler, Michael. United States. Lawerence Berkely National Labrartory, Department of Energy. *Distributed Energy Resources in Practice: A Case Study Analysis and Validation of LBNL's Customer Adoption Model*. p. 37. 2003. Web. Nov. 2011 <http://eetd.lbl.gov/EA/EMP>.

Microturbine Cost Benefit Summary: The costs in Table 2-3 are from the DOE Federal Energy Management Program,[107] which summarizes some of the installation costs for smaller microturbine CHP systems. The microturbine efficiency percentages stated earlier (70 to 75 percent), include fuel efficiencies, thus they are higher than the 28 percent efficiency in Table 2-3. The average life cycle for microturbine varies upon the size, usage and fuel type. One estimate for the specified service life of microturbine power stations is 200,000 hours on average.[109] This is equivalent to the average lifetime of approximately 23 years. See Box 2.6 Microturbine Life Efficiency for more details.

TABLE 2-3 MICROTURBINE COSTS

TECNOLOGY	SIZE RANGE (kW)	INSTALLATION COSTS ($/kW)b	HEAT RATE (BTU/ kWhe)	EFFICIENCY (%)	VARIABLE O&M ($/kWh)	EMISSIONS (lb/kWh)	
						NO_x	CO_2
Microturbine w/ CHP c	15-60	1,100-1,850	12,200	28	0.014	0.00049	1.19

Department of Energy, 10/12/2011

BOX 2.6 MICROTURBINE LIFE EFFICIENCY

Using the estimate for expected lifetime warranty of a microturbine (200,000 hours):*

24 hours a day x 365 days a year = 8760 hours a year

200,000 hours / 8760 hours a year = 22.83 OR **~23 years average life**

*"Energy (Gas) Turbine." *ProTrainer India*. ProTrainer India, 2011. Web. <http://protrainerindia.com/services/energy-gas-turbine/>. Web accessed November 10, 2011.

Over the course of its lifetime, a microturbine can provide several benefits. Some of the benefits that previously installed microturbine systems provided are highlighted in the following case studies:

Sheboygan, Wisconsin / Wastewater Treatment Facility: In 2006, a wastewater treatment facility in Sheboygan Wisconsin installed 10 microturbines generating 300 kW of electrical power. The benefits included a 5 year stable electric bill, despite

[107] "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program*. U.S. Department Of Energy, 12 Oct 2011. Web. 28 Nov. 2011 <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.

[109] "Energy (Gas) Turbine." *ProTrainer India*. ProTrainer India, 2011. Web.10 Nov. 2011. <http://protrainerindia.com/services/energy-gas-turbine/>.

increasing utility rate increases. A 2007 production of 1,681 MW of electricity valued at $121,000 and 61,000 therms of biogas valued at nearly $57,000.[110]

College Dormitory / Carneys Point New Jersey: In 2009, Salem Community College in Carneys Point, NJ installed 3 microturbines in one of the dormitories, so it could serve as a shelter in an emergency.

The microturbines produced more than 80 percent of the buildings electricity needs and 100 percent of the buildings heating needs. Additionally there was an anticipated 30% overall energy savings.[111]

Philadelphia, PA / Hotel: In 2009, the Four Seasons Hotel in Philadelphia, PA installed 3 microturbines as a part of CHP system. The benefits included $80,000 in savings in the first 2 months; 195 kW of electricity; electricity costs 20 percent lower than utility power; 100 percent of the hotels domestic hot water needs, 30% of the electricity needs and 15 percent heating needs.[112]

These case studies show the benefits of implementing microturbines. With the variety of different building types being proposed in this new development, along with the potential for biogas being produced in Bridgeport, the usage of microturbines is feasible.

Promising Strategy: ***Utilize microturbine CHP systems in commercial projects proposed in the East Bridgeport Development corridor and take advantage of existing natural gas infrastructure.***

[110] "Sheboygan Wastewater Plant." *Capstone Turbine Corporation*. Capstone Turbine Corporation, 2009. Web. 10 Nov. 2011. <http://www.microturbine.com/_docs/CS_CAP381_Sheboygan_lowres.pdf>.
[111] "Salem Community College." *Capstone Turbine Corporation*. Capstone Turbine Corporation, 2010. Web. 10 Nov. 2011. <http://www.microturbine.com/_docs/CS_CAP391_SalemCC_lowres.pdf>.
[112] "Four Seasons Hotel Philadelphia." *Capstone Turbine Corporation*. Capstone Turbine Corporation, 2010. Web. 10 Nov. 2011. <http://www.microturbine.com/_docs/CS_CAP397_FourSeasonsPA_lowres.pdf>.

Microturbines offer scalability in kW size and can be installed to operate on a variety of fuels. Additionally, the infrastructure for natural gas delivery is available in Bridgeport. If a cleaner fuel is desired, the potential for local biogas production has been studied and could be feasible in the future. Both of these fuel sources used in a microturbine offer a reduction in CO_2 emissions, compared to the burning of coal in a centralized plant as previously mentioned. Bridgeport 2020 states that the East Side neighborhood contains 10.5 percent commercial land use.[113] If the new East Bridgeport Development Corridor is comprised of the same neighborhood composition and microturbines are implemented at new commercial developments then a potential of 6,240 kW of new demand could be offset. See Box 2.7 "Microturbines and Fuel Cells for East Bridgeport Development Corridor" for a detailed analysis.

Box 2.7 MICROTURBINES AND FUEL CELLS FOR EAST BRIDGEPORT DEVELOPMENT CORRIDOR

Using Bridgeport 2020's 10.5 percent estimation for commercial land-use in Bridgeport's Eastside Neighborhood as a basis for the East Bridgeport Development Corridor (700 acres):

700 acres x .105 is 73.5 acres

1 acre = 43,560 ft^2

73.5 acres x 43,560 ft^2 = **3,201,660 ft^2**

Using the estimate of ~ 12,298 ft^2 needed to generate the ~ 24 kW estimated average commercial office building demand.

3,201,660 ft^2 / 12,298 ft^2 = 260.34 OR ~260 commercial office buildings

260 x 24 kW = **6,240 kW**

* Key assumptions in this scenario are that the microturbines and fuel cells would have to be running all of the time and that all the commercial buildings in the East Side Development Corridor are average sized office buildings. While they cannot run realistically all of the time, they are able to run with only minor down time for operations and maintenance.

[113] Bridgeport 2020: A Vision for the Future, BJF Planning, p.147, March 2008

While microturbines are able to run the majority of the time, it is necessary to shut down the equipment for maintenance periodically. Although interconnection to the grid is necessary to ensure continuous power, there could be minimal draw from the grid.

Particularly at peak times, microturbines would be able to offset this sizeable new commercial demand thus reducing the stress on already congested Bridgeport distribution lines.[114] For commercial facilities that implement microturbines, this reduction of draw from the grid would mean lower electricity bills and a reduction in CO_2 emissions.

FUEL CELLS

Similar to microturbines, fuel cells provide flexibility in a number of ways. They range in kW size, can be combined with other equipment to form CHP systems and can run on a variety of fuel types. These include natural gas, and clean fuels like biofuels and hydrogen. Sizes can vary from 1 kW – 10 MW in size.[115]

Fuel cells have already been utilized in Bridgeport and parts of Connecticut, and have a strong backing from local organizations. The Connecticut Hydrogen-Fuel Cell Coalition is a collection of representatives from the CT hydrogen and fuel cell industry, and is administered by the Connecticut Center for Advanced Technology (CCAT). The coalition "works to enhance economic growth through the development, manufacturing, and deployment of fuel cell and hydrogen technologies and associated fueling systems in Connecticut."[116] In a 2010, CCAT reported that "Connecticut was the current world leader in research, design and manufacturing of hydrogen and fuel cell related technologies."[117]

In Bridgeport, a natural gas-fired fuel cell park has been proposed. According to Ted Grabarz, Bridgeport's Director of Sustainability, the city is moving forward with this project.[118] The Fuel Cell Park will be located on two acres of brownfield redevelopment land and the power generated will be delivered to UI with hopes to

[114] "Petition No. 957 Bridgeport Fuel Cell Park, LLC Bridgeport, Connecticut September 23, 2010 Staff Report." *Official Website of the State of Connecticut*. State of Connecticut. 2010. Web. 14 Nov. 2011. <http://www.ct.gov/csc/lib/csc/petition_staff_reports/sr957_20100924153532.pdf>.

[115] "California Distributed Energy Resource Guide: Fuel Cells." *California Energy Commission*. California Energy Commission. 19 Aug 2003. Web. 28 Nov. 2011. <http://www.energy.ca.gov/distgen/equipment/fuel_cells/fuel_cells.htm>.

[116] "Welcome to the Connecticut Hydrogen-Fuel Cell Coalition." *Connecticut Hydrogen-Fuel Cell Coalition*. Connecticut Hydrogen-Fuel Cell Coalition, 2009. Web. 12 Nov. 2011. <http://www.chfcc.org/>.

[117] "Connecticut Hydrogen Fuel Cell Industry Status and Direction 2010 and 2011." *Connecticut Hydrogen Fuel Cell Coalition*. Connecticut Center for Advanced Technology Inc., Sep 2010. Web. 14 Nov. 2011.<http://www.chfcc.org/Publications/reports/PRELIMINARY STATUS AND DIRECTION FC 2010 9-20-2010.pdf>.

[118] Grabarz, Ted. "RE:Columbia University Sustainability Project on Bridgeport." Message to Nicholas Walker. 14 Nov 2011. E-mail.

reduce the electrical congestion transmission in the Bridgeport area.[119] Edward Lavernoich, Deputy Director of the Office of Planning and Economic Development in Bridgeport, reports that the park will be 15 MW in size and the power will be sold back to UI at a rate intended to subsidize the project.[120] While this specific fuel cell project is large in scale, the opportunity to further implement fuel cells commercially in Bridgeport exists due to the abundance of current and proposed development.

Fuel Cell Cost Benefit Summary: Fuel cells are relatively new technology compared to other forms of distributed energy generation resources. The installation costs estimates vary. The fuel cell cost table (see Table 2-4) by the Federal Energy Management Program (FEMP) shows an estimate of $5,500 per kW for smaller sized fuel cells.[121]

TABLE 2-4 FUEL CELL COST

TECNOLOGY	SIZE RANGE (kW)	INSTALLATION COSTS ($/kW)b	HEAT RATE (BTU/ kWhe)	EFFICIENCY (%)	VARIABLE O&M ($/kWh)	EMISSIONS (lb/kWh)	
						NO_x	CO_2
Fuel Cell with CHP	100-250	5500+	5,850	50	0.01- 0.05	0.000015	0.85

Department of Energy, 10/12/2011

The CCAT estimates that from 2002 to 2010 the installed cost of fuel cells dropped, and in 2010 was approximately just below $6,000 per kW.[122] In terms of efficiencies, the FEMP gives an approximate efficiency of 50 percent for just fuel cell systems.[123] Fuel Cell CHP systems are 80 to 90 percent efficient.[124] Specific examples of fuel cell benefits are described below.

[119] "Petition No. 957 Bridgeport Fuel Cell Park, LLC Bridgeport, Connecticut September 23, 2010 Staff Report." *Official Website of the State of Connecticut*. State of Connecticut, 2010. Web.14 Nov. 2011. <http://www.ct.gov/csc/lib/csc/petition_staff_reports/sr957_20100924153532.pdf>.

[120] Lavernoich, Edward."RE:RE:Columbia University Sustainability Project on Bridgeport."Message to Nicholas Walker. 14 Nov 2011. E-mail.

[121] "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program.* U.S. Department of Energy, 12 Oct 2011. Web. 28 Nov. 2011 <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.

[122] "Connecticut Hydrogen Fuel Cell Industry Status and Direction 2010 and 2011." *Connecticut Hydrogen Fuel Cell Coalition*. p. 4. Connecticut Center for Advanced Technology Inc. Sep 2010. Web. 14 Nov. 2011<http://www.chfcc.org/Publications/reports/PRELIMINARY STATUS AND DIRECTION FC 2010 9-20-2010.pdf>.

[123] "Distributed Energy Resource Basics." *U.S. Department of Energy Federal Energy Management Program*. U.S. Department Of Energy, 12 Oct 2011. Web. 28 Nov. 2011 <http://www1.eere.energy.gov/femp/technologies/derchp_derbasics.html>.

[124] "Connecticut Hydrogen Fuel Cell Industry Status and Direction 2010 and 2011." *Connecticut Hydrogen Fuel Cell Coalition*. p. 7. Connecticut Center for Advanced Technology Inc., Sep 2010. Web. 14 Nov 2011. <http://www.chfcc.org/Publications/reports/PRELIMINARY STATUS AND DIRECTION FC 2010 9-20-2010.pdf>.

Commercial Brewery / Sierra Nevada, CA: In Sierra Nevada, California four 250kW fuel cells were installed in a brewery. The 1 MW system provided nearly 100 percent of the facilities base load power requirements and the waste heat was harvested and used for various needs throughout the brewery as well. Additional benefits included lower emissions and lower energy costs.[125]

Wastewater Treatment Facility / Tulare, CA: At the Regional Wastewater Treatment Facility in Tulare, California installed three fuel cells creating a 900 kW system. The system also utilized digester gas being created on site. The fuel cell system lowered emissions, reduced energy costs and reliance on the local power grid. Because of the utilization of the digester gas the system was eligible for $4 million in incentives for a California self-generation program.[126]

Hotel & Marina / San Diego, CA: In 2005, the Sheraton Hotel and Marina in San Diego installed four 250 kW fuels cells. The waste heat was used to help meet the hotel's hot water needs including the heating of swimming pools. The system supplied 60 to 80 percent of the hotels base load power requirements. Additional benefits included high reliability, ultra-low emissions, and minimal noise pollution. The system was so successful that the facility added another 250 kW.[127]

***Promising Strategy:* Utilize fuel cell CHP systems in commercial projects proposed in the East Bridgeport Development corridor and take advantage of existing natural gas infrastructure.**

Utilization of fuel cells in Bridgeport is a promising strategy, given its flexibility in meeting different load demands and ability to run on different fuels. Like microturbines, fuel cells offer commercial projects in Bridgeport the capacity to meet the average commercial office building demand of ~24 kW. Larger commercial projects can still have their electricity demand met by implementing fuel cells due to their wide size range in kW. Using the same assumptions as microturbine technologies, fuel cells can potentially offset 6,240 kW of new Bridgeport commercial demand if implemented. Fuel cells offer fuel flexibility and can be installed to run on

125 "Sierra Nevada." *Fuel Cell Energy*. Fuel Cell Energy, Inc. 2008.Web. 10 Nov. 2011. <http://www.fuelcellenergy.com/files/FCE_SierraNeveda_120808LR.pdf>.
126 "City of Tulare, CA." *Fuel Cell Energy Inc*. Fuel Cell Energy Inc. 2008. Web.10 Nov. 2011. <http://www.fuelcellenergy.com/files/FCE_Tulare_070208-LR.pdf>.
127 "Sheraton San Diego." *Fuel Cell Energy*. Fuel Cell Energy, Inc. 2008. Web. 10 Nov. 2011. <http://www.fuelcellenergy.com/files/FCE_SheratonSanDiego_120808LR.pdf>.

natural gas or biogas if local production were to begin. Additionally, a slight advantage over microturbines is that fuel cells can generate electricity and produce fewer emissions. Furthermore, by implementing fuel cells Bridgeport commercial project could take advantage of local fuel cell knowledge and support from organizations like the Connecticut Hydrogen-Fuel Cell Coalition and the Connecticut Center for Advanced Technology. In doing so, Bridgeport can contribute to Connecticut's role as a leader in fuel cell technology.

CONCLUSION

The distributed energy generation resources of solar PV, microturbines and fuel cells are being utilized in Bridgeport, but there are opportunities for greater usage. At the residential level solar PV offers the potential to meet the ~1 kW average demand. The space required to meet this demand is ~495 ft^2, when using PV equipment with 12 percent efficiency. Solar PV systems also can potentially offset 4,312 kW's of new residential demand given the optimal conditions, while producing zero emissions.

For projects with larger demands microturbines and fuel cells can be implemented. Both microturbines and fuel cells offer flexibility in terms of demand size and fuel usage. The flexibility in meeting demand size offers scalability and replication in future projects in Bridgeport and other locations of all sizes. Microturbines and fuel cells both offer the opportunity to offset significant new commercial electrical demand in Bridgeport, potentially up to 6,240 kW as highlighted in the scenarios above.

Fuel usage flexibility means that Bridgeport projects can take advantage of local conditions. Both microturbines and fuel cells can operate on natural gas. The infrastructure for transmission and delivery of natural gas already exists in Northeastern U.S. as it is commonly used to meet local heating demands. Biogas can be used as an alternative fuel. The potential for local production of biogas through the anaerobic digestion of biosolids produced at the city's two waste water treatment facilities has been studied. If this project were to go forward, the locally produced biogas could be used to fuel locally sited microturbines and fuel cells. Using either of these fuel sources in microturbines or fuel cells, would lead to a reduction in emissions as compared to a coal burning centralized generation plant. To improve efficiency, these distributed energy generation resources can be installed with combined heat and power (CHP) equipment.

Ultimately, an increased implementation in Bridgeport relies heavily on the policy environment and available funding to potentially offset the costs associated with these distributed energy generation resources. In the next sections these aspects of distributed energy generation implementation in Bridgeport East Side Barnum Station will be examined.

DISTRIBUTED ENERGY GENERATION AND ENVIRONMENTAL JUSTICE

Low, income and predominantly minority communities are routinely the location of facilities that have negative environmental impacts. Environmental justice refers to the disproportionate environmental burden placed on these communities and their struggle to improve and maintain a clean and healthful environment.[128]

The energy industry has co-existed with the city's residential neighborhoods for decades. The Bridgeport coal plant in Fairfield, the Public Service Electric and Gas Company (commonly known as PSE&G), emits more than 3 million tons of carbon dioxide, 2,800 tons of sulfur dioxide and 2,000 tons of nitrogen oxide each year.[129] See Figure for PSE&G's location in relation to the East Bridgeport Development Corridor.[130] PSE&G services 1.7 million gas customers and 2.1 million electric customers in more than 300 urban, suburban and rural communities.[131]

FIGURE 2-2 EAST BRIDGEPORT DEVELOPMENT CORRIDOR AND PSE&G

A study commissioned by the Clean Air Task Force, a nonprofit research and advocacy organization, concluded that fine particle pollution[132] from coal-fired power plants contributed to over 13,000 deaths and tens of thousands of cases of chronic bronchitis, acute bronchitis, asthma, congestive heart failure, acute myocardial infarction, dysrhythmia, ischemic heart disease, chronic lung disease, and

[128] "Environmental Justice." *Natural Resource Defense Council*. Natural Resource Defense Council.*NRDC*. Web. Nov. 2011. <http://www.nrdc.org/ej/default.asp>.
[129] "Bridgeport Harbor Station."*Sourcewatch*. Web. Nov. 2011. <http://www.sourcewatch.org/index.php?title=Bridgeport_Harbor_Station>.
[130] "Google Earth Bridgeport County". *Google Maps*. Web. Nov. 2011. <http://maps.google.com>.
[131] "Bridgeport Harbor Station."*Sourcewatch*. Web. Nov. 2011. <http://www.sourcewatch.org/index.php?title=Bridgeport_Harbor_Station>.
[132] Fine particle pollution consists of a complex mixture of soot, heavy metals, sulfur dioxide, and nitrogen oxides.

TABLE 2-5 FOSSIL FUEL EMISSION LEVELS			
POUNDS PER BILLION BTU OF ENERGY INPUT			
POLLUTANT	NATURAL GAS	OIL	COAL
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998

pneumonia each year especially severe among the elderly, children, and those with respiratory disease.[133]

In 2007 and 2010, the City of Bridgeport, received a grant of $100,000 from the EPA to address environmental justice challenges. EPA selected Bridgeport for this effort to build on previous work to develop community capacity and engagement, identify a broad network of partnerships and connect with the goals of the city government.[139] For the past four years, the Connecticut Coalition for Environmental Justice (CCEJ) received funding from U.S. EPA's Community Action for a Renewed Environment Program for the community of Bridgeport to determine the major environmental health threats facing the city. The study considered the impact of city pollution on asthma and lead poisoning rates. The results showed that sources of air pollution were more concentrated in the city's largely low-income East End and East Side.[140]

CCEJ has used the grant to develop solutions to prevent pollution in several of the areas located near the Eastside region of Bridgeport; however, these efforts are mostly concentrated on controlling dust from industrial sites in the region. There is limited awareness of the benefits to the community of using distributed energy generation.

***Promising Strategy:* Through the Connecticut Environmental Coalition and BGreen's Green Marketing and Education Committee utilize the EPA Environmental Justice grant to increase awareness about the environmental and financial benefits of implementing distributed energy generation.**

[133] "Bridgeport Harbor Station." *Sourcewatch*. Web. Nov. 2011. <http://www.sourcewatch.org/index.php?title=Bridgeport_Harbor_Station>.
[139] *US Environmental Protection Agency.* Web. Nov. 2011. <http://yosemite.epa.gov/opa/admpress.nsf/e51aa292bac25b0b85257359003d925f/55d7882c574e3939852576730055ce7c!OpenDocument>.
[140] "Care: Assessing Environmental Risks."*Connecticut Coalition for Environmental Justice.* Environmental Justice Organization. Web. Nov. 2011. <http://www.environmental-justice.org/FCEJN/carebkgd.html>.

Bridgeport already has a technical committee that addresses Green Marketing, Education and Outreach and NYCT has partnered with Connecticut Environmental Coalition as a stakeholder. The Educational outreach program has several factors in place to educate and increase awareness about sustainability best practices. An additional promising strategy could be to partner with these established committees to inform and educate the community why distributed energy generation strategies should be implemented on the site.

Although there are many environmental benefits to using distributed energy generation resources, funding still remains the most common issue preventing the successful implementation of these technologies. The next section discusses available grant and rebate programs that can be used to help implement these technologies on the East Bridgeport Development Corridor.

DISTRIBUTED ENERGY GENERATION FUNDING

Installation costs for distributed energy generation technologies are usually high. This makes funding an important and difficult aspect for implementing this technology. Developers have access to both public as well as private funding to help meet the capital cost requirements. Considerations for funding clean energy projects include a programmatic approach with durable and long-term funding for Energy Efficient (EE) and Renewable Energy (RE) programs. Most importantly, the developers looking to take advantage of distributed energy generation need to explore innovative public, state and local sources to maximize their opportunities.[142]

LOCAL AND STATE

Connecticut passed a Renewable Energy Bill – S.B. 1243. A program sponsored by SB 1243 is the Property-Assessed Clean Energy (PACE) program which helps home and business owners enhance energy efficiency by offering low-interest and low-risk loans through their municipality. PACE financing allows property owners to borrow money from the local government to pay for energy improvements. The home-owners repay this loan via a periodic special assessment on the property over many years.

In Connecticut, PACE is known as the Sustainable Energy Program and municipalities that wish to use this program are first required to declare the public need for such a program followed by issuing a public notice that informs the residents and business-owners of their intention. Afterwards, that municipality enters into contracts for assessing a property to evaluate its funding requirements for energy upgrades. This assessment is considered a lien on the property entitling the municipality to collect property taxes.[143]

The City of Sonoma County has pioneered PACE financing in California. Sonoma County Energy Independence Program is one of the country's first PACE programs and continues to finance energy efficiency improvements today. Sonoma County has financed over 1,400 clean energy projects to date; 39 of these are on commercial

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[142] Kubert, C., and Sinclaire, M.Web. Nov. 2011. "State Support for Clean Energy Deployment: Lessons Learnt for Potential FRuture Policy." April 2011. *NREL*.NREL. Web. Nov. 2011. <http://www.nrel.gov/docs/fy11osti/49340.pdf>.
[143] "Connecticut Local Option: Sustainable Energy Program." *Database of State Incentives for Renewables and Energy*.US Dept. of Energy, IREC,North Carolina Solar Center.8 Aug. 2011. Web. 28 Nov. 2011. <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT90F&RE=1&EE=1>.

properties, and 11 of the 39 are comprised of, or include, energy efficiency measures. Under this program any property type is eligible.[144,145]

The State provides individuals and businesses with a suite of funding tools to enhance the energy efficiency of their homes and business units. This is evident in that the PACE program was enhanced with a "Green Bank." A Green Bank leverages private and public funding or a mix of both for funding of large-scale Energy Efficiency (EE) and Renewable Energy (RE) projects accompanied with Green Loan Guarantee Funds. This plan is supportive of residential solar zero-emission solar electric generation.

Another source of funding for implementation of distributed energy generation technologies that could prove beneficial for the East Bridgeport Development Corridor is a leasing program. This type of program helps eliminate high installation costs of both EE/RE while taking advantage of all federal tax incentives. Under this kind of funding program, an outside financing company owns the RE system or EE improvements, and the host (residential or commercial) makes a fixed monthly payment for its use. This monthly payment does not vary with the output of the system – or with the energy savings in the case of EE improvements – and therefore must be paid even if the system is not operational. All tax benefits and other incentives are enjoyed by the financing company with the energy-savings flowing to the host. The lessee or host could be responsible for system maintenance (e.g., replacement of the inverter for a solar PV system) unless these services are provided for within the lease.[146] Connecticut has already utilized this kind of leasing program, see "Case Study: Leasing Solar PV in Connecticut." [147]

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144 "Sonoma County Energy Independence Program, California, USA." *Energy Upgrade California*. Web. Nov. 2011. <http://www.sonomacountyenergy.org/>.

145 "Sonoma County-Energy Efficiency Program." *Database of State Incentives for Renewables and Energy Efficiency*. Web. Nov. 2011. <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA188F&re=1&ee=1>.

146 Kubert, C., and Sinclair, M.,"State Support for Clean Energy Deployment: Lessons Learned for Potential Future Policy." *NREL*.U.S. Department of Energy. Web. Nov.2011. <http://www.nrel.gov/docs/fy11osti/49340.pdf>.

147 Ibid.

CASE STUDY: LEASING SOLAR PV IN CONNECTICUT

The Connecticut Solar Lease Program, targeted at residential solar installations, is sponsored by the Connecticut Clean Energy Fund (CCEF) and administered by AFC First Financial, an independent financing company. The responsibility of providing low-cost capital is on CCEF. CCEF uses a combination of low-cost capital with monetized tax benefits to assist the financing company with contractor installation costs. To take benefit from this program, the homeowners must use an approved solar PV system installer and be credit-approved by the leasing company. Usually monthly lease payments for a 5 kW residential system are $120 per month for 15 years with an option to purchase the system or pay a reduced lease fee after that point. This funding option is a win-win situation for all parties involved. It is beneficial to the homeowner because they can save by using distributed energy resources in their home. Additionally, the homeowner has the flexibility to pre-pay lease payments, but can purchase it only after all tax benefits have been captured by the lease owner. It is beneficial for the finance company because it can aggregate and sell renewable energy certificates (RECs) from all projects to utilities for compliance with the state's Renewables Portfolio Standard program.[1] The RPS program requires that four percent of electricity be generated from renewable sources with the percentage increasing to a total of 20 percent in 2020.* Since CCEF continues to provide the up-front rebate to lower the capital costs, homeowners enjoy a reduced monthly lease payment for use of the system.

[1] "Connecticut Renewable Portfolio Standard Summary." *Union of Concerned Scientists*. Web. Nov. 2011. <http://www.ucsusa.org/assets/documents/clean_energy/connecticut.pdf>.

More state financing options for distributed energy generation technologies can be state-sponsored through a Revolving Loan Fund (RLF). In this funding option the state either acts as a lender or delegates the lending functions to a third-party financial institution. A RLF targets the loans to specific markets – residential, commercial, industry or institutional. When the loans are repaid, the RLF re-lends the funds. See "Case Study: Implementing Revolving Loan Funds in Nebraska." [149]

[149] "Dollar and Energy Savings Loans." *Official Nebraska Government Website.* Govt. of Nebraska. Web. Nov. 2011. <http://www.neo.ne.gov/loan/>.

CASE STUDY: IMPLEMENTING REVOLVING LOAN FUNDS IN NEBRASKA

The Nebraska Energy Office (NEO) uses a revolving loan fund, the "Dollar and Energy Savings Loan Program", a long-standing financial program that delivers affordable commercial loans to Nebraska residents that want to reduce energy costs through retrofitting their buildings.

The program is available for a variety of buildings including multifamily, commercial, non-profits, businesses and agricultural facilities. This program has a ranges of eligibility requirements, including energy and water efficiency, and renewables. The program does not require documentation of energy savings; rather NEO has established prequalified measures for which they expect 10 to 15 year paybacks.

According to NEO the program has facilitated 26,000 loans (including residential and commercial) for approximately $225 million dollars of projects over the past 20 years. Their current fund size is $36 million per year. This state energy program is entirely funded with public capital.

In April 1998, the original electric-industry restructuring legislation in Connecticut (Conn. Gen. Stat. § 16-245m), created a separate fund to support Energy Efficiency/Renewable Energy. This mandated for each of Connecticut's municipal electric utilities to establish a fund for renewable energy, energy efficiency, conservation, and load-management programs. One source of state funding available to the East Bridgeport Development Corridor is the Energy Efficiency Fund that is financed through a surcharge of $0.003 per kWh on United Illuminating customers' electric bills. Additionally, the Regional Greenhouse Gas Initiative (RGGI), the Forward Capacity Market (FCM) and Class III Renewable Credits extend funding to the Energy Efficiency Fund. The utility has approval from Connecticut's Department of Public Utility (DPU).

Another state funding source that can help facilitate the DEG program at this TOD project is the Connecticut Clean Energy Fund (CCEF) administered by Connecticut Innovations, a quasi-governmental investment organization that has been authorized by the Connecticut General Assembly to develop programs and fund projects that meet the stated mission of the CCEF.[150] The CCEF is funded by a surcharge of $0.001 per kWh for customers. There are three basic funding models that CCEF uses for its fund allocation. These are:

- Investment Model: Uses state loans and equity to provide initial investment in clean energy companies and projects.
- Project Development Model: Directly promotes clean energy project installation through production incentives and grants/rebates.
- Industry Development Model: Uses business development grants, marketing support programs, research and development grants, resource assessments, technical assistance, consumer education, and demonstration projects to facilitate market transformation.

Besides these funding programs another effective funding tool developers can utilize is clean energy rebates that include installation of solar PV systems. In 2010, Connecticut was provided the highest national rebate for residential solar PV usage along with New York State. For Connecticut, the solar PV incentive was $1.75 per watt (for the first 5 kW); $1.25 per watt (for the next 5 kW) with maximum system rebate capped at $15,000. For commercial usage, when combined with federal tax credits and accelerated depreciation, total incentives can exceed 70 percent of project cost.

FEDERAL FUNDING

Federal funding options for implementing distributed energy generation technologies on this project are applicable to both homeowners and businesses.[151] Funds available to homeowners for improving energy-efficiency in their home can be Residential Renewable Energy Tax Credits. These credits were established by the Energy Policy Act of 2005 and are applicable to fuel cell systems. This credit program entitles the tax payer to a credit of 30 percent of qualified expenditures for a system that serves a dwelling unit and used as a residence by the taxpayer.

The American Recovery and Reinvestment Act of 2009 (H.R. 1), created a renewable energy grant program administered by the U.S. Department of Treasury that can be used in conjunction with federal business energy investment tax credits (ITC). Commercial and industrial property-owners can take advantage of this grant. The

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[150] "Public Benefit Funds." *Pew Climate*.Web. Nov. 2011. <http://www.pewclimate.org/sites/default/modules/usmap/pdf.php?file=5893>

[151] "Financial Incentives." *Database of State Incentives for Renewables and Efficiency.* U.S. Department of Energy, IREC, North Carolina Energy Center. Web. Nov. 2011. <http://www.dsireusa.org/incentives>.

eligible technologies include solar PV modules, fuel cells, microturbines and CHP systems.

The specific benefits for solar PV modules and fuel cell technology is that this grant would equal up to 30 percent of the property value in which the application is going to be installed. There is a maximum cap of $1,500 per 0.5 kW for fuel cells. Additional requirements for fuel cell technology are that it should have an electricity generation efficiency of 30 percent or higher.

The requirements applicable for microturbines and CHP are that the grant would equal up to 10 percent of the property value for the application of these technologies. For microturbines the grant is capped at $200 per kW of capacity and the eligible property includes microturbines up to two megawatts (MW) in capacity that have an electricity-only generation efficiency of 26 percent or higher. For CHP systems the property generally includes systems up to 50 MW in capacity that exceeds 60 percent energy efficiency, subject to certain limitations and reductions for large systems. The efficiency requirement does not apply to CHP systems that use biomass for at least 90 percent of the system's energy source, but the grant may be reduced for less-efficient systems.

Clean Renewable Energy Bonds (CREB) and Qualified Energy Conservation Bonds (QBECS) are more federal financial instruments that can be used for both residential and commercial properties for clean energy projects. The Energy Improvement and Extension Act of 2008 (Div. A, Sec. 107) allocated $800 million for new Clean Renewable Energy Bonds (CREBs). In February 2009, the American Recovery and Reinvestment Act of 2009 (Div. B, Sec. 1111) allocated an additional $1.6 billion for New CREBs, for a total New CREB allocation of $2.4 billion. CREBS and QBECS are qualified tax credit bonds that may be used by state, local and tribal governments to finance certain types of energy projects. The definition of "qualified energy conservation projects" is fairly flexible including within its folds elements relating to mass commuting facilities and energy-related pilot projects. This is especially applicable to the East Bridgeport Development Corridor as it’s the project’s intent to orient development around a new train station.

Finally, another financing mechanism that can be used for the East Bridgeport Development Corridor is utility based financing. In this mechanism, profits are separated from sales and the utility company has the flexibility to adjust their revenue account as a decrease in sales. This makes distributed energy generation more valuable to the utilities. The most common program is the “On-bill finance” in which the utility provides loan capital for EE/RE. This usually is collected from ratepayer funds or through a partnership with a commercial, financial institution to promote energy efficiency. The financing obligation is displayed on and paid alongside the utility bill and, in either case, the utility acts as a retrofit-finance collection agent. The utility may guarantee repayment of the financing or act as collections agent only. Additionally, the utility can impose a 'lien-at-the-meter' if the customer defaults on the payment and the utility service is suspended. This can be applied to residential or commercial customers for the utility.

Ultimately, Connecticut has a suite of financial tools available to fund solar PV modules, microturbines, fuel cells and CHP. Utilizing a combination of federal, state, local and innovative funding strategies would assist in implementing distributed energy generation technologies on the proposed East Bridgeport Barnum station and East Bridgeport Development Corridor.

Also, if the decision to use distributed energy generation technologies is left to developers then the probability that they would adapt such a strategy decreases. This would mean that the East Bridgeport Development Corridor project forgoes the maximum funding that can be received to implement these technologies. Additionally, it would forgo the money reinvested back into the site once the project is developed. The process of garnering funds for the East Bridgeport Development Corridor needs to be streamlined through a strategic governance structure. This structure should specialize in implementing distributed energy resources on the project site. The Governance section of this report describes strategies on how this can be accomplished.

GREEN INFRASTRUCTURE

CHAPTER 3: GREEN INFRASTRUCTURE

3.1 STORMWATER MANAGEMENT IN BRIDGEPORT: GREEN INFRASTRUCTURE'S ROLE

Bridgeport, like many cities in Connecticut and across the nation, is grappling with burdensome costs associated with modernizing antiquated, inefficient, and under-sized infrastructure to manage stormwater runoff. The 2009 Report Card published by the American Society of Civil Engineers awarded a letter grade of D for the national water infrastructure. It cited an investment requirement of $255 billion compared to a projected $146.4 billion in spending outlay over a five-year period.[199] This creates a $108.6 billion deficit. Currently, Bridgeport, is estimating a required investment in excess of $400 million and decades to complete a grey infrastructure project of separating the combined sewer system.[200]

As an alternative to the costly time and labor–intensive, conventional interventions of installing more pipes, building stormwater retention facilities, and increasing treatment facility capacity through expansion, green infrastructure is being studied and applied as an approach to manage stormwater as a supplement or substitute. One way in which grey infrastructure fails to meet the immediate and persistent needs of stormwater management is depicted in Figure 3-1which was taken from New York City's *Green Infrastructure Plan*.[201] The graph demonstrates how grey infrastructure, while capable of managing the volume of water does not have the capacity to alleviate any percentage of the problem until completion of the project. Considering the duration of some sewer-separation projects that can last more than a decade, as is the case for Bridgeport, the problem potentially will not be fixed during the life of this generation leaving a legacy of pollution and lack of foresight. Conversely, the image depicts green infrastructure as having a short installation time with some level of benefit realized immediately. The gradual increase is depicted as continuous; increasing to ultimately meet the same demand levels of the grey infrastructure even surpassing it in this image.

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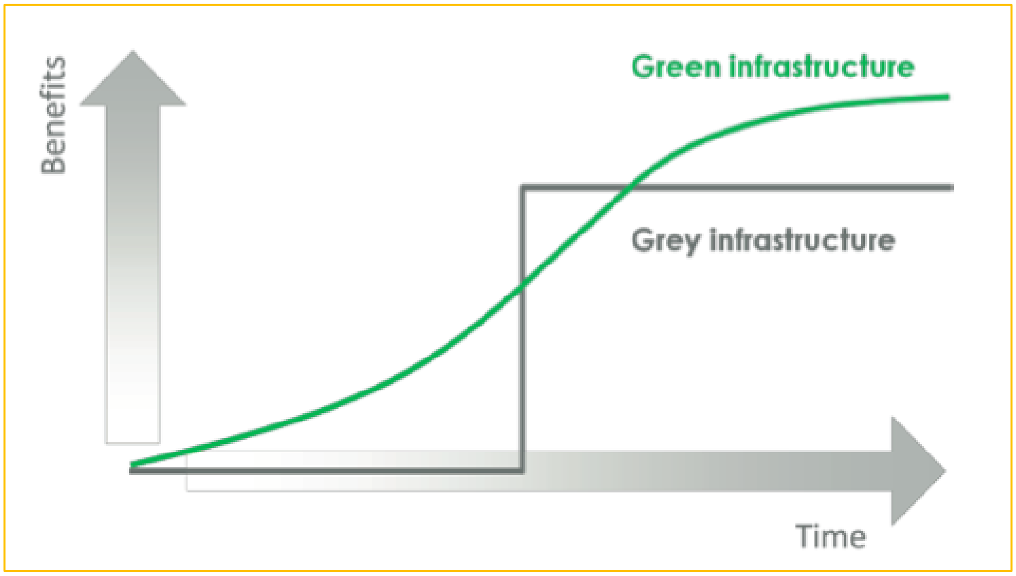
199 "2009 Report Card for America's Infrastructure." *Report Card for America's Infrastructure.* American Society of Civil Engineers. 2009. Web. Nov. 2011. <http://www.infrastructurereportcard.org/sites/default/files/RC2009_full_report.pdf>.
200 Kooris, David. "Bridgeport's BGreen 2020 Initiative and Stormwater." Press release. Sound Update. Fall 2010.
201 Ibid.

FIGURE 3-1 – TIME BENEFIT OF GREEN INFRASTRUCTURE AND GREY INFRASTRUCTURE



Source: New York City Green Infrastructure Plan[202]

While grey infrastructure is still considered the paradigm to which alternative methods of managing stormwater are compared,[203] empirical and modeled data is suggesting that green infrastructure has the capacity to fully manage the stormwater loads at a reduced cost with increased external benefits. In the same report from *NYC Green Infrastructure Plan*, a public investment of $1.5 billion in green infrastructure would be required to manage the same amount of stormwater as $3.9 billion invested in grey infrastructure. The *Green City Clean Water* report[204] prepared by the Philadelphia Department of Water provides similar numbers supporting the utilization of Green Infrastructure as a supplement to gray infrastructure; this is described the section "Cost of grey vs. green Infrastructure." Both reports expand on the benefits and need for increased funding in green infrastructure projects; however they also address the need for grey infrastructure. Investment in alternative strategies does not require a municipality to abandon grey infrastructure nor to overlook the substantial role it plays

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202 "NYC Green Infrastructure Plan." *NYC.GOV*. New York City Department of Environmental Protection. NYC Green Infrastructure Plan September 2010. Web. Nov. 2011. <http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_ExecutiveSummary.pdf>.
203 "Gowanus Canal Watershed/Waterbody Facility Plan." *NYC.GOV*. New York City Department of Environmental Protection. August 2010. Web. Nov. 2011. <http://www.hydroqual.com/temp/gowanus.pdf>.
204 "Green City Clean Water: The City of Philadelphia's Program for Combined Sewer Overflow Control." *Philadelphia Water Department*. September 2009. Web. Nov. 2011. <http://www.phillywatersheds.org/ltcpu/LTCPU_Contents.pdf>.

in effectively managing stormwater. This is demonstrated by the first three strategies of the *NYC Green Infrastructure Plan*:[205]

1. Build Cost Effective Grey Infrastructure – This strategy entails a $2.9 billion investment over 20 years to improve targeted gray infrastructure projects that will reduce CSO
2. Optimize the Existing Wastewater System – This strategy is to provide funding for maintenance to optimize the existing stormwater systems
3. Control Runoff from 10 Percent Impervious Surfaces through Green Infrastructure – This strategy entails investing $1.5 billion to fund green infrastructure initiatives from green roofs to rain barrels

The first two steps are to fund and build new grey infrastructure and to better utilize the existing setup. Additionally, the focus is to manage the surface conditions through green infrastructure strategies. This is a strong endorsement for utilizing both green and grey infrastructure so that their effects are maximized. In BGreen 2020, the second recommendation under Water Resources is to, "limit stormwater flow into the waste treatment system"[206] through grey infrastructure improvements and incorporating green infrastructure to better manage the stormwater runoff.

The benefits of an approach which draws on the best practices from grey infrastructure optimization along with best practices of utilizing large-scale investment in green infrastructure is depicted in Table 3-1, [207] which is based on information from *Green City Clean Water*.[208] The report recommends a combination of green infrastructure and grey infrastructure to manage stormwater runoff and prevent further CSO events. The chart establishes a new method of cost benefit analysis in which not only is the benefit of the immediate strategy examined, but also the indirect benefits are given equal weight. This school of thinking is better able to account for the social and environmental impacts of both strategies, green and grey. Table 3-1, also demonstrates the capacity for an array of strategies to adequately manage the necessary amount of water. Engineers and designers have innovated and developed techniques that are more than capable of satisfying the load demands. Cost is the primary consideration and impediment for

[205] "NYC Green Infrastructure Plan." *NYC.GOV*. New York City Department of Environmental Protection. NYC Green Infrastructure Plan September 2010. Web. Nov. 2011. <http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_ExecutiveSummary.pdf>.
[206] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2008. Web. Nov. 2011. <http://www.rpa.org/bgreen/BGreen-2020.pdf>.
[207] Ibid.
[208] "Green City Clean Water: The City of Philadelphia's Program for Combined Sewer Overflow Control." *Philadelphia Water Department*. September 2009. Web. Nov. 2011. <http://www.phillywatersheds.org/ltcpu/LTCPU_Contents.pdf>.

both grey and green infrastructure. However, green infrastructure requires more studies to calcify its uncertainties.

TABLE 3-1 SYSTEM BENEFITS FOR FIVE STORMWATER MANAGEMENT STRATEGIES						
INDEX	BENEFIT	COMPLETE SEWER SEPARATION	LARGE SCALE STORAGE (GREY INFRASTRUCTURE)	PLANT EXPANSION (GREY INFRASTRUCTURE)	GREEN STORMWATER INFRASTRUCTURE	GREEN STORMWATER INFRASTRUCTURE WITH TARGETED TRADITIONAL INFRASTRUCTURE
1	Affordable			ϴ	ϴ	Ø
2	Scalable			ϴ	ϴ	Ø
3	Meets Combined Sewer Overflow Policy Goals	Ø	Ø	Ø	Ø	Ø
4	Meets Watershed-Based Planning Goals	ϴ	ϴ	ϴ	Ø	Ø
5	Creates Jobs: Reduces Social Cost of Povert				ϴ	Ø
6	Enhances Recreation				Ø	Ø
7	Improves Community Quality of Life				ϴ	Ø
8	Reduces Effects of Excessive Heat				ϴ	Ø
9	Restores Ecosystems				Ø	Ø
10	Improves Air Quality				ϴ	Ø
11	Saves Energy and Offsets Climate Change				ϴ	Ø
12	Public Support				ϴ	Ø
13	Benefits Accrual Method	At Completion	At Completion	At Completion	Incremental	Incremental
14	Total Completely Satisfied Criteria	1	1	1	4	12
15	Totally Partially Satisfied Criteria	1	1	3	8	0
				LEGEND	ϴ Criterion Partially Satisfied Ø Criterion Satisfied	

3.2 COST OF GREEN VS. GREY INFRASTRUCTURE

It is important to utilize all possible avenues to better manage stormwater runoff; however, green infrastructure requires a stronger argument to justify an outlay of money relative to grey infrastructure. Below are two cost benefit case studies from Kansas City, Missouri and Philadelphia, Pennsylvania. The study from Kansas City demonstrates a direct comparison of grey infrastructure and green infrastructure to manage the same amount of water over a 774-acre site. The Philadelphia case study allocates benefit beyond water management and attaches value to societal, environmental, and economic aspects that are affected by improved stormwater management and a reduction in CSO.

In June 2008, a report prepared by the Kansas City, Missouri Overflow Control Program report titled *Green Alternatives for Outfalls 059 and 069,*[209] addressed the cost of managing the 2.375 million gallons. The conventional, grey infrastructure strategy of stormwater storage was compared to the aggregate contribution of four green infrastructure strategies. These strategies were permeable pavements, vegetated swales, green roofs and catch basin improvements.[210]

The effects were measured for the 744-acre area that fed outfalls 059 and 069. The results are as follows:

- 2.375 million gallons of water was projected to be managed by green infrastructure for outfall 069 costing an estimated $24.6 million. This is 82 percent of the cost for the grey infrastructure project which estimated $30.6 million to manage the same volume of water.
- 1.125 millions gallons of water was projected to be managed by green infrastructure for outfall 059 costing an estimated $10.3 million. This is a reduction of just under 50 percent. The cost of the grey infrastructure project was $20 million.

[209] "Green Alternatives for Outfalls 059 and 069." *City of Kansas City Mo.* Kansas City Water Service Department. June 2008. p. 3 – 10. Web. Nov. 2011. <http://www.kcmo.org/idc/groups/water/documents/adacct/mbrgray_green.pdf.>.
[210] Ibid.

The results in Table 3-2[211] depict a significant cost reduction in favor of green infrastructure as opposed to grey infrastructure to manage a comparable quantity of water.

TABLE 3-2 GREEN ALTERNATIVES FOR OUTFALLS 059 AND 069			
Outfalls	Grey Infrastructure $/Gallon	Green Infrastructure $/Gallon	Percent Difference
059	17.78	9.15	49
069	12.88	10.36	20

TABLE 3-3 COST EVALUATION OF SOCIAL, ENVIRONMENTAL, AND ECONOMIC BENEFITS OF GREEN INFRASTRUCTURE AND GREY INFRASTRUCTURE IN PHILADELPHIA			
BENEFIT CATEGORIES	**VALUE - 50% GREEN INFRASTRUCTURE OPTION**	**VALUE - 30-INCH TUNNEL, GREY INFRASTRUCTURE OPTION**	**VALUE DIFFERENCE FOR GREEN INFRASTRUCTURE**
Increased recreational opportunities	524.5		524.5
Improved aesthetic/property value	574.7		574.7
Reduction in heat stress mortality	1,057.60		1,057.60
Water quality/aquatic habitat enhancement	336.4	189	147.4
Wetland services	1.6		1.6
Social costs avoided by green collar jobs	124.9		124.9
Air quality improvements from trees	131		131
Energy savings/usage	33.7	-2.5	36.2
Reduced (increased) damage from SO_2 and NO_x emissions	46.3	-45.2	91.5
Reduced (increased) damage from CO_2 emissions	21.2	-5.9	27.1
Disruption costs from construction and maintenance	-5.6	-13.4	7.8
TOTAL	**2,846.30**	**122**	**2742.3**
Note: All values are represented in 2009 dollars			

[211] "Green Alternatives for Outfalls 059 and 069." *City of Kansas City Mo.* Kansas City Water Service Department. June 2008. p 3 – 10. Web. Nov. 2011. <http://www.kcmo.org/idc/groups/water/documents/adacct/mbrgray_green.pdf>.

The results in Table 3-3[212] depict a significant cost reduction in favor of green infrastructure as opposed to grey infrastructure to manage a comparable quantity of water.

To look at the costs compared to benefits in a different way, Philadelphia contracted Stratus Consulting to prepare a report in August 2009 titled *A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds*.[213] The report not only considered the construction and operations cost and also the social implications and associated values to utilizing green infrastructure compared to grey infrastructure, specifically targeted at controlling CSO events. The report explored the benefit of managing 50 percent of stormwater runoff using green infrastructure and installing a 30-inch storage tunnel. The cumulative benefit through 2049 (in 2009 dollars) is $2,846.4 million for green infrastructure and $122.0 million for grey infrastructure; the findings are summarized in Table 3-3.[214]

STORMWATER AND CSO IN BRIDGEPORT

The following sections discuss the current state of stormwater management in Bridgeport and how green infrastructure can be utilized to reduce the number of occurrences and total volume of combined sewer overflow (CSO) entering Bridgeport and Black Rock Harbors and ultimately Long Island Sound.

A combined sewer system (CSS) is a network of sewers that transport a mixture of both stormwater runoff and sanitary sewage. In normal conditions, the CSS transports stormwater and raw-waste to one of two wastewater treatment facilities (WWTF) in Bridgeport, East Side Plant and West Side Plant. However, when the system becomes overwhelmed due to large precipitation events or snow melts, the untreated mixture of stormwater and sanitary sewage is diverted prior to entering the WWTF and is discharged into Bridgeport Harbor; the effluent is called CSO. Nationally, thousands of overflow events occur each year discharging approximately 850 billion gallons of contaminated, untreated wastewater into the lakes, rivers, harbors, and other bodies of water.[215] As depicted in Figure 3-2, the green area represents the southern third of

[212] "Green Alternatives for Outfalls 059 and 069." *City of Kansas City Mo.* Kansas City Water Service Department. June 2008. p 3 – 10. Web. Nov 2011. <http://www.kcmo.org/idc/groups/water/documents/adacct/mbrgray_green.pdf>.

[213] "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds". *Michigan.gov.* Philadelphia Office of Watersheds and Stratus Consulting. Aug. 2009. Web. Nov. 2011. <http://www.michigan.gov/documents/dnr/TBL.AssessmentGreenVsTraditionalStormwaterMgt_293337_7.pdf>.

[214] Ibid. p. S - 3

[215] "Report to Congress on the Impacts and Controls of CSO and SSO." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. Aug. 2004. Web. Nov. 2011. <http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm>

Bridgeport, which is serviced by a CSS.[216] This CSS has been established for over 100 years.[217] Additionally, approximately 86 percent of Bridgeport land area is covered by impervious surfaces,[218] allowing few points for stormwater runoff to infiltrate the ground or areas of vegetation to abate the rate of flow. Hence, the aged CSS receives no assistance in managing stormwater.

FIGURE 3-2

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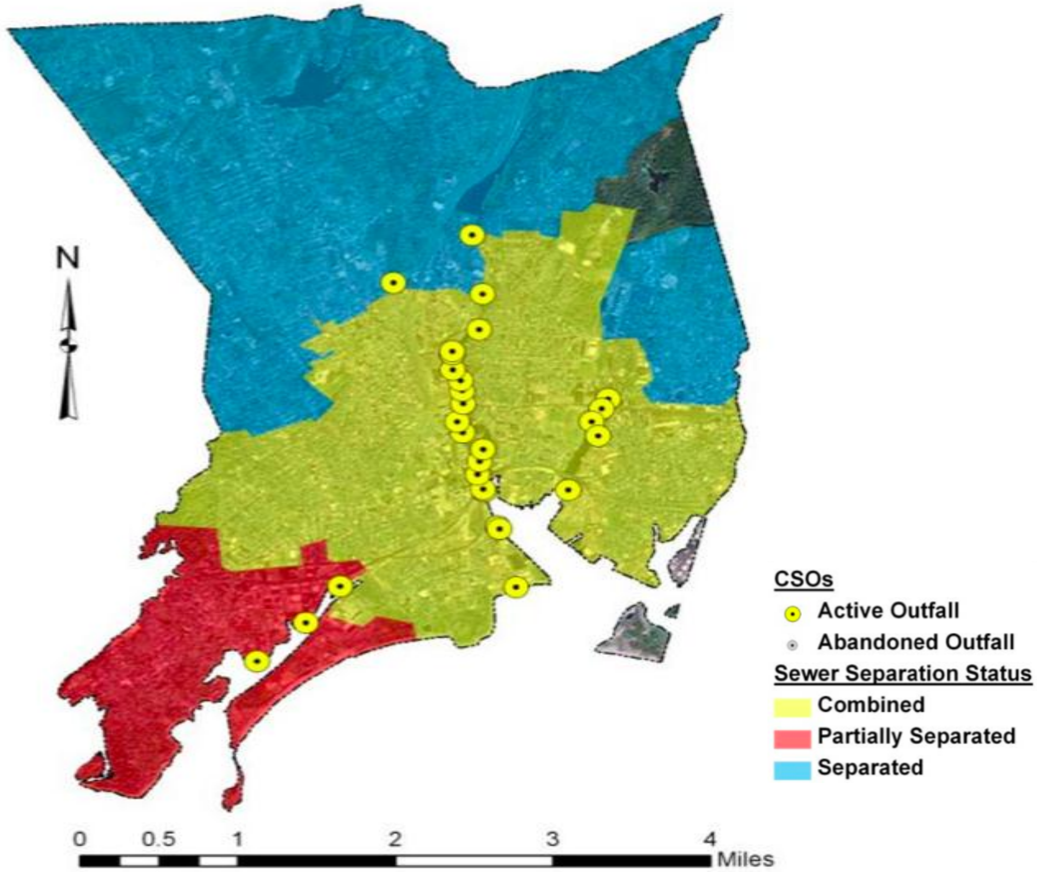

Source: Green Infrastructure in CT: A Recipe for Job Growth, Green Neighborhoods, Clean Water[219]

Table 3-4[220] lists the estimated volume and number of CSO occurrences in Bridgeport in 2008.

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[216] Keerthy, Ravi. Telephone interview. 16 Nov. 2011.
[217] "CSO, Long Term Control Plan". *City of Bridgeport* . City of Bridgeport. 2010. Web. Nov. 2011. <http://www.bridgeportct.gov/wpca/Documents/CSO%20Long%20Term%20Control%20Plan.pdf>
[218] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2008. Web. Nov. 2011. <http://www.rpa.org/bgreen/BGreen-2020.pdf>
[219] Johnson, Curt. "Green Infrastructure in CT, A recipe for job growth, green neighborhoods, clean water." Connecticut Council for Philanthropy. Graustein Memorial Fund. 26 Oct. 2011

TABLE 3-4 ESTIMATED CSO IN BRIDGEPORT FOR 2008		
ITEM	VOLUME DISCHARGE	NUMBER OF OCCURRENCES
Estimated CSO	350 million gallons	47

The northern two-thirds of Bridgeport is serviced by a separated sewer system in which the stormwater and wastewater are diverted into separate conduits.[221] Currently, Bridgeport is in the process of reviewing bids to service the combined sewer segment titled Area 41;[222] a project aimed at replacing an estimated 14,700 linear feet of pipe of varying diameters. The state has allocated $74 million to fund the construction phase of the project.[223] The purpose is to limit the occurrence of CSO by rehabilitating or replacing the sewer system as outlined by the federally mandated Long Term Control Plan (LTCP).

WASTEWATER TREATMENT FACILITY CAPACITY

The capacities of Bridgeport's two wastewater treatment facilities, East Side Plant and West Side Plant, have a combined design load of 40 million gallons per day (mgd). Ravi Keerthy of the Water Pollution Control Authority (WPCA) identified the points at which the system begins to overflow at 24 mgd and 54 mgd for the East Side Plant and the West Side Plant, respectively. In addition to the amount of stormwater entering the system, Mr. Keerthy indicated the tidal patterns had an effect on the Treatment Plants' capacity; when tides are high, less combined stormwater and sewer water could enter the WWTFs. However, based on the correspondence with Mr. Keerthy, the effect was not quantified or measured.

The average daily combined wastewater and stormwater flow in Bridgeport is 31.4 mgd. This leaves, on average, 8.6 mgd below design capacity[224] and 46.6 mgd below overflow. The Water Pollution Control Administration (WPCA) in Bridgeport warns that an overflow can occur due to as little as 0.4 inches of rain in the Long Term Control

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220 "Connecticut Fund for the Environment Urges Action on Bridgeport Plants." Press release. Connecticut Fund for the Environment. Jan. 2009.

221 Keerthy, Ravi. Telephone interview. 16 Nov. 2011.

222 "Bid #WPB27115 - CSO Project H2 Part A." *Bid Sync Links.* City of Bridgeport. May 2010. Nov. 2011. Web. <http://www.bidsync.com/DPX?ac=view&auc=1740010>.

223 "Connecticut Clean Water Fund. Financial Assistance Programs – Municipal Water Pollution Control State Fiscal Years 2010 and 2011." *CT.GOV.* Connecticut Department of Environmental Protection and CT Clean Water Fund. June 2010. Nov. 2011. Web. <http://www.ct.gov/dep/lib/dep/water/municipal_wastewater/final_cwf_priority_2011.pdf>.

224 GHD Inc. *City of Bridgeport Connecticut: Biosolids to Energy Feasibility Study*. Page 2-2. February 2011.

Plan.[225] However, this indicator can be misleading as 0.4 inches of rain over a 48-hour period can be managed by the existing system while 0.4 inches over 15 minutes can cause an overflow.[226]

The volume of water covering Bridgeport during a 0.4-inch rainfall event is 111 million gallons. The amount of retained water, ground-absorbed water, runoff that enters bodies of water, and evapotranspiration is equal to the difference between the volume of water for a 0.4-inch rain event and the excess design capacity of the treatment facilities. Although a simple arithmetic solution might appear reasonable, the capacity of the sewer system, distances water must travel prior to entering the CSS, velocity of the water entering the CSS, and intensity of rainfall all contribute to the point at which overflow occurs. According to Marshall Hoover of the Connecticut Department of Energy and Environmental Protection - Water Division, "discussions of rainfall relative to depth do not account for all overflow data."[227] Mr. Hoover elaborated by mentioning the need for this information.

Calculations using data collected from the National Weather Service's (NWS) Cooperative Observer Program (COOP) show that Bridgeport experiences approximately 35 precipitation events greater than 0.4 inches; however the intensity and duration of each event are not recorded.

3.3 GREEN INFRASTRUCTURE PROMISING STRATEGIES

This section outlines recommendations for the East Bridgeport Development Corridor (EBDC) for vegetated swales, permeable pavements, green roofs, and rain harvesting as a means to manage stormwater. The recommendations in this section look to build on the sustainability objectives outlined in *BGreen 2020: A Sustainability Plan for Bridgeport Connecticut.* The second strategy outlined under Water Resources is to, "Limit stormwater flow into the waste treatment system"[228] which can be achieved by investing in a "combination of traditional infrastructure and green infrastructure."[229]

EAST BRIDGEPORT DEVELOPMENT CORRIDOR OPPORTUNITY

[225] "CSO, Long Term Control Plan". *City of Bridgeport* . City of Bridgeport. 2010. Nov. 2011. Web. <http://www.bridgeportct.gov/wpca/Documents/CSO%20Long%20Term%20Control%20Plan.pdf>.
[226] Keerthy, Ravi. Telephone interview. 16 Nov. 2011.
[227] Hoover, Marshall. Telephone interview 14 Nov. 2011.
[228] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2008. Web. Nov. 2011. <http://www.rpa.org/bgreen/BGreen-2020.pdf>.
[229] Ibid.

The EBDC affords Bridgeport an opportunity to utilize Green Infrastructure strategies to manage stormwater runoff, as the 700 acres of underdeveloped land is comprised of mostly permeable surfaces in the form of roads, contiguous hardscapes, vacant and underdeveloped land, and conventional roof surfaces.

Seven hundred acres or approximately 1.1 square miles corresponds to 6.9 percent of the total land area in Bridgeport, measured to be 15.97 square miles.[230] The total amount of water entering the site during a 0.4-inch rain event is estimated to be 7.66 million gallons. Assuming 86 percent of the land is impermeable cover, 55 percent of the stormwater entering the EBDC will turn to stormwater runoff.[231] Assuming that all of the stormwater runoff enters the sewer system, the current, contribution from the EBDC is 4.2 million gallons – this is a conservative estimate.

Assume all 700 acres developed utilizes green infrastructure best management practices giving the site the hydrologic characteristics of natural undeveloped landscape. Rather than 55 percent, 10 percent of stormwater falling over the EBDC will turn to stormwater runoff.[232] Then, the total amount of stormwater entering the sewer system would be 0.77 million gallons. This is a reduction of 3.4 million gallons from the current, 86 percent impermeable coverage during an identical weather event. While this is not an insignificant quantity of stormwater runoff, when compared to the potential benefit that could be gained from employing green infrastructure strategies throughout the entirety of Bridgeport, 3.4 million gallons only accounts for 3 percent of the total 111 million gallons falling over Bridgeport and 6.5 percent of the total stormwater runoff (this quantity is proportionate to the relative land area of the East Bridgeport Development Corridor). Table 3-5 quantifies the reduction in stormwater runoff compared to impermeable cover for the East Bridgeport Development Corridor.

[230] "State and County QuickFacts." *U.S. Census Bureau* Website. U.S. Census Bureau. 8 Oct. 2011. Web. Oct. 2011. <http://quickfacts.census.gov/qfd/states/09/0908000.html>.

[231] "Protecting Water Quality Runoff." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. Feb. 2003. Web. Nov. 2011. < http://www.epa.gov/owow_keep/NPS/urban_facts.html>.

TABLE 3-5 REDUCTION IN STORMWATER RUNOFF COMPARED TO PERCENT OF IMPERMEABLE GROUND COVER			
Percent Impermeable Cover	233Percent Stormwater Runoff[1]	Volume of Stormwater Runoff for a 0.4 inch Rain Event [million gallons]	Reduction in Stormwater Runoff Compared to Current Conditions [million gallons]
86 (current)	55	4.2	0
35 – 50	30	2.3	1.9
20-Oct	20	1.5	2.7
Natural Ground Cover	10	0.77	3.4

ESTIMATED CONTRIBUTION OF SPECIFIC STRATEGIES

***Promising Strategy:* The East Bridgeport Development Corridor should act as a testing ground where select green infrastructure strategies are applied to a number of types of development and the benefit, specifically; the quantity reduction of stormwater runoff is measured and monitored.**

Many opportunities to implement green infrastructure on the East Bridgeport Development Corridor to manage stormwater at the source and reduce the quantity entering the CSS exist. This section quantifies the benefit of installing one acre of green roof and ten acres of permeable pavement in aggregate and will qualitatively discuss the benefits of placing bioswales adjacent to impermeable hardscapes and impermeable spaces. Additionally, the section discusses how continuing to promote rain barrel use in Bridgeport can serve to better educate the population on how to easily manage stormwater in new developments and retrofits.

Green Roofs During a 0.4 inch rain event, one acre of intensive, five-inch deep, green roofing material depicted below has the potential to retain 0.45 to 0.60[234] percent of the rain water. The total amount of water that lands on the one acre of green roof would be approximately 1,100 gallons of water of which the green roof would be able to effectively prevent between 495 to 660 gallons from turning into stormwater runoff. This accounts for less than one percent of the total runoff compared to the current conditions. This number can be easily scaled based on the extent of green roofs installed

[233] "Protecting Water Quality Runoff." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. Feb. 2003. Web. Nov. 2011. < http://www.epa.gov/owow_keep/NPS/urban_facts.html>.

[234] "VA DCR Stormwater Design Specification No. 5 – Vegetated Roof. Version 2.1." *Center for Watershed Protection.* Virginia Department of Conservation and Recreation. Mar. 2010. Web. Nov. 2011 <http://www.cwp.org/cbstp/Resources/d2s2a-dcs-bmp-veg-roof.pdf>.

in the East Bridgeport Development Corridor. For example, two acres would double the forecasted benefit and three acres would triple that benefit.

It is important that green roofing systems are designed according to local codes and satisfy building requirements in Bridgeport. Each roofing system should be designed with sensitivity to the context in which it is being installed. Vegetation that can flourish in Bridgeport's weather should be selected. Figures 3-3 and 3-4 are a typical intensive roof section and the green roof system installed on Chicago City Hall.

FIGURE 3-3 Section of an Intensive Roof System

Source – NY Department of Design and Construction[235]

FIGURE 3-4 – Chicago City Hall Green Roof

Source – Greenarbytheday.com[236]

Permeable Pavements During a 0.4-inch rain event, ten acres of permeable pavement have the capacity to manage 45 to 75 percent[237] of the rainwater directly falling on the surface. This corresponds to approximately 49,5000 to 82,500 gallons of runoff reduced

[235] New York City Department of Design and Construction website. Web. Oct. 2011 <http://www.nyc.gov/html/ddc/html/home/home.shtml>.
[236] "Web_Chicago City Hall_Cook Jenshel." *Green Ar by the Day*. GreenAr by the Day. 4 Apr. 2011. Web. Nov. 2011 <http://greenarbytheday.com/2011/04/04/4411-james-patchett-to-discuss-water-as-key-of-sustainable-design/web_chicago-city-hall_cook-jenshel/>.
[237] "VA DCR Stormwater Design Specification No. 7 – Permeable Pavement. Version 1.7" *Center for Watershed Protection.* Virginia Department of Conservation and Recreation. Mar. 2010. Web. Nov. 2011 <http://www.cwp.org/cbstp/Resources/d2s2a-dcs-bmp-veg-roof.pdf>.

out of a total of 110,000 gallons entering the site. The benefits are linearly proportionate to the area of permeable pavement installed.

It is important that permeable pavement systems are designed according to the local codes and satisfy site-specific load requirements and account for local weather conditions in Bridgeport. Each permeable pavement system should be designed with sensitivity to the context in which it is being installed. Depicted below is the intended function of a permeable pavement.

FIGURE 3-5 – Example of function of permeable pavement

Source – Virginia Tech, College of Natural Resources and Environment[238]

Vegetated Swales are designed systems that take into account a number of factors as predicted by the Manning equation for measuring flow in a channel or pipe and rational method for measuring flow over a planar surface. A compiled average for runoff retention predicts between 10 and 30 percent runoff reduction depending on the soil type below and the area the swale is managing. Predicting a scenario for applying a vegetated would provide a fascicle understanding of a complex balance of factors from area of the swale, depth of the swale, pitch of the swale, vegetated medium of the swale, distance the stormwater runoff travels prior to entering the swale, among a number of other items. While vegetated swales do require an amount of land to devote, they can be effectively employed to manage the stormwater runoff of hardscapes greater than 10,000 square feet and can manage the flow of large rain events.

[238] *Virginia Tech College of Natural Resources and Environment.* Web. Oct. 2011. <http://cnre.vt.edu/virginia Tech, College of Natural Resources and Environment>.

It is important that vegetated systems are designed according to the local codes and consider the surface and subsurface conditions in Bridgeport. Each vegetated system should be designed with sensitivity to the context in which it is being installed.

FIGURE 3-6– Vegetated Swale Adjacent to Parking Lot

Source: Stormwater Solutions Handbook, Portland, Oregon

Rain Harvesting The rain barrel program in Bridgeport provided a useful tool to educate residents of the need to manage and control stormwater runoff. While the debate of rain barrels as an effective measure to manage great quantities of water,[239] the educational impact can be seen through improved community involvement and awareness of the need for improved stormwater management. Figure 3-7 depicts a typical residential rain barrel.

[239] "Rain Barrels and Water Conservation." *Conserveh2o.org.* Regional Water Providers Consortium. Web. Nov. 2011. <http://conserveh2o.org/rainbarrels>.

FIGURE 3-7 Rain Barrel

Source: Riverkeeper.org[240]

CSO AND THE LACK OF DATA

One of the requirements of discharge permitting is that a municipality reports when an overflow has occurs. In Connecticut, the governing body that oversees and maintains the records is the Connecticut Department of Energy and Environmental Protection. However, of combined stormwater and wastewater are not measured to any degree of precision; they are estimates. This demonstrates that in general, CSO is an understudied issue.

In the United States, a few cities have started to measure and monitor CSO events with precision, three examples are Washington D.C., New York, and Philadelphia. While the efforts and knowledge that has been acquired from the efforts of these three cities can serve as a reference. It also provides general guidance, site-specific context which is required to determine best management practices for green infrastructure as it pertains to Bridgeport.

240 "Rain Barrels." *RiverKeeper.Org*. River Keeper.Org. Web. Nov. 2011 <http://bnriverkeeper.org/programs/rain-barrels/>.

3.4 STRATEGY AND NEXT STEPS

In 2009, the Illinois General Assembly passed Public Act 096-0026, or the "Green Infrastructure for Clean Water Act," in which the Assembly declared a need to explore the capacity of green infrastructure to combat the mal-effects of urban stormwater runoff. The act enumerated 11 potential benefits from utilizing green infrastructure as outlined in Table 3-1 in the Appendix.

The Assembly also required a study to be completed by June 30, 2010 – one year from the Public Act being enacted. Table 3-6 lists the seven topics the report(s) should address. As a result Illinois has performed the required analysis that not only addresses the existence of the problem and the size of the problem but takes the next step which is proving the effectiveness of an alternative approach. It is not stated in any of the subsequent documents that stemmed from this report, but to change the paradigm, human health and external benefits are not enough – it all comes down to cost. Continuing in that theme, the Connecticut Clean Water Fund (CWF) as one of the recommendations for further action declared in the 2007 report titled *The Clean Water Fund Dilemma: Increasing Demands with Diminishing Fiscal Resources*:

> *"The CWF program is not broken and needs no major surgery to fix it; its ills are caused by inadequate funding."*[241]

This statement defines the CWF as risk averse. Even if the benefits of green infrastructure are known and measured in other municipalities, the lack of topical data for specific initiatives in Bridgeport seeking funding prohibits the CWF from acting. This is entirely attributable to the lack of certainty and the unproven nature of green infrastructure in Bridgeport.

[241] "The Clean Water Fund Dilemma: Increasing Demands with Diminishing Fiscal Resources." *CT.GOV*. Connecticut Clean Water Fund Advisory Group. Feb. 2007. Web. Nov. 2011. <http://www.ct.gov/dep/lib/dep/water/municipal_wastewater/cwf_a_g_report.pdf>.

TABLE 3-6 REPORT TOPICS REQUIRED BY PUBIC ACT 096-0026		
INDEX	**REPORT SUBJECT**	**COMPARABLE DOCUMENT IN EXISTENCE FOR BRIDGEPORT***
1	Nature and extent of urban stormwater impacts on water quality	Baseline Watershed Assessment Pequonnock River Watershed, September 2010
2	Potential urban stormwater management performance standards to address • Flooding • Water pollution • Stream erosion • Habitat quality Effectiveness of green infrastructure practices	Pequonnock River Watershed Management Plan, July 2011
3	Green infrastructure use across the State	No document found Other documents that touch on this subject: • 2004 CT Stormwater Quality Manual
4	Cost and benefits of green versus grey infrastructure	No document found
5	Existing and potential stormwater management regulatory practices	Stormwater Management Manual, 2008 (partially addresses issues)
6	Recommendations for adopting an urban stormwater management regulatory program that promotes the use of green infrastructure	BGreen Stormwater Management Manual, 2008 (both partially address issue)
7	Address the consequence and feasibility of devoting 20% of current funding sources (Water Revolving Fund) to green infrastructure, water and energy efficiency improvements, and other environmentally innovative activities on a long-term basis	No document found

MEASUREMENT PROGRAM

Promising Strategy: ***Bridgeport should install flow meters throughout the sewer system to attain measureable and comparable values.***

To support green infrastructure projects as a substitute or supplement to conventional stormwater management projects, data needs to be obtained through topical, contextual study and monitoring. A few useful locations to install flow meters are: sewer entry points both proximate and not proximate to areas before and after any GI installations; at bypass junctions in the CSS; at the bypass release points; and at the treatment outfalls. Additionally, the data collected from the sewer system should be measured against rain data (intensity, duration and tide data to move beyond models and simulations as the basis of understanding for CSO).

This information would allow for greater valuation of the effect of green infrastructure on stormwater management by allowing for calculations to be performed based on performance data as opposed to estimates. This is the type of verifiable information that is required to garner greater government funding for what is considered to be an alternative strategy.

In January 1999, the EPA released a document titled *Combined Sewer Overflows: Guidance for Monitoring and Modeling*[242] in which methods and standards for monitoring sewer flow and sewer overflow volumes and flow rates. While designing a specific program to study the system in Bridgeport is outside the scope of this report. This document could prove useful when addressing monitoring and measurement in Bridgeport. It can provide a baseline for measuring the effectiveness of green infrastructure strategies throughout the East Bridgeport Development Corridor.

BRANDING BRIDGEPORT A "MODEL GREEN CITY"[243]

The final initiative of BGreen "Brand Bridgeport as A Model Green Community" speaks to the desire to redefine and rebrand Bridgeport as a green city. This is a strategy to improve its standing and stature. The continuing efforts of BGreen have proven effective and substantive. However, proceeding with a robust and rigorous plan to prove the effectiveness of green infrastructure strategies will allow for Bridgeport to 1) contribute to the national dialogue on how best to manage stormwater and CSO and 2) place them at the forefront to which other cities will look for guidance.

By utilizing the East Bridgeport Development Corridor as a testing ground Bridgeport will set itself apart offering a potential source of substantial funding for green infrastructure from the Connecticut Clean Water Fund, and afford the residents the

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[242] "Combined Sewer Overflows: Guidance for Monitoring and Modeling." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. Jan. 1999. Web. Nov. 2011 <http://yosemite.epa.gov/water/owrccatalog.nsf/1ffc8769fdecb48085256ad3006f39fa/4ba346c54d41920a85256b06007232c0!OpenDocument>.

[243] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2008. Web. Nov. 2011. <http://www.rpa.org/bgreen/BGreen-2020.pdf>.

external benefits associated with a greener city with cleaner waterways. The next section examines Environmental Justice issues in Bridgeport that pertain to CSO.

GREEN INFRASTRUCTURE AND ENVIRONMENTAL JUSTICE

The residents of Bridgeport are directly affected by CSO issues. Currently, approximately 86 percent of Bridgeport's land area is covered by impermeable surfaces,[244] which lead to water impairment within the city's water bodies and coastal regions.[245] In addition, pollutants which are usually found in urban stormwater can be toxic. These pollutants include lead, copper, zinc, and insecticides that can bring serious impact in human health and raise concerns about carcinogenic effects.[246]

TABLE 3-8 IMPAIRED WATER BODY EXTENSION IN CONNECTICUT		
TYPE OF WATER BODY	**PROBABLE SOURCE**	**THREATENED OR IMPAIRED**
Rivers and Streams	Urban-Related Runoff/ Stormwater	221.8 miles
Lakes, Reservoirs and Ponds	Urban-Related Runoff/ Stormwater	2211.3 acres
Bays and Estuaries	Urban-Related Runoff/ Stormwater	413.4 square miles

Source: EPA

The Connecticut Water Quality Assessment Report, developed by the EPA in 2010, assessed part of the state's river and streams, lakes and ponds, and bays and estuaries. Out of the total water bodies assessed in 2010, urban stormwater runoff was found to be a source of impairment amongst all types of water bodies in the state.[247]

Additionally, between 2008 and 2010, the EPA listed Bridgeport's water bodies as impaired due to fecal coliform, enterococcus bacteria, lead, mercury and oil and grease.[248] These causes of impairment are mostly attributed to urban stormwater and

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244 "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2008. Web. Nov. 2011. <http://www.rpa.org/bgreen/BGreen-2020.pdf>.
245 Carson, H. "Human Health Impacts from Stormwater Runoff, Stormwater Factsheet No.2." *River Link*. River Link. 2011. Web. 4 Dec. 2011. <www.riverlink.org/stormwaterseriesfinal2.pdf>.
246 "Fishery Harbour Manual on the Prevention of Pollution - Bay of Bengal Programme." FAO Corporate Document Repository. Fisheries and Aquaculture Department. Web. 4 Dec. 2011. <http://www.fao.org/docrep/X5624E/x5624e04.htm>.
247 "Connecticut Water Quality Assessment Report: Assessed Waters of Connecticut by Watershed." *U.S. Environmental Protection Agency*. U.S. Environmental Protection Agency. 2010. Web. 4 Dec. 2011. <http://iaspub.epa.gov/waters10/attains_state.control?p_state=CT.>.
248 "Connecticut Water Quality Assessment Report: Assessed Waters of Connecticut by Watershed." *U.S. Environmental Protection Agency*. U.S. Environmental Protection Agency. 2010. Web. 4 Dec. 2011. <http://iaspub.epa.gov/waters10/attains_state.control?p_state=CT>.

industrial activity.[249] According to the Bridgeport's Health Index, on a scale from 1 to 100, Bridgeport's water rates a score of 32 (100 being the best).[250] This is far less than the U.S. national average of 52.[251]

Bridgeport and the EPA intends to work collaboratively with a wide-range of stakeholders to develop projects focused on improving community capacity for green jobs, water and air quality and reducing toxic exposure.[252] This is done with federal grant money provided by the EPA. Environmental justice grants support and empower the communities that are working on local solutions devoted to local environmental and/or public health issues.[253] The Table 1.1 in Appendix B provides the grants and cooperative agreements, available at the municipal level and regional level.

Currently, Bridgeport is engaged in awareness campaigns intended to inform its citizens about pressing environmental issues. In 2010, the city was awarded a grant worth $25,000 to facilitate a project called Water Boot Camp.[254] This program introduces senior high-school students to complex issues facing the water industry and green initiatives.[255] The plan is innovative because it encourages students to utilize advanced technological tools such as Geographic Information Systems (GIS).[256] This initiative helps to strengthen the environmental awareness in local communities and encourages the use of environmentally friendly initiatives for clean water conservation.

The Groundwork Bridgeport program, a non-profit organization focused on serving the greater Bridgeport area, has revitalized degraded areas in the city and converted them into greener and cleaner places. Groundwork Bridgeport has fostered environmental education by raising awareness on managing Bridgeport's physical environment and promoting initiatives that increase the city's sustainable living

[249] "Connecticut Water Quality Assessment Report: Assessed Waters of Connecticut by Watershed." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. 2010. Web. 4 Dec. 2011. <http://iaspub.epa.gov/waters10/attains_state.control?p_state=CT>.
[250] "Health in Bridgeport Connecticut." *Sperling's Best Places*. Sperling's Best Places. 2011. Web. Nov. 2011. <http://www.bestplaces.net/health/city/connecticut/bridgeport>.
[251] Ibid.
[252] "Grants and Programs." *U.S. Environmental Protection Agency*. U.S. Environmental Protection Agency. May 2011. Web. Nov. 2011. <http://www.epa.gov/environmentaljustice/grants/ej-showcase.html>.
[253] "Environmental Justice Small Grants Fact Sheet." *U.S. Environmental Protection Agency*. U.S. Environmental Protection Agency. 2011. Feb. 2011. Web. Nov. 2011. <http://www.epa.gov/environmentaljustice/resources/publications/factsheets/fact-sheet-ej-small-grant-01-2011.pdf>.
[254] "Environmental Justice Showcase Communities." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. June 2011. Web. Dec. 2011. <http://www.epa.gov/compliance/ej/grants/ej-showcase.html>.
[255] Ibid.
[256] "CTAWWA Water Boot Camp Intrigues Bridgeport's Youngsters." *InFlow Line.* InFlow Line. 2011. Web. Nov. 2011. <http://www.inflow-line.com/summer2010/articles/page6-7.pdf>.

standards.[257] Another active organization known for its environmental services through legal and scientific expertise is Save the Sound.[258] This organization advocates protecting and restoring the Long Island Sound. They promote the use of green infrastructure techniques like vegetated swales, green roofs, and permeable pavement in new construction developments or retrofits to decrease the amount of stormwater runoff and slow its entry into the stormwater system by adopting appropriate management and local solutions.[259]

Projects such as Water Boot Camp, Groundwork Bridgeport, and Save the Sound are examples of initiatives that foster environmental awareness on methods to improve water quality. These initiatives have provided Bridgeport residents with reliable information about the benefits of green infrastructure, water protection, information technology, and environmental education.

In 1991, the University of Connecticut collaborated with the Cooperative Extension System, Connecticut Sea Grant and Natural Resources Management and Engineering Department to create the Nonpoint Education for Municipal Officials (NEMO).[260] This program promotes environmental education to local land-use boards on how to sustain growth while preserving natural resources and community character.[261] NEMO's unique approach to promoting environmental justice uses state-of-the-art technology such as remote sensing to provide information to decision makers on the relationship between impervious surface and water pollution.[262] This technology intends to demonstrate a cost-effective way to improve land use and protect natural resources and is extremely valuable in fostering green infrastructure initiatives.[263] See "Case Study 3.1: NEMO in Action". [264]

[257] "Grants and Projects Water Quality." *U.S. Environmental Protection Agency*. U.S. Environmental Protection Agency. 2010. Web. Nov. 2011 <http://www.epa.gov/region1/eco/uep/ct/waterquality>.
[258] "Save the Sound for More than Three Decades." *Connecticut Fund for the Environment.* Connecticut Fund for the Environment. Web. Nov. 2011. <http://ctenvironment.org/save-the-sound.cfm>.
[259] "On the Ground, In the Sound." *Connecticut Fund for the Environment.* Connecticut Fund for the Environment. Web. 4 Dec. 2011 <http://ctenvironment.org/stormwater.cfm>.
[260] "Nemo Brief History." *CT Nemo*. University of Connecticut. Web. 4 Dec. 2011. <http://nemo.uconn.edu/about/history.htm>.
[261] Ibid
[262] Ibid
[263] Ibid.
[264] "NEMO: Non-point Education for Municipal Officials: Using Geographic Information To Protect And Improve Water Quality." *CT.GOV.* Department of Energy and Environmental Protection. 2011. Web. 4 Dec. 2011 <www.ct.gov/dep/lib/dep/water/nps/success_stories/nemo.pdf>.

CASE STUDY: NEMO in Action

Nonpoint sources (NPS) of pollution are generally associated with rainfall, thunderstorms and snowmelts that happen in a diffuse manner and lead to water pollution in surface and ground water. This source of pollution mostly happens in areas with large paved surfaces.

In 1992, NEMO held workshops on visual maps and created a number of supporting publications that were aimed at educating the citizens of Connecticut about non-point sources of pollution.

The project was successful; it received funds from the federal government to expand research on watershed programming and Internet tools that provided technical assistance to improve data collection for water quality assessment. As a consequence, government officials updated the plans and regulations to address NPS pollution.

Asphalt, concrete, and rooftops increase runoff volume. The more impervious surfaces there are the worse the water quality.[265] Knowing the amount of impervious area along a watershed region is essential to monitoring as it assists in evaluating the condition of a watershed. This information is beneficial to developing a comprehensive management plan to improve water quality and ultimately human health.[266]

Additionally, monitoring watershed quality provides municipalities technical assistance on demonstration projects that facilitate public outreach for community-based watershed management. Accurate data assists local communities in designing and implementing water quality projects. Providing reliable information helps to establish accurate benchmarks and facilitates targeting funds.[267]

Currently, the latest data provided for impervious surfaces by the University of Connecticut is limited because it does not include the impervious surface footprint.[268] However, web mapping systems have the ability to capture and interpret impervious

[265] "Impervious Surfaces: Long Island Sound Regional Impervious Study." *College of Agriculture and Natural Resources Center for Land Use Education and Research.* University of Connecticut. Web. 4 Dec. 2011. <http://clear.uconn.edu/projects/imperviouslis/index.htm>.

[266] Ongley, E.D. "Water Quality Management: Design, Financing and Sustainability Considerations-II." *Gems Water.* United Nations Environmental Protection. 4 Apr. 2000. Web. 4 Dec. 2011. <http://www.gemswater.org/freshwater_assessments/pdfs/water_quality_management2.pdf>.

[267] "Connecticut Non-Point Source Management Program 2006-2007." *CT.GOV.* Connecticut Department of Energy and Environmental Protection. Sept. 2010. Web. Nov. 2011. <www.ct.gov/dep/lib/dep/water/nps/.../2005annualreport.pdf>.

[268] Chester, Arnold, Jr. Telephone interview. Dec. 2011

surface coverage which provides an easier way to share information publicly.[269] These tools can help justify the need for improvement projects such as the installation of green roofs, vegetated swales, pervious pavement and rain harvesting. Furthermore, mapping impervious areas assist in delineating where green infrastructure technologies should be implemented.[270]

The state of Connecticut has contracted through the US Geological Survey a statewide aerial flyover; this is scheduled to begin in spring 2012.[271] This flight will deliver the most recent data provided by digital aerial imagery "at a 1-foot ground resolution and at a horizontal accuracy of ± 5-feet (200-scale)."[272] This information is expected to be publicly available by summer or autumn 2012. This provides a great opportunity for Bridgeport Enterprise GIS office to enhance its mapping systems.

Additionally, there is an opportunity for Bridgeport GIS office to develop a public private partnership with Photo Science Inc., a firm specialized in spatial solutions that provides in-depth land use analysis including building footprints, land cover classification, and impervious surface interpretation.[273] The PPP would improve Bridgeport's GIS services and would facilitate to determine the most vulnerable areas in the city. Knowing the regions in most need for green infrastructure helps to create a list from which to prioritize potential stormwater retrofits.

***Promising Strategy:* Bridgeport should expand its current GIS mapping system to include communities affected by CSO.**

One way to engage community members is by sharing government findings and publicizing water quality results in relation to impervious surfaces. These can be advertised in many ways such as local newspapers, pamphlets, brochures, radio and television. This way, citizens are better informed about the negative impacts of impervious surfaces and the benefits of green infrastructure. This kind of public

[269] Chester, Arnold, Jr. Telephone interview. Dec. 2011
[270] "MapGeo."*AppGeo*. Applied Geograpics Inc. Web. Nov. 2011. <http://www.appgeo.com/solutions/mapgeo/>.
[271] "State of Connecticut 2010 Aerial Flyover Plan."*AppGeo*. AppGeo. Web. 4 Dec. 2011. <http://www.appgeo.com/services/state--of--connecticut--buy--up--program/>.
[272] Ibid.
[273] Ibid.

campaign encourages individual behavior on adopting green infrastructure technologies and can be funded through government incentives.

Bridgeport should expand its current GIS to include communities affected most by CSO and educate communities on ways to mitigate water pollution through the use of green infrastructure strategies. Two opportunities that Bridgeport can explore are through partnerships with the Water Boot Camp Program and Photo Science Inc. These partnerships would enhance the quality of information provided by Bridgeport's GIS department. These enhancements include an easier virtual representation of existing infrastructures, support of on-going operations for green infrastructure initiatives and summarizing results that facilitate strategic managerial decision-making and policy formulation.

The benefits of applying green infrastructure strategies are understood however funding remains the number one impediment to implementation. The next section examines funding opportunities for employing these strategies.

GREEN INFRASTRUCTURE FUNDING

Green Infrastructure funding is available through federal and state sources such as the U.S. Environmental Protection Agency (EPA), U.S. Department of Energy & Environmental Protection (DEEP), and the Department of Transportation (DOT) grants. Bridgeport has previously received funding for stormwater management initiatives. Bridgeport's Water Pollution Control Authority receives funding primarily from Connecticut's Department of Environmental Protection. Connecticut's Clean Water Fund (CWF) is the state's environmental infrastructure assistance program under DEP.

In an interview, Bill Robinson, Manager of Water Pollution Control Authority (WPCA) for the City of Bridgeport, explained that EPA transfers funding to Connecticut's DEP under the Clean Water Funding Program.[274] In this same interview he discussed how Connecticut's DEP recently recognized previously classified "streetscape" design elements such as swales, recharge basins, and impermeable pavers that can now be incorporated into CSO project design since sewer rehabilitation programs had ended three years ago. WPCA is currently working on a CSO project design where they incorporate these design elements. The intent is to approach DEP for funding. Green infrastructure strategies such as vegetated swales and porous pavements are likely to be favored projects in Bridgeport's TOD area based on WPCA's current efforts. However, based on the GI recommendations permeable pavements are imperative in maximizing the amount of stormwater that can be diverted from the CSO.

***Promising Strategy:* Secure green infrastructure funding through programs that promote improvements in maintaining fresh-water quality.**

Funding for green infrastructure can be public, private or a combination of the two. It can be a direct source that finances green infrastructure or an indirect source that is aimed to all projects that safe-guard and improves the quality of drinking water.

An aged water management system can lead to contamination of drinking water. Therefore, developers of green infrastructure applications are also eligible to receive finance from funds that are used for investments to install, upgrade and replace

[274] Robinson, Bill. Telephone interview. 16 Nov. 2011

erstwhile infrastructures to provide safe drinking water to communities. The Drinking Water State Revolving Fund (DWSRF)[275] of EPA is one such that was established under the Safe Drinking Water Act in 1996. For fiscal year 2011, Connecticut State has been allotted $13,573,000 under this fund.[276]

For similar reasons, developers of green infrastructure projects can apply to EPA's Non-point Source Pollution Fund and Water Pollution Control Program grants.[277] Section 106 of the Clean Water Act authorizes EPA to provide federal assistance to states and interstate agencies to establish and implement ongoing water pollution control programs. Prevention and control measures supported by pollution control programs include permitting, development of water quality standards and total maximum daily loads, surveillance, ambient water quality monitoring, and enforcement, advice and assistance to local agencies, and the provision of training and public information. [278]

Additional funding from the EPA includes the Community Action for a Renewed Environment (CARE) grant and the Targeted Watershed Grants program. CARE addresses pollution levels and the applicant criteria include county and local governments. The Targeted Watershed Grants Program of EPA is a source of finance for community-based approaches and management techniques to protect and restore the nation's waters and encourages the organizations (government agencies, NGOs) to enhance and sustain water quality in an innovative fashion**.** [279]

***Promising Strategy:* Utilize a creative mechanism to secure funding such as Green Innovation Grant Program or Green Innovation Fund.**

Bridgeport had previously utilized this funding strategy when it received an $11 million TIGER grant for infrastructure improvements from Department of Transportation

[275] Within the context of the DWSRF program, environmentally innovative projects' would include those that ...demonstrate new and/or innovative approaches to delivering service and /or managing water resources in a more sustainable way. Examples of projects include but are not limited to...ii. Projects, or components of projects, consistent with a "Total Water Management" planning framework; or other planning framework which project life cycle costs (including infrastructure, energy consumption and other operational costs) are minimized.
[276] "Drinking Water State Revolving Fund." *U.S. Environmental Protection Agency.* U.S. Environmental Protection Agency. Sep. 2011. Web. 15 Nov. 2011 <http://water.epa.gov/grants_funding/dwsrf/index.cfm>.
[277] Ibid.
[278] Ibid.
[279] "Grants." *U.S. Environmental Agency.* U.S. Environmental Agency. 1 Dec. 2011. Web. Nov. 2011. <http://water.epa.gov/grants_funding>.

(DOT) and an $18 million contribution from Bridgeport Landing LLC.[280] The funding was used for specific roadways improvements on Route 130 and Route 127 and incorporated a separation and reduction of site drainage with enhanced landscaping.[281]

Boston crafted a similar strategy. Boston's TOD plan was once threatened by new highways planned for the city. The city planners of Boston decided that they needed to divert funds from Massachusetts's federal highway funds and to use them instead for transit improvements.[282]

Another good example of this funding strategy is Green Innovation Grant Program (GIGP) administered by New York State. The federal economic recovery plan, American Recovery and Reinvestment Act of 2009 (ARRA) requires that 20 percent of State Revolving Funds (SRF) should be used for green infrastructure projects. It is estimated that GIGP will use $35 million from Clean Water State Revolving Fund and $3 million from Drinking water State Revolving Fund for these projects. Green innovation includes capital projects, technologies, and activities that meet basic regulatory requirements for water quality protection. See "Case Study: GIGP Funding in Utica" for an example of using this funding source.[283]

CASE STUDY: GIGP FUNDING IN UTICA, NY

Utica, NY the GIGP allocated funds for stormwater tree pits and rainwater barrels. The purpose of the project is to reduce the stormwater entering the City's Combined Sewer System during a weather event, reducing peak flows, and providing additional filtering and treatment of stormwater that ultimately reaches the Mohawk River. The grant is to be given for retrofit. For the project Rain barrels, downspout removal, porous pavers, curb cuts are to be installed. Grants of up to 90% of eligible project costs may be provided to eligible recipients with GIGP projects that comply with all requirements. The recipient must contribute 10%, in matching funds, which may include direct cash funding or documented in-kind services.

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[280] "Grants." *U.S. Environmental Agency.* U.S. Environmental Agency. 1 Dec. 2011. Web. Nov. 2011. <http://water.epa.gov/grants_funding>.

[281] Ibid.

[282] "TCRP 102: Transit-Oriented Development in the United States: Experiences, Challenges and Prospects." *Transportation Research Board.* The Federal Transit Administration. 2004. Web. Nov. 2011 <http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_102.pdf>.

[283] "TCRP 102: Transit-Oriented Development in the United States: Experiences, Challenges and Prospects." *Transportation Research Board.* The Federal Transit Administration. 2004. Web. Nov. 2011 <http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_102.pdf.>.

A project that received funding from GIGP is Project Solar 2 in New York City. The funding is to be used for wastewater treatment systems, a rainwater collection system and for construction of a new 8,000 sq. ft. environmental learning center designed according to LEED Platinum standards. The grant allotted by GIGP for this construction is $ 712,500.[284]

Green Innovative funds can be used not only for construction but also for training personnel in application of green infrastructure strategies**.** Connecticut has a similar fund and it is called Green Jobs innovation fund. This was announced in June this year by Senators Joe Lieberman (ID-CT) and Richard Blumenthal (D-CT). The grant is worth $5,800,000 and was given to the Connecticut Department of Labor for its Connecticut Green Jobs Funnel Initiative (CGJFI). Per media reports[285] this grant will help the Connecticut Green Jobs Funnel Initiative promote career pathways in the green construction industry.

The goal of this fund is to train unemployed and underemployed workers the skills of green construction and associated activities such as Brownfield remediation, energy management and solar panel installation. It will create jobs for 975 unemployed Connecticut residents in seven communities: Bridgeport, Bristol, Hartford, New Britain, New Haven, New London, and Waterbury.

This fund can be used for the East Bridgeport Development Corridor to help build up a workforce that could employ green infrastructure technologies.

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284 New York State Environmental Facilities Corporation. Web. 18 Nov. 2011. <www.nysefc.org/GreenGrants/GIGPProjects.aspx>.

285 **"**Lieberman and Blumenthal Announce $5.8 Million Green Jobs Innovation Grant" *Joe Lieberman United States Senator for Connecticut.* Joe Lieberman United States Senator for Connecticut. 22 June. 2011. Web Nov. 2011. <http://lieberman.senate.gov/index.cfm/news-events/news/2011/6/lieberman-and-blumenthal-announce-58-million-green-jobs-innovation-grant>.

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GOVERNANCE

CHAPTER 4: GOVERNANCE

Distributed energy generation and green infrastructure have been presented as distinct sustainability strategies that can be implemented on East Bridgeport Development Corridor. Both strategies have unique technologies, funding sources and ways to support environmental justice. However, these characteristics alone do not ensure their successful implementation on the project site nor maximizes their benefits.

Governance needs to be an organizational structure capable of streamlining these best practices to ensure the East Barnum train station project is completed. The best way to ensure successful implementation is by combining distributed energy generation and green infrastructure as a collective strategy aimed at supporting TOD in the East Bridgeport Development Corridor. TOD employs unique strategies to solicit private and federal funds. Grouping distributed energy generation and green infrastructure funding sources as one aspect of TOD funding helps to streamline these separate strategies as one.

This also makes it easier to maneuver land use policy to support TOD. The first part of this section shows how value capture can be used for distributed energy generation and green infrastructure through TOD. These will be discussed in the next sections.

4.1 VALUE–CAPTURE FINANCING FOR DISTRIBUTED ENERGY GENERATION AND GREEN INFRASTRUCTURE THROUGH TOD

TOD projects receive finance through public agencies. For example, the Department of Transportation and the Federal Transit Administration are the main sources of federal transportation-related funds for the states. Additionally, TODs are provided funds by the Department of Housing and Urban Development and the Economic Development Agency. The American Recovery and Reinvestment Act focuses on existing programs and provides extra funding for programs that support TOD projects. For TOD infrastructure, the plan announced $27 billion in funds to be allotted to and administered by the states. [286, 287]

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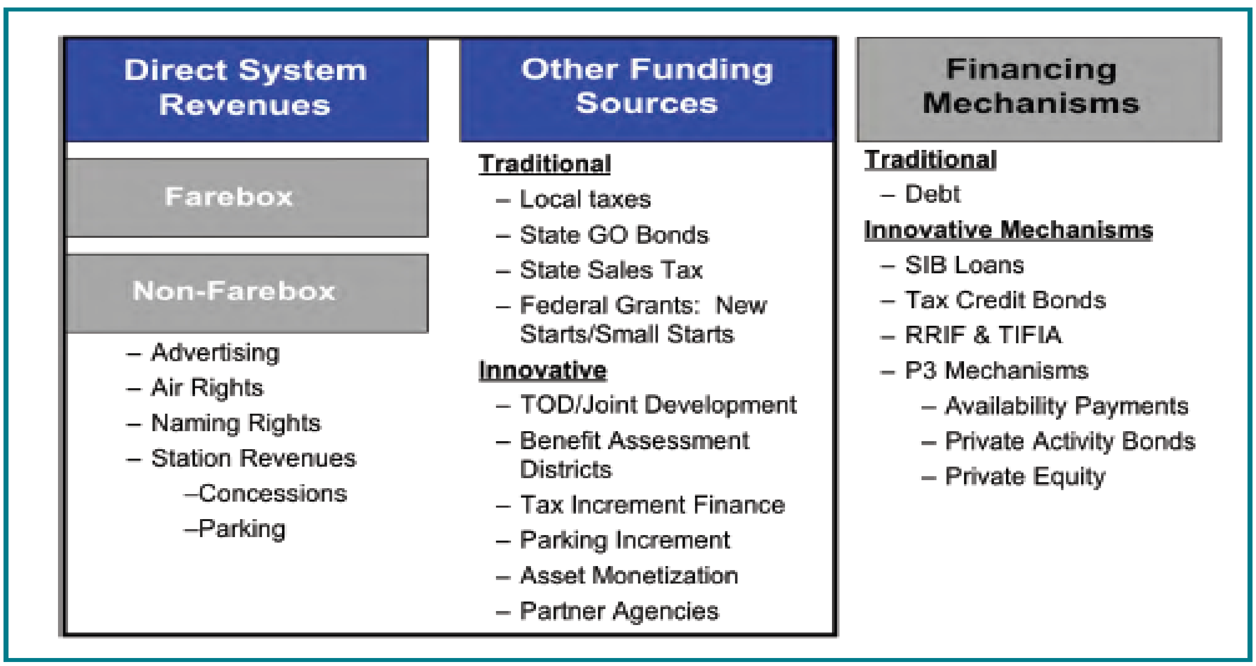
[286] "Recipient Projects." *Recovery.GOV.* Recovery.Gov. 2011. Web. Dec. 2011. <http://www.recovery.gov/Transparency/RecipientReportedData/Pages/RecipientReportedDataMap.aspx>.

[287] The American Recovery and Reinvestment Act of 2009 distributes funds in three ways namely tax benefits; contracts, grants and loans; entitlements. Out of these the Federal government has already paid out $300.1 billion in tax benefits; 216.9 billion in contracts, grants and loans; and 214.9 billion as entitlements. 2,556,098.

A reason why TOD projects attract funding from both private and public agencies is because it is seen as an opportunity for both parties to work together at the planning and implementation phase. Often joint development arrangements are ground leases and operations cost sharing. TOD is seen as an economic stimulus; attracting quality work-force and private-public partnership. An active market involves an increase in property prices. For example, in Charlotte, North Carolina, the development of a TOD project has increased property prices from between $4 and $6 per square foot in 1994 to around $60 per square foot today.[288] In 2001, a study by Robert Cervero, showed that the value of commercial property in California's Santa Clara County was 23 percent higher near light rail and 120 percent higher near commuter rail. A 2003 study by the

FIGURE 4-1: Potential Funding Sources and Financing Mechanisms



Source: Evaluating Innovative Financing Opportunities for Miami-Dade Transit, Miami Dade County

University of North Texas showed the value of office properties near suburban DART rail stations increased 53 percent more than comparable properties not served by rail, and the value of residential properties was 39 percent greater.[289]

288 Greene, Richard K. "Transit Oriented Development as Economic Stimulus." *Area Development Online*. Hamilton County ing Greater Indianapolis. May 2009. Web. Dec. 2011. <http://www.areadevelopment.com/logisticsInfrastructure/Apr09/transit-oriented-development-public-transportation001.shtml?Page=2>.

289 Ohland, Gloria. "Value Capture: How to Get a Return on the Investment in Transit and TOD." *Center for Transit-Oriented Development*. Center for Transit Oriented Development. Jan. 2011. Web. Dec. 2011 <http://www.ctod.org/portal/sites/default/files/valuecap.pdf>.

For the East Side Barnum Train Station project both distributed energy generation and green infrastructure strategies can be funded through value capture mechanism. Value capture is a type of infrastructure financing in which increases in private land values generated by public investment are in part "captured" through a variety of approaches to help pay for infrastructure projects.

There are a number of tools to implement value capture in generating TOD finance. One of these tools that have been effective in funding many TOD projects in the US is tax increment financing (TIF). TIFs work by capturing all new property tax revenues from a specific area and re-investing them in that same area**.**

Promising Strategy: ***Declare the East Barnum TOD site as a tax increment financing (TIF) district to receive subsidies to help offset the costs of redevelopment***

TIF is a method to use future gains in taxes to finance current improvements that can create future gains. The increased value of property (as happened in the example of Charlotte, North Carolina) translate into increased tax revenues or tax increments that are used within a defined district to pay off debts incurred to plan and implement a TOD project there TIF is beneficial to improve underdeveloped areas that might not otherwise be developed if this fund was not channelized in this manner. TIF generates money through increased Equalized Assessed Values (EAV) of the total property within the district. The EAV is the Assessor's way of assigning similar taxes to similar structures and spreading the property tax burden equally.[290]

In case of a proposed TIF district, the City captures the increase in property-prices by first fixing a base rate that is the total of EAVs in this district. The difference between the base EAV and new EAV after the development of the district due to the TOD project is the "increment." This is reinvested into the district for the improvement of its communities and local businesses. Please see "Case Study: TIF Strategies in Arlington Heights, Chicago".[291]

[290] "Tax Increment Financing." *Green Bay Economic Development.* Economic Development City of Green Bay. 2007. Web. Nov. 2011 <http://www.ci.green-bay.wi.us/EconomicDevelopment/tifs.html>.

[291] "TCRP 102: Transit-Oriented Development in the United States: Experiences, Challenges and Prospects." *Transportation Research Board.* The Federal Transit Administration. 2004. Web. Nov. 2011 <http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_102.pdf>.

CASE STUDY: TIF STRATEGIES IN ARLINGTON HEIGHTS, CHICAGO

The TIF strategies proved successful in Arlington Heights, Chicago. The city completed numerous downtown plans and studies in the 1950s, 1960s, and 1970s. However, by the end of the 1970s, Arlington needed to revitalize its downtown that was in a state of decline. To do this the village introduced new zoning that permitted mixed uses and higher densities downtown, reduced parking requirements near the rail station, and the establishment of two TIF districts. To implement these improvements the village provided $13.9 million in public financing for the project, comprising of$9.9 million for the garage, $2.6 million for developer gap financing, and an additional $1 million to underwrite land costs. All these were TIF funds. Before the project, Arlington received $65,000 in annual property taxes. Now this has increased to $1.5 million annually in as property- and sales-tax income.

In some instances the state and the local governments take recourse to declaring the TOD area a special assessment district to capture the value of the heightened property prices and raise funds for the TOD. Special assessment districts are defined as a specifically defined geographical area of property owners who have requested some public improvement and agreed to pay for that improvement through pro rata charges levied against owners within the district. There are opportunities to utilize this strategy to implement sustainability strategies both within the Bridgeport TOD project and the city at large. For example, in Los Angeles, CA, a special assessment district was set up to fund a new infill station.

***Promising Strategy:* Declare Bridgeport to be special assessment district to receive federal funding for construction.**

California: Property-owners within 200 feet of a new infill station at New York Avenue on Washington Metropolitan Area Transit Authority (WMATA) Red Line will pay annual assessments for 20 years to retire $25 million in general obligation bonds. Special assessment districts around 5 subway stations in Los Angeles have annually generated $ 130 million to help fund the first segment of the transit line. In another instance the Valley Transportation Authority in Santa Clara County used a special assessment district to fund construction of a station in Sunnyvale and has indicated it will use assessed districts to help pay for the stations on the BART extension to San Jose.[292]

Portland: Two assessment districts was combined together with tax increment financing, parking fees, a parking bond, and federal and local transportation dollars to pay for the streetcar, which has leveraged a significant increase in development.[293]

A similar value capture mechanism would prove beneficial for Bridgeport East Side Barnum Station TOD project. According to urban planners and economists a specialized value capture tool that has historically led to generating TOD funding is a joint development with real estate companies.

***Promising Strategy:* Utilize the expertise of a real estate company to generate investor development by submitting Requests for Proposals (RFPs) for the TOD development projects.**

Washington Metropolitan Area Transit Authority: WMATA did not have an access to a dedicated funding source and had to rely heavily on contributions from passenger fares and state and governments. By using an aggressive strategy of seeking out developer interest with Request for Proposals (RFPs), WMATA managed to initiate developer interest. It negotiated with groups of developers before drawing up a contract with a selected team.

The same strategy could be applied to the East Bridgeport Development Corridor if the appropriate party (i.e. Metro North or RPA) purchases the land and shows interest in developing it.

Another controversial but effective value capture strategy for raising finance for a TOD project that can be applicable to Bridgeport East Side Barnum Station TOD is through an increment in sales tax. This might be more difficult to implement than other value capture tools but there are good examples in TOD finance case studies that show that if utilized this strategy prove to be effective as a source of funding.

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[292] Ohland, Gloria. "Value Capture: How to Get a Return on the Investment in Transit and TOD." *Center for Transit-Oriented Development*. Center for Transit Oriented Development. Jan. 2011. Web. Nov. 2011 <http://www.ctod.org/portal/sites/default/files/valuecap.pdf>.

[293] Ibid.

***Promising Strategy:* Raise local sales tax 0.5% and mandate that the tax revenues be reinvested for transportation and public improvements of the community in question.**

Florida: To support and encourage TOD, Miami-Dade County in Florida passed the People's Transportation Plan (PTP) in November 2002. PTP raised local sales taxes by 0.5% and mandated that these revenues be used only for transportation and public transit improvements. PTP is projected to raise more than $140 to $150 million or more annually leading to a smart growth TOD. By employing this strategy, the Eastside site could see similar revenues.

4.2 STREAMLINING GOVERNANCE

Bridgeport's current BGreen2020 Sustainability Plan (BGreen) outlines several initiatives that the city has taken to address its social, economic and environmental challenges—"a legacy of unsustainable land use, transportation, waste, and stormwater practices".[294] Climate change has been addressed by reassessing ways to curb carbon emissions and planning for its inevitable impact.

The plan purports to achieve these goals by institutionalizing Bridgeport's efforts into a comprehensive strategy as follows:

1. Reestablish goals for reducing carbon emissions;
2. Establish a Sustainability Community Advisory Committee composed of nearly 40 community leaders to oversee a citywide sustainability initiative;
3. Launch a citywide sustainability initiative in partnership with the Bridgeport Regional Business Council.[295]

The success of BGreen depends on broad public participation however a public-private partnership structure has been the primary strategy for these initiatives. The public body participation facilitates in providing a policy framework and initial investments while the private side is able to mobilize a large range of stakeholders and supplement additional financial investment in the projects.

[294] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2010. Web. Nov. 2011. < http://www.rpa.org/bgreen/BGreen-2020.pdf>.
[295] Ibid.

To lead the initiative, a Project Management Team comprised of the RPA, Global Infrastructure Strategies, Meridian Institute and MP & Associates was developed. The governance structure stems from organizational chart in Figure 4-2 in which five technical committees, under the instruction of the Project Management Team, have been designated to oversee the overall development of BGreen's policy strategy.

FIGURE 4-2

Source: BGreen 2020[296]

The five technical committees oversee the following goals and implementation strategies:

Green Energy and Buildings- Encourage the use of sustainable practices as an economic driver, improve energy efficiency in facilities and residences and lower energy costs. As a step to implement this goal, Bridgeport is established as an Energy Improvement District (EID). Such districts can reduce energy costs and improve reliability for customers located within the districts. Additionally, the PA 07-242 act which underwrites the EID, allows a municipality, by a vote of its legislative body, to exercise a wide range of powers regarding distributed resources. It allows the board to:

[296] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2010. Web. Nov. 2011. < http://www.rpa.org/bgreen/BGreen-2020.pdf>.

1. Determine the location, type, size, and construction of distributed resources in the district;
2. Make plans for developing and operating these resources and for coordinating its facilities with public and private agencies;
3. Fix and collect fees and charges for the resources it owns; and
4. Operate and maintain resources the board owns or leases and use their revenues for the board's corporate purposes. [297]

Greenfields and Green Wheels- to reduce the number of single-occupancy automobile trips, facilitate the redevelopment of underutilized sites throughout the city, and provide less carbon intensive forms of mobility to city inhabitants.

Green Spaces, Water Resources and Recycling- to ensure that residents have access to safe clean drinking water and coastal services, open spaces, reduced waste streams and regulate stormwater through its stormwater management programs.

Green Businesses, Jobs and Purchasing to diversify Bridgeport's business base, assist green business development, create new jobs and encourage both businesses and private consumers to buy green products.

Green Marketing, Education and Outreach- to educate the population about energy efficiency and conservation efforts.

BGreen has already identified essential components to support TOD however it does not focus on East Barnum Train Station. For example, BGreen's Transit and Mobility working group lists among its initiative's progress that a grant has been received from HUD to determine the feasibility of an East side station.[298] However, besides the issuance of an RFP to determine the feasibility for the project no other progress has been listed or updated that suggests further action has been taken to solidify additional investment in the project.

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[297] McCarthy, Kevin. "OLR Research Report: Energy Improvement Districts." *Connecticut General Assembly.* CT.GOV. Nov. 2007. Web. Dec. 4 2011. <http://www.cga.ct.gov/2007/rpt/2007-R-0672.htm>.

[298] "BGreen 2020: A Sustainability Report for Bridgeport, Connecticut." *Regional Plan Association*. Regional Plan Association. 2010. Web. Nov. 2011.< http://www.rpa.org/bgreen/BGreen-2020.pdf>.

***Promising Strategy:* Create an appointed East Barnum Station TOD Advisory Group that functions as a Board of Directors facilitating**

(1) Connecticut's support in adoption of TOD-friendly planning, zoning, infrastructure adequacy, housing, and/ or other measures by the local government; and

(2) Aligning stakeholder interests to incentivize private investment for the area surrounding the station to expedite the project development. It is also advised that this advisory group should be formed taking members from within the already existing governance framework in Bridgeport.

The East Barnum Station TOD Advisory Group should consist of the following members:

- Energy Liaison Officer: Responsible for coordinating all funding for distributed energy generation resources
- Stormwater Management Liaison Officer: Responsible for coordinating all funding for green infrastructure strategies
- Environmental Justice Marketing Officer: Responsible for community engagement on environmental issues
- Real-Estate Liaison Officer- Responsible for land purchasing strategies as it relates to East Bridgeport Development Corridor
- Public Policy and Land-Use Coordinator: Responsible for organizing land-use strategies and zoning to expedite the completion of the East Barnum Train Station

Maryland is successful in their prioritizing their TOD projects primarily by designating task forces to specifically oversee clearly defined designated places for development in different parts of the state. These designated places for TOD will establish shared commitments for State agencies and local governments and must ensure that these commitments are sustained via a PlanMaryland Consistency Process.[299]

This advisory group could coordinate fund allocation for the Eastside and Downtown Bridgeport TOD projects. Currently, the East Barnum Train Station is in the feasibility stage whereas several components of the Downtown Bridgeport TOD project are in its

[299] "Plan Maryland Draft Plan Executive Summary." *Plan Maryland.* Maryland Department of Planning. Apr. 2011. Web. 4 Dec. 2011. <http://plan.maryland.gov/PDF/draftPlan/PM_draft_execsummary.pdf>.

design or construction phase. Public and private funding have already been allocated and secured to see these projects through completion. Obtaining further funding could be difficult if the East Barnum Train Station is delayed indefinitely. The special advisory group could monitor the timeline for each project and assess funding opportunities generally.

A general land use plan (GLUP) is a tool of urban planning that is used for zoning which would be a useful tool to incentivize development. The Rosslyn-Ballston corridor of Northern Virginia was marked by loss of status as Northern Virginia's main retail district moved to new shopping centers in Fairfax County, resulting in declining retail sales. As a resolution Arlington County chose to place the rail line and five stations beneath this corridor to facilitate commercial development.

There were two approaches to this redevelopment initiative. The key aspect was to use the Metrorail transit investment as the catalyst for intensive redevelopment of the commercial spine of central Arlington. Other aspects of the approach included preserving and reinvesting in established residential neighborhoods adjacent to the corridor, and concentrating density and promoting mixed use at the five stations and tapering development down to adjacent neighborhoods. One of the policy tools used in the corridor redevelopment effort was the General Land Use Plan (GLUP), which set the broad framework for guiding all development decisions along targeted growth axes. The other plan included land-use and zoning ordinances, urban design, transportation, and open-space guidelines.[300]

Promising Strategy: ***The East Barnum Station Advisory Group should establish a General Land Use Plan (GLUP) for East Bridgeport Development Corridor. This land-use plan should stipulate that any developer willing to develop projects on the parcels of land adjacent to the station will be required to utilize both DEG and GI technologies.***

The GLUP could include the distributed energy generation and green infrastructure strategies. The developer would have the flexibility to choose from a combination of sustainability strategies that would be the most energy efficient and economically feasible for their project. This tool could be developed and streamlined by the East Barnum Train Station Advisory Group. In addition to outlining the distributed energy

[300] "Evaluating Innovative Financing Strategy for Miami Dade Area." Miami*Dade.Gov.* Infrastructure Management Group Inc. 29 Oct. 2009. Web. Dec. 2011. <http://www.miamidade.gov/citt/pdf_library/innovative_financing_report.pdf>.

generation and green infrastructure strategies are the applicable financial incentives associated with utilizing these strategies.

Funding for these sustainability strategies can be included within the criteria of the GLUP. For instance, the infrastructure to accommodate fuel cell projects with natural gas in Bridgeport exists this tool would provide the developer with clear information on how to access this fuel source. By including green infrastructure strategies as part of the plan, the cost of retrofitting the streetscape to utilize permeable pavements would become the developers' responsibility.

One of the recommended strategies to funding TOD for this project has been to accumulate a large amount of the real estate and actively solicit developer interest through RFPs. Developers responding to the RFPs would be committing to any land-use designation given to the property. Therefore, this RFP process could serve as an apparatus to advance the goals of the GLUP and in turn the GLUP serves as a tool to finance distributed energy generation and green infrastructure through private investment.

This strategy of preparing an illustrative general land-use plan was successful for the Arlington County's Metrorail corridor. The promising strategies for distributed energy generation and green infrastructure can be applied to both existing and new residential and commercial development. The Environmental Justice group can proactively advertise the environmental and financial benefits of implementing these strategies thereby, incentivizing individual behavior in adopting the strategies. The GLUP would incentivize developers in adopting the same strategies. Hence, these two plans of action streamline the adoption of distributed energy generation and green infrastructure for both existing and new development. Streamlining this process through the East Barnum TOD Advisory Board allows for the opportunity for the East Bridgeport Development Corridor to fully benefit from the federal grants and tax incentives offered for implementing and utilizing these strategies.

CONCLUSION

CHAPTER 5: CONCLUSION

The proposed East Bridgeport Barnum Station sited in the East Bridgeport Development Corridor (EBDC) affords an opportunity to address issues pertaining to energy production and stormwater management by examining the benefits and implementation opportunities for distributed energy generation and green infrastructure.

DISTRIBUTED ENERGY GENERATION

Projected volatility and associated environmental costs of energy production have led to many municipalities investigating and adopting plans to enhance distributed energy generation in their communities. Bridgeport has begun distributed energy generation implementation both at the residential and commercial levels, however increased utilization can still be achieved. By doing so Bridgeport can reduce the stress on the local commercial transmission grid and provide the benefits of distributed energy generation systems to the end user.

DISTRIBUTED ENERGY GENERATION PROMISING STRATEGIES FOR BRIDGEPORT

The installation of solar PV modules with at least 12 percent efficiency for residential development in the East Bridgeport Development Corridor helps Bridgeport residents reduce energy bills in the long-run and meet energy demands. The residential development especially the affordable housing region, can be built with solar PV modules. The community greatly benefits from an economic and environmental perspective.

The installation of microturbines in commercial facilities is another method to meet energy needs while offering the flexibility of scalability and fuel options. Bridgeport's infrastructure is capable of delivering on natural gas and there exists the possibility of incorporating local biogas produced at the local wastewater treatment facilities. Microturbines combined heat and power systems can increase fuel source efficiency for facilities requiring above average load. The commercial development directly on and near the proposed East Bridgpeport Barnum Train Station can utilize microturbine CHP systems due to great energy demand needs.

The installation of fuel cells in commercial facilities also has the potential to meet energy needs and offer flexibility in fuel options such as natural gas. Bridgeport's current fuel cell park project highlights the established municipal support for this strategy. The Connecticut Hydrogen Full Cell Coalition is a local organization that can provide fuel cell expertise, guidance and implementation recommendations. Bridgeport's future fuel cells implementations can help Connecticut move forward as a fuel cell technology leader. The commercial development directly on and near the proposed East Bridgeport Barnum Train Station can also utilize this technology for high reliability, low emissions, and minimal noise pollution.

NEXT STEPS

Bridgeport can conduct a commercial and residential survey in order to calculate a baseline consumption regarding the total amount of energy usage. The survey results can therefore be used for further studies. Bridgeport can appoint a City Energy Funding Liaison Officer who assists residents and commercial entities in identifying and applying for funding opportunities. This specialized officer can help seek out specific grants and determine the eligibility criteria.

GREEN INFRASTRUCTURE

The antiquated combined sewer system, which conveys both sewage and stormwater during a precipitation event, discharges approximately 350 million gallons of combined sewer overflow (CSO) into Bridgeport Harbor every year. Many cities across Connecticut, New England, and the Nation are exploring best management practices to alleviate the economic and environmental burden posed by CSO. As a remedy, Bridgeport is in the process of incrementally improving and separating the CSS into segregated storm sewer and waste sewer systems.

Green Infrastructure, applicable to Bridgeport, is a strategy to alleviate a portion of the cost required to modernize the sewers by reducing the load requirements attributable to stormwater. This is achieved by creating urban ecologies that replicate the predevelopment habitats that naturally allow for ground absorption and reduced runoff flow.

GREEN INFRASTRUCTURE RECOMMENDATIONS FOR BRIDGEPORT

Green infrastructure in coordination with grey infrastructure is the most effective method for combating CSO rather than relying on only one or the other. However, it is important to note that green infrastructure has many benefits beyond managing stormwater, it has the potential to improve air and water quality, reduce emissions associated with water treatment, less disruption due to construction, among a variety of societal benefits from green jobs to less heat related fatalities.

For this reason a greater percentage of funding for stormwater treatment should be dedicated to green infrastructure strategies. This will not be completed until the effectiveness of green infrastructure strategies is monitored and measured so as to make the case to the Connecticut Clean Water Fund for increased funding of an "alternative" strategy.

To gather the data required to make a compelling case, Bridgeport should utilize the 700-acres of developable land in the East Bridgeport Development Corridor to serve as testing ground where green infrastructure strategies such as permeable pavements, green roofs, bioswales, and rain harvesting can be utilized to provide relief, but more importantly, can be utilized as the subject of study to determine specific benefits relevant to Bridgeport.

NEXT STEPS

The design and implementation of a stormwater overflow measurement system for the entirety of Bridgeport serves multi-purposes. The study and monitoring of stormwater overflow can help formulate mitigation efforts in order to address problems that occur based on various situations. This helps estimate what green infrastructure strategies are needed and to what degree they are needed. Financing options can be appropriately applied as well.

The proposed PT Barnum Train Station and surrounding TOD area will not entirely combat CSO issues. The success of Green Infrastructure pilot projects can be used as a means to get more funding available for further implementations. The expansion of Green Infrastructure strategies throughout Bridgeport can make an even greater impact in the overall reduction of stormwater runoff. Measurements and monitoring are again important as further documentation and proof can permit expansion.

Green infrastructure zoning legislation could reduce bureaucracy. The establishment of a Green Infrastructure Development Zone can help in promoting the implementation of permeable pavements, vegetated swales, green roofs and rainwater harvesting strategies. Zoning revisions can ensure these are part of development requirements.

The funding options for the Distributed Energy Generation and Green Infrastructure strategies commonly consist of Federal and State grants such as the US Department of Energy, US Environmental Protection Agency, Department of Environmental Protection, and if applicable foundation resources and corporate funds. A few recommended innovative strategies include the declaration of the East Barnum TOD site as a tax increment financing district. This can help to receive subsidies which offset the costs of redevelopment. Bridgeport can also become an equity partner with the developer in order to receive a significant portion of accumulated cash flow. Bridgeport can declare to be a special assessment district to generate additional funding. These options are strategic methods in garnering private financing and support.

Both promising strategies can provide an alternative approach to improving the livability component of Bridgeport. Green infrastructure and distributed energy generation can be coordinated in a fashion that can promote greater quality of life to Bridgeport's residents and enhance future economic progress. Societal benefits will be a result of these joint efforts generated by a dynamic urban shift from the old to a new green sustainable Bridgeport.

GLOSSARY

Base Load– The lowest level of power production needs during a season or year.

Biofuels– Fuel produced from renewable biomass material, commonly used as an alternative, cleaner fuel source.

Biogas– The mixture of methane, carbon dioxide, and other minor gases formed from the decomposition of organic materials.

Brownfield – are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant(US Environmental Protection Agency. (Web access on November 16, 2011. http://epa.gov/brownfields/)

British Thermal Unit (Btu)- The standard measure of heat energy. It takes one Btu to raise the temperature of one pound of water by one degree Fahrenheit at sea level. For example, it takes about 2,000 Btu to make a pot of coffee. One Btu is equivalent to 252 calories, 778 foot-pounds, 1055 joules, and 0.293 watt-hours.

E85- ethanol (also know as Ethyl Alcohol or Grain Alcohol, CH3CH2OH)- a liquid that is produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. Used in the United States as a gasoline octane enhancer and oxygenate, it increases octane 2.5 to 3.0 numbers at 10 percent concentration. Ethanol can also be used in higher concentration (E85) in vehicles optimized for its use.

GigaWatt (GW)– One thousand megawatts (1,000 MW), or one million kilowatts (1,000,000 kw) or one billion watts (1,000,0000,000 watts) of electricity

GigaWatt hour (GWh)– One million kilowatt-hours of electric power.

Installed (or Nameplate) Capacity- The total manufacturer-rated capacities of equipment such as turbines, generators, condensers, transformers, and other system components.

kiloWatt (kW)– One thousand (1,000) watts. A unit of measure of the amount of electricity needed to operate given equipment.

kiloWatt hour (kWh)– The most commonly-used unit of measure telling the amount of electricity consumed over time. It means one kilowatt of electricity supplied for one hour.

MegaWatt (MW) – One megawatt equals one million watts, or 1,000 kilowatts.

MegaWatt hour (MWh – One thousand kilowatt-hours.

RECS (Renewable Energy Certificate)– A REC represents the property rights to the environmental, social, and other nonpower qualities of renewable electricity generation. A REC, and its associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable-based generation (US Environmental Protection Agency, Web access on November 16, 2011.www.epa.gov)

Therm- One hundred thousand (100,000) British thermal units (1 therm = 100,000 Btu).

Blue Roof- A **blue roof** is a roof design that is explicitly intended to store water, typically rainfall. (Encyclo. On-line Encyclopaedia. Web access on November 16, 2011. http://www.encyclo.co.uk/define/Blue%20roof) A **blue roof** is a roof design that is explicitly intended to store water, typically rainfall

Combined Sewer Overflow (CSO)- Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. (National Pollutant Discharge Elimination System, US Environmental Protection Agency. Web access on November 16, 2011. http://cfpub.epa.gov/npdes/home.cfm?program_id=5)

Dam- a barrier that impounds water or underground streams. Dams generally serve the primary purpose of retaining water (Wikipedia.Web access on November 16, 2011. http://en.wikipedia.org/wiki/Dam).

Gray Infrastructure- Gray infrastructure is the man-made substructure that supports societal functions such as communications, movement, and commerce. Gray infrastructure consists of engineered and built systems that support community functions, for example: roads; sewer and water facilities; gas pipelines and electrical transmission lines; and communication towers.[i]
(Lancaster County Smart Growth Toolbox .Web access on November 16, 2011. http://www.co.lancaster.pa.us/toolbox/cwp/view.asp?a=3&q=617214&toolboxNav=%7C10078%7C)

Gravel System: It is a system consisting of "an injection molded ring and grid structure, underlying by geotextile fabric and a sandy gravel base course". The cost of this material ranges from medium to high and it has a durability of 10-20 years (University of Arkansas Community Design Center. Web access on November 16, 2011. http://uacdc.uark.edu/)

Green Infrastructure- Green infrastructure refers to systems and practices that use or mimic natural processes to infiltrate, evapotranspirate or reuse stormwater or runoff on the site where it is generated (**National Service Center for Environmental Publications**. Web access on November 16,2011. http://nepis.epa.gov) Green infrastructure planning integrates outdoor recreation, open space, cultural resources and conservation lands into ongoing planning and land use management decisions. Using green infrastructure land planning guides development to less sensitive lands, which reduces time needed for permits, lowers costs of development, protects water quality and creates sustainable communities (Web access on November 16, 2011.
http://www.dcr.virginia.gov/recreational_planning/documents/vopchapt04.pdf)

Green Roof- A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane (Greenscaped Buildings.Web access on November 16, 2011. http://www.greenscapedbuildings.com/greenroofs/). It may also include additional layers such as a root barrier and drainage and irrigation systems. Also known as "**living roofs**", green roofs serve several purposes for a building, such as absorbing rainwater, providing insulation, creating a habitat for wildlife, and helping to lower urban air temperatures and combat the heat island effect. There are two types of green roofs: intensive roofs, which are thicker and can support a wider variety of plants but are heavier and require more maintenance, and extensive roofs, which are covered in a light layer of vegetation and are lighter than an intensive green roof.

Infill- building homes, businesses and public facilities on unused and underutilized lands within existing urban areas. Infill development keeps resources where people already live and allows rebuilding to occur (Greenbelt Alliance. Web access on November 16, 2011.http://www.greenbelt.org/downloads/about/infill.pdf).It is the key to accommodating growth and redesigning our cities to be environmentally and socially sustainable (Virginia Department of Conservation and Recreation. Web access on November 16, 2011. http://www.dcr.virginia.gov/recreational_planning/giback.shtml)
.

Infiltration– The process by which a portion of the precipitation sweeps into the subsurface of soil and rock.

Interlocking Paver System: It is a pre-cast concrete in "a natural stone, or brick unit that allows water to permeate around our trough surfaces". Its initial cost is high, since its durability is above average, 10-50 years (University of Arkansas Community Design Center. Web access on November 16, 2011.http://uacdc.uark.edu/).

Low Impact Development (LID) - LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product (US Environmental Protection Agency. Web access on November 16, 2011. http://www.epa.gov/owow/NPS/lid/)

Nonpoint Sources – These are sources that are unlike pollution from industrial and sewage treatment plants and comes from many diffuse sources. Non-point Source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters(US Environmental Protection Agency. Web access on November 16,2011. http://www.epa.gov/owow/NPS/qa.html)

Municipal Separate Storm Sewer Systems (MS4) - A municipal separate storm sewer system (MS4) is a publicly-owned conveyance or system of conveyances (i.e., ditches, curbs, catch basins, underground pipes, etc.) that is designed or used for collecting or conveying stormwater and that discharges to surface waters of the State(Florida department of Environmental Protection. Web access on November 16, 2011. http://www.dep.state.fl.us/water/stormwater/npdes/ms4_1.htm)

Pervious Concrete: It is a technology that "eliminates the need for retention ponds and other stormwater best managements practices", turning the strategy more cost effective. The initial cost is approximately 10% above the conventional costs and it has a durability of 10-30 years (University of Arkansas Community Design Center. Web access on November 16, 2011. http://uacdc.uark.edu/).

Porous Asphalt: Mostly used for parking lots, porous asphalt "allows water to drain through the pavement surface into a stone recharge bed and infiltrate into soils below the pavement".. The Initial cost is approximately 10% above the conventional and it has a durability of 10-30 years. Vacuum maintenance is required (University of Arkansas Community Design Center. Web access on November 16, 2011. http://uacdc.uark.edu/).

Rain Barrel – A barrel used as cistern to hold rainwater.

Rainwater Harvesting –It is a process of accumulating and storing of rainwater for reuse before it reaches the aquifer.

Sanitary Sewer - A sanitary sewer overflow (SSO) is any overflow, spill, release, discharge or diversion of untreated or partially treated wastewater from a sanitary sewer system. SSOs often contain high levels of suspended solids, pathogenic organisms, toxic pollutants, nutrients, oil, and grease. SSOs pollute surface and ground waters, threaten public health, adversely affect aquatic life, and impair the recreational use and aesthetic enjoyment of surface waters. Typical consequences of SSOs include the closure of beaches and other recreational areas, inundated properties, and polluted rivers and streams (State Water Control Control Board.California Environmental Protection Agency.Web access on November 16, 2011. http://www.waterboards.ca.gov/water_issues/programs/sso/)

Soakage Trench (Infiltration trench) – Soakage trenches are shallow lined trenches backfilled with sand and coarse stone. The trench surface can be covered with grating, stone, sand, grass or similar vegetation. They accept stormwater runoff from roofs, parking lots, and other impervious surfaces, and can be placed under any ground-level porous surface such as yards and landscaped areas. Stormwater runoff flows through an inlet pipe into an underground concrete collection box that removes sediment and debris (for roof runoff a washer or equivalent technology- above or below ground - may be used). The runoff then enters the trench through a perforated pipe that allows it to drain through the backfill material and soak slowly into the underlying soil. It is usually not necessary to have an overflow mechanism to a secondary disposal or conveyance system (Web access on November 16, 2011. http://www.portlandonline.com/bes/index.cfm?a=127481&c=31870)

Stormwater- The water that originates during precipitation events.

Stormwater Runoff - Stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground. As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated(National Pollutant Discharge Elimination System. Environmental Protection Agency. Web access on November 16, 20011. http://cfpub.epa.gov/npdes/home.cfm?program_id=6)

Vegetated Filter Strips - (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment (National Pollution Discharge Elimination System.US Environmental Protection Agency. Web access on November 16, 2011.

http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=76)

Vegetated Swales - A vegetated swale is a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom. Swales can be natural or manmade, and are designed to trap particulate pollutants (suspended solids and trace metals), promote infiltration, and reduce the flow velocity of stormwater runoff(Stormwater Technology Factsheet.Vegetated Swales.US Environmental Protection Agency.September ,1999.Web access on November 16, 2011. http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_vegswale.pdf)

Wastewater - water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations.

Wastewater Treatment Facilities (WWTF) - Also known as Publicly Owned Treatment Works or POTWs, WWTFs are facilities with anaerobic digesters. Biogas flow from these digesters can be used in a combined heat and power system as fuel to generate reliable electricity and heat for the WWTF. They are critical for maintaining public sanitation and a healthy environment, and must be able to operate in the event of a natural or man-made disaster, as well as a utility power outage (Combined Heat and Power Partnership.US Environmental Protection Agency. Web access on November 16, 2011. http://www.epa.gov/chp/markets/wastewater.html)

Total Maximum Daily Load (TMDL): A TMDL is a numerical limit on the amount of a particular contaminant that can be discharged to a waterbody from all sources. If a TMDL requiring reduction of a pollutant associated with stormwater is approved by the EPA for any waterbody or watershed into which the MS4 discharges, the program for the six minimum measures must ensure that reduction of the pollutant of concern specified in the TMDL is achieved (Overview of the Municipal Separate Storm Sewer System.Phase two Stormwater Permit Program.Feb 2003.Rev.August 2003. Web access on November 16, 2011. http://www.dec.ny.gov/docs/water_pdf/ms4_overview.pdf)

APPENDIX

TABLE 3-1 BENEFITS DEFINED BY PUBLIC ACT 096-0026		
INDEX	**GENERAL BENEFIT**	**TARGETED BENEFIT**
1	**Cleaner Water**	• Reduced volume of water entering CSS • Reduced concentration of pollutants
2	**Enhanced Water Supplies**	• Improved groundwater recharge • Conservation through capture and reuse
3	**Reduced Flooding**	• Stabilize local hydrology by reducing peak flow
4	**Cleaner Air**	• Filtration air removing airborne pollutants reducing respiratory illness
5	**Increased Energy Efficiency**	• Reduces urban island effect • Building temperature stabilization • Reduced process needs to convey and collect water at treatment facilities
6	**Mitigation of and Adaptation to Impacts of Climate Change**	• Reduced energy demands • Greater adaptation to manage increased storm intensity urban flooding potential, and water supplies
7	**Wildlife Habitat**	• Increase biodiversity
8	**Community Benefits**	• Improved urban "aesthetics and community livability" • Increased property values • Reduction in violence • Reduction in crime
9	**Health Benefits**	• Increased life span • Improved "general health" • Improved "mental functioning, reduces stress, and reduces recovery time from surgery"
10	**Green Jobs**	• Creates new jobs for AEC community and workers
11	**Cost Savings**	• Reduces capital costs associated with conventional infrastructure • Reduces operations and maintenance for treatment facilities • Reduces energy costs for pumping water • Reduces the costs for repairing damage caused by stormwater (stream bank restoration and flood damage)

GREEN INFRASTRUCTURE AND ENVIRONMENTAL JUSTICE

Environmental Justice Grants and Cooperative Agreements	Purpose
Environmental Justice Small Grants Program (Community level)	Provides financial assistance to eligible organizations to build collaborative partnerships, to identify the local environmental and/or public health issues, and to envision solutions and empower the community through education, training, and outreach.
Environmental Justice Collaborative Problem-Solving Cooperative Agreement Program (Community level)	Provides financial assistance to eligible organizations working on or planning to work on projects to address local environmental and/or public health issues in their communities, using EPA's Environmental Justice Collaborative Problem-Solving Model.
Environmental Justice Showcase Communities Project – (Regional Level)	Brings together governmental and non-governmental organizations to pool their collective resources and expertise on the best ways to achieve real results in communities. The successes and lessons learned in these demonstration projects will be used to help guide on the design and implementation of future Environmental Justice projects and will help EPA increase its ability to address local environmental challenges in more effective, efficient, and sustainable ways.

Source: EPA. Web accessed on Nov 12th, on website page
http://www.epa.gov/compliance/ej/grants/index.html

GREEN INFRASTRUCTURE FUNDING

Additional List of Grants

A. Green Jobs Innovation Fund will help the Connecticut Green Jobs Funnel Initiative promote career pathways in the green construction industry.

B. Non-point Source Pollution Fund helps in providing information on grant opportunities to implement efforts to address nonpoint source pollution, including Clean Water Act Section 319 grants and Nonpoint Source

C. The Targeted Watershed Grants Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's waters.

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