

Incentivization Zoning and Green Development on Rooftops in the City of Norwalk: A Climate Resiliency Case Study

Heating needs have decreased in Connecticut while the need to cool down buildings and communities has increased. As average temperatures rise, Connecticut residents will experience a greater need for cooling rather than heating. Modern buildings often easily absorb heat from solar radiation. With rising temperatures from climate change, costs for air-conditioning will rise for tenants, homeowners and businesses. Increased air conditioning increases energy consumption, which in the case of fossil fuels and natural gas, contributes even more to carbon emissions that created climate change. Since 1950, the average temperature in Connecticut has increased by 2.2 degrees Fahrenheit (Quincy, 2020). As a result of this heat increase, Connecticut will face more health concerns including from disease, clean air, and water quality. A means of cooling exists in raising the “albedo” of rooftops. Albedo is the amount of light or solar radiation reflected by a surface. The rest of the solar radiation is absorbed by the surface, and in doing so causes it to heat up. Dark colored roofs don’t reflect a lot of solar radiation; in fact, they absorb a lot and that generates heat! That results in the warming of the building. Fortunately, energy- and cost-efficient solutions exist for cooling down buildings. Cooling down or making buildings more energy-efficient starts from the top: the roof. Roofs can be designed to absorb solar energy, or to cool down buildings without expending more energy or dollars. These solutions are generally known as white roof, green roof, blue roof, and installing solar panels.

One of the leading municipalities in efforts to cool down buildings, or otherwise make them energy efficient comes from a recent action enacted in Norwalk. This action from Norwalk’s 2020 Plan of Conservation and Development (POCD) was “Develop and promote strategies to mitigate increased heat. Actions can include “cool roofs” programs to paint roofs white or other light colors to reflect sunlight and increase albedo; green roofs (vegetated roofs); tree planting; and green parking lots that use surfaces that reduce heat production.” (Norwalk, POCD, 2020). This project was placed under the authority of the Emergency Management; Economic and Community Development as well as Public Works.

Changing Zoning Codes

In 2021, Connecticut Public Act No. 21-29 Sec. 4(c)(3) called for changes in zoning regulations to advance greater climate adaptation and/or mitigation: “Require or promote (A) energy-efficient patterns of development; (B) the use of distributed generation or freestanding solar, wind and other renewable forms of energy; (C) combined heat and power; and (D) energy conservation.”

Given this push towards sustainable living, it was then up to motivated and knowledgeable town planners and zoning boards to apply the Act to their towns. Now from this Act, zoning boards may require or promote energy efficient development, something that in the past could only be encouraged. Along with this, the Act gives developers a new class of incentives for renewables, water, and energy conservation. For example, now that vehicle miles traveled (VMT) calculations can be included, so there is another type of information for approving or denying projects. If a project would generate a lot of VMT, then it could be denied on environmental grounds lest it is mitigated with pedestrian or bike paths. See “Resources” for more on utilizing VMT. There were not a lot of pre-established guidelines or suggestions for how to evaluate and implement such a policy before. To this day, it comes down to having motivated, curious, and dedicated town staff and their surrounding community to make such changes. Municipalities like Norwalk took a leading role in Connecticut to develop ways to incentivize and change their zoning policy to make their town greener.



Funding for this project is provided by the U.S. Department of Housing and Urban Development through the Community Development Block Grant National Disaster Recovery Program, as administered by the Connecticut Department of Housing.

Motivating Zoning Changes

Norwalk's Planning and Zoning Commission and Common Council—which governs Norwalk's sustainable infrastructure push—was motivated to introduce sustainable development standards including to implement cooling on the roofs of new developments. To bring aboard other stakeholders who may not have the same motivation to take on climate action, Norwalk determined it would be easier to mandate roof cooling actions when the rezoning or amending of zoning text would be in someone's favor. So, an incentivization point system was created in Norwalk for new developments to encourage and make the shift to more environmental rooftops that would be accepted by other stakeholders in Norwalk, especially developers. Norwalk implemented such climate action requirements for roofs on new developments within updates to Article 50 "Using Regulations Controlling Business Zones" in the zoning regulations for certain development areas in Norwalk. This would balance the desires of developers with desires for certain public amenities prospects and resilient development standards.

How Do Incentive Zoning Systems Work?

Zoning incentive systems trade-off between a community and a private developer. Often, the developer is allowed to build a project that may otherwise be unpermitted such as a larger, higher-density project or one with modified standards for height, setback, or other in exchange for providing some aspect of development in favor of the community's interests otherwise not required by the developer (Morris, 2000).

Originally, zoning incentive systems were experimented with, and became attractive for cities and towns in the late 1950s and early 1960s. Cities desired to encourage private developers to improve the appearance of the community without using public funds. As a result, planners began breaking out of rigidly defined land use as separate, which is known as Euclidean zoning, so that a piece of land would meet social objectives including affordable housing and day care. Under Connecticut's General Statutes, Section 8-2g(a) within inclusionary zoning legislation, local governments can allow special exemptions to developers within zoning in exchange for promoting some value of the community, such as including climate adaptations as part of the development project (Morris, 2000).

More information on Incentive Zoning can be found here:

[Incentive Zoning - Meeting Urban Design and Affordable Housing Objectives](#)

Requiring Green Infrastructure Development

Some developmental areas in Norwalk require application of "green" infrastructure. Most recently this is stated in their Article-50 update for development parks on the west side of Glover Avenue and within northern Norwalk for an area where there is the construction of a renovated and improved train station at Merritt/7. These are requiring:

The site is designed with following minimum LID/"green development" techniques:

- a. all buildings must provide a minimum of 25% of either green roofs, blue roofs, or contain solar panels for that portion of such roof not used for recreation area improvements or utilities
- b. all surface water shall be handled through onsite retention. the use of rain gardens and bioswales is recommended and encouraged where feasible.
- c. all parking lots and parking structures must include electric vehicle charging stations
- d. sheltered bike parking and storage must be provided
- e. all landscaping shall be native species, except that perimeter screening may contain alternate species as approved by the Commission



Funding for this project is provided by the U.S. Department of Housing and Urban Development through the Community Development Block Grant National Disaster Recovery Program, as administered by the Connecticut Department of Housing.

The Point System

Next, Norwalk created means of incentivizing required sustainability through a point system for the construction of a development park in the East Norwalk Village Transit-Oriented Development. Now, a certain number of points must be achieved for the area to meet sustainability requirements. Zoning rewards exist for meeting this requirement. This is similar to the point system for sustainable amenities in another area for Norwalk's Central Business District.

Article-50: The point system

1. if 15 points are achieved, provided that at least ten points must be sustainable amenities:
 - a. the height of the building may be increased from 2 1/2 stories (35 feet) to 3 1/2 stories (45 feet)
 - b. the residential density may be increased from 1 dwelling unit per 1,650 square feet of lot area to 1 dwelling unit per 1,250 SF of lot area
2. if 20 points are achieved, provided that at least thirteen points must be sustainable amenities:
 - a. the height of the building may be increased from 2 1/2 stories (35 feet) to 3 1/2 stories (45 feet)
 - b. the residential density may be increased from 1 dwelling unit per 1650 square feet of lot area to 1 dwelling unit per 825 square feet of lot area (City of Norwalk, Article 50, pg. 27, 2022).

Exploring Rooftop Green Infrastructure in Norwalk's Point System

Cooling in infrastructure contexts involves engineering parts of the building to lower the overall temperature of the building. Dark colored roofs and structures absorb more solar radiation than lighter colored surfaces. The color light reflects more solar radiation (heat) back to the atmosphere (Kotecki, 2018). Raising the albedo of roofs has been shown to be a valuable means of decreasing the urban heat island effect. Lighter colored roofs have the potential to lower the temperature of urban environments by reflecting more solar radiation rather than absorbing it. The results are decreasing the temperature of both the reflecting surface and the surrounding air (Jacobson and Ten Hoeve, 2011). Light-colored roofs can slow the effects of climate change without as much risk of negative impacts like from practices like geothermal engineering, though if done properly, geothermal engineering has merit (Oleson et al., 2010).

One study has shown that increasing the surface albedo—having lighter colored surfaces—across ten cities in the United States reduced the “near surface daytime summer air temperature by 0.5 to 1.5°C and decreased peak electricity demand by up to 10%.” (Oleson et al., 2010).

<p>Green or Blue Roof (minimum of 50% of roof area)</p>		<p>2 points for every 1,000 SF. Max of 6 points</p>
--	--	---

Excerpt from Article 50 on point incentive for implementing green or blue roof on design project (City of Norwalk, Article 50, p. 89)

“Cool” Blue and Green Roofs

Green roofs aid in reducing the temperature of roofs by installing and maintaining a vegetative layer on top of a rooftop. These topside gardens provide environmental and cost-benefit considerations by lowering the temperature and energy demand of a building and have social benefits for its aestheticism and presence. Green roofs have been shown to moderate the heat island effect, reducing city-wide ambient temperatures by up to 5 F (EPA, 2022).

Green roofs in Connecticut match the color and—from that, albedo of the forest environment that makes up much of Connecticut, which relays to the building underneath of the green roof a similar temperature.

Benefits of Green Roofs

Green roofs improve economic, social, and environmental conditions for the building and surrounding area. Economically, though they have high initial costs, green roofs have long life expectancy. They are ideal for projects emphasizing on saving energy, lifecycle costs, and broader public and environmental benefits within limited budgets. Socially, green roofs improve human health and comfort by increasing indoor comfort and reducing heat stress related to heat waves (EPA, 2022). These also improve quality of life through aesthetic value from the plant and animal species that make-up green spaces and increase the amount of interaction humans have with natural environments. These human-nature connections have been shown to “benefit human physical and mental health and productivity and reduce blood pressure and hospital stays,” (EPA, 2022) though only if the roof is accessible to people.

Environmentally, green roofs “lower surface and air temperatures,” as well as reduce and filter stormwater runoff while “absorbing pollutants and CO2, providing natural habitat,” and even can work as recreational green spaces (EPA, 2022). Less energy is expended to lower the temperature of the building through air conditioning, causing fewer greenhouse gas emissions. Green roofs remove heat from the air through [evapotranspiration](#), while acting as insulators to the building, which decreases the energy needed for both cooling and heating (EPA, 2022). The vegetation too will act to draw down carbon dioxide from the atmosphere, possibly storing it through dry deposition. By slowing down the stormwater runoff into the urban environment, green roofs provide a number of benefits.

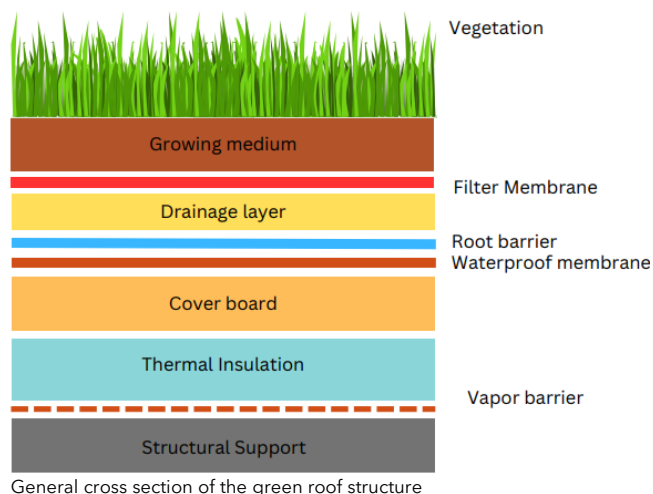
Green Roof Impacts on Stormwater

DEEP identified a number of mechanisms by which Green Roofs can contribute to stormwater management, a pressing problem for municipalities across Connecticut, including through

- “Reducing local flooding
- “Reducing the need for sewer upgrades by reducing the amount of stormwater entering sanitary sewer lines
- “Reducing heating and cooling costs
- “Reducing greenhouse gas emissions
- “Improve water quality
- “Create wildlife habitat
- “Provide “green” public [or private] spaces” (DEEP stormwater).

Green roofs can absorb precipitation with vegetation and soil, which helps to manage stormwater and associated runoff water from storms. Storms can contribute to erosion, flooding, and polluting of groundwater through pollutants such as sediment, nutrients, bacteria, and chemicals that threaten aquatic health and limit areas available to water dependent recreational activities.

Typical Green Roof Cross Section



Blue Roofs are specifically engineered systems that provide stormwater detention by controlling the discharge rate of captured precipitation, which in turn reduces negative impacts of otherwise uncontrolled stormwater. Orifices and weirs among other devices are examples of technology for managing rooftop runoff.

This type of roof is most effective where roofs constitute many impervious surfaces on a site or for sites that have little space available to build other types of best management practices (BMP). Roofs that are relatively flat are best for this type of system. Steeper roofs create greater “ponding depths.” (Government of New Jersey, p. 2, 2021). The strength and bearing capacity depends on the foundation. Evaluating these aspects of the roof and structure is important to see if it can bear a blue roof system. Blue roofs can be implemented on recently built buildings or built on existing structures through retrofits. Surroundings around the building must also be considered; blue roof outlets can be clogged from trees or other types of sources that create debris to the system.

Evaluation and compliance with state law through a maintenance plan is important when attempting to incorporate a blue roof into a building’s structure and surroundings. For example, regarding downstream stormwater management facilities, blind connections (the point where a storm sewer connects to another but not through a helpful structure such as a manhole) are prohibited. Before installing a blue roof, connections must have entry points for inspection ports and manholes that ensure “visual inspection and maintenance, as appropriate, to prevent blockage of flow and ensure operation as intended.” (Government of New Jersey, p. 6, 2021). All entrance points should be in agreement with “Federal, State, County and municipal safety standards such as those for confined space entry.” (Government of New Jersey, p. 6, 2021). Privately owned roofs may require protection for their blue roofs by legal measures such as deed restriction, ordinance or easement to ensure updated maintenance plans are in effect that prevent negligence, adverse alteration or the removal of the blue roof.

Blue roofs and green roofs can be used jointly as “blue-green” roofs to capture precipitation and modulate the temperature of the rooftop and building below.

White roofs, though a form of rooftop cooling, are not included in the Norwalk incentivization point system. White roofs have a higher albedo than the natural Connecticut environment typically has, making them a point of discussion on the cooling effects of the roof come wintertime; would cooling benefits in the warmer months be offset by higher heating costs in the winter? In what environment are white roofs most efficiently applied for net benefits to buildings and the planet?

For a discussion and to read more please see Brian Kahn (2022) White Roofs May Partially Offset Summer Warming by 2100. Climate Central. <https://www.climatecentral.org/news/white-roofs-provide-summer-climate-benefits-to-cities-17054> and Mark Z. Jacobson and John E. Ten Hoeve (2011) Effects of Urban Surfaces and White Roofs on Global and Regional Climate. Dept, of Civil and Environmental Engineering, Stanford University. <http://web.stanford.edu/group/efmh/jacobson/Articles/Others/HeatIsland+WhiteRfs0911.pdf>.

Solar Panels on Rooftops

Solar panels generate renewable energy and notably, lower the temperature of rooftops. Efficiency of solar panels has improved from a previous average of 15% to now about 22% (Svarc, 2022), as photovoltaic technology has made advancements. Far from the original 250W power rating of solar panels, 370W is the typical power rating of a panel. Overall panel efficiency rests on this individual photovoltaic (PV) cell efficiency, as well as total panel efficiency, which is determined by “the maximum power rating under standard test conditions divided by the total area of the panels (in meters).” (Zito, 2023). The most powerful solar panels now achieve rates of 700W (Svarc, 2022).



Funding for this project is provided by the U.S. Department of Housing and Urban Development through the Community Development Block Grant National Disaster Recovery Program, as administered by the Connecticut Department of Housing.

<p>Rooftop Solar (minimum of 50% of roof area)</p>		<p>1 point for every 1,000 SF. of roof area Max of 5 points</p>
---	--	--

Point system description for solar panel implementation and reward. (SF=square foot). (Article-50, City of Norwalk, p. 89, 2022).

Additionally, it has been found that solar panels have a cooling effect on buildings. A study from the UC San Diego Jacobs School of Engineering discovered that 38% less heat reached into the building; a building’s ceiling was 5 degrees Fahrenheit cooler during the day under solar panels than under an exposed roof. Meanwhile at night, the panels aid in trapping heat, reducing heating costs during the winter (University of California, San Diego, 2011).

Within Norwalk, certain businesses have adopted solar panels and green infrastructure that improve their overall design. Over the Summer 2022, new headquarters for vinyl tile supplier HMTX in Norwalk became one of the greenest buildings in Connecticut. Along with solar panels that “provide more than enough power for the building,” the building has “rainwater storage systems for plumbing,” and rests on stilts that allow wildlife to move across the property without inhibition (Soule, 2022). The building will be the first in Connecticut to submit an application for certification by the Living Building Challenge.

A number of programs exist in Connecticut regarding solar panel installation. These may provide incentives or cost-free programs if eligible. If interested in adopting a program or providing resources to buildings or homeowners, here are some suggestions for starting.

Example of Including Rooftop Cooling in Zoning and Development Projects

The following is an excerpt from the “North 7” master plan that originated from Norwalk’s POCD for a 14-acre development project. The Department of Transportation (DOT) is building a new train station and adding another 1,300 housing units. The project is an excellent example of requiring local municipal values of sustainability while potentially giving developers “points” from this kind of implementation to permit development in ways normally not afforded to them by the municipality’s zoning and development regulations.

1. Roofs

- a. Not less than 50% of all roof area is to be dedicated either to tenant amenity space, green space, or solar panels
- b. all roof area not dedicated to amenity space or needed for mechanical equipment, including venting, shall consist of green roof, blue roof or solar panels; provided that a minimum of 20% of each building roof area must be green roof, blue roof, and/or solar panels
- c. parking garage shall be roofed and treated as usable space as specified in (a) above

2. Design outdoor public and recreation space to maximize solar exposure. 75% of such space shall have a minimum of 4 hours of sun exposure daily throughout the year. (City of Norwalk, Article 50, 2022).



Funding for this project is provided by the U.S. Department of Housing and Urban Development through the Community Development Block Grant National Disaster Recovery Program, as administered by the Connecticut Department of Housing.

Such actions align with community efforts to become more sustainable, mitigate greenhouse gasses, and be better adapted to climate change. Following this plan will also afford the DOT points to permit types of development normally unallowed, such as to increase building height or decrease required lot area per unit.

Recent Citywide Sustainability Efforts in Zoning Regulation

Further developments in Norwalk necessitate application of “green” infrastructure as stated in their Article-50 for development parks on the west side of Glover Avenue and within northern Norwalk for an area where there is the construction of a renovated and improved train station at Merritt/7 in northern Norwalk. These are requiring:

Section 6.11 of Norwalk’s “Zoning Regulations Update” reads:

A. Requirements.

Unless demonstrated by the Applicant that the proposed Use(s) or Building Construction makes it unfeasible, all new Construction, including Parking Structures and Parking Lot, with an area of twenty-five thousand (25,000) square feet or greater, shall at a minimum, have at least 25% of that area contain Solar Panels, a Green Roof or a Blue Roof. If the Applicant indicates that this is unfeasible, the City may seek, at the applicant’s expense, review from a third party architect or engineer, to evaluate the proposal. All new Construction with a footprint of twenty-five thousand (25,000) square feet or greater shall also include stormwater management strategies identified in Section 6.11.2.C and the LID Site Planning and Design Strategies in the City of Norwalk Drainage Manual and Low-Impact Development Appendix of the latest Connecticut Stormwater Quality Manual, unless demonstrated by the Applicant that it is unfeasible.

Similar to the requirements to East Norwalk, these recently introduced regulations would promote measures that strengthen the area’s climate resiliency capacity through requirements for sustainability in new developments. The values being pushed forward emphasize long-term community wellbeing for now and future generations in addition to preservation of the local values and character.

Conclusion

Norwalk and other towns are leading the way for green development in Connecticut. By creating systems for incentivizing changes made to zoning, the town created a positive transition to mandated green infrastructure that will benefit the individual building and surrounding community. Adapting to and mitigating climate change from the roof has benefits beyond reducing energy expenditure and associated costs—it creates aesthetic spaces and provides benefits to the surrounding natural environment, whether through removal of pollutants, natural habitat, or better control and erosion prevention caused by stormwater runoff. Municipalities in Connecticut with the motivation to implement a similar system can similarly study and adapt such means to their own municipality’s needs and culture that would improve the resiliency of their own communities and inspire others.



Funding for this project is provided by the U.S. Department of Housing and Urban Development through the Community Development Block Grant National Disaster Recovery Program, as administered by the Connecticut Department of Housing.

Resources

- Susan Quincy (2020) *Connecticut: Our Changing Climate*. Connecticut Department of Energy and Environmental protection. <https://portal.ct.gov/-/media/DEEP/education/kellogg/CT-Changing-Climate-Booklet.pdf/>.
- City of Norwalk (2019) *Norwalk Citywide Plan: 2019-2029 Plan of Conservation and Development*. <https://tomorrow.norwalkct.org/wp-content/uploads/2020/10/Norwalk-Citywide-Plan.pdf>.
- City of Norwalk (2023) *Zoning Regulations Update*. p. 345 <https://www.norwalkct.gov/DocumentCenter/View/29515/Norwalk-Building-Zone-Regulations-Final-Public-Draft-March-2023>.
- Jason Svarc (2022) *Most Efficient Solar Panels 2022*. Clean Energy Reviews. <https://www.cleanenergyreviews.info/blog/most-efficient-solar-panels>.
- Barbara Zito (2023) *The Most Efficient Types of Solar Panel of 2023*. Forbes. <https://www.forbes.com/home-improvement/solar/most-efficient-solar-panels/>.
- City of Norwalk (Updated 2022) *ARTICLE 50, Use Regulations Controlling Business Zones*. <https://www.norwalkct.org/DocumentCenter/View/355/ARTICLE-50?bidId=>.
- Peter Kotecki (2018) *New York City has painted over 9.2 million square feet of rooftops white - and it could be a brilliant heat-fighting plan*. Business Insider. <https://www.businessinsider.com/new-york-city-painted-6-million-square-feet-of-rooftop-white-2018-8>.
- K.W. Oleson, G.B. Bonan, J. Feddema (2010) *Effects of white roofs on urban temperature in a global climate model*. Advancing Earth and Space Science. <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2009GL042194>.
- See Planning and Development Committee (2021) H.B. No. 6107 // Public Act No. 21-29. Connecticut General Assembly https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?bill_num=HB06107&selBillType=Bill&which_year=2021 for information regarding utilizing vehicle miles traveled standard for zoning regulation and further see Connecticut Department of Transportation (2019) 2030 VMT Goal and Strategies. <https://portal.ct.gov/-/media/DOT/documents/dpolicy/VMT-Reduction-Target.pdf> for VMT objectives related to carbon emissions and building climate resiliency in Connecticut.

Additional Resources

Readings on Green Roofs

- [Using Green Roofs to Reduce Heat Islands](#)
- [Estimating the Environmental Effects of Green Roofs](#)
- [Chapter 3 of EPA's Reducing Urban Heat Islands: Compendium of Strategies](#)
- [Rainfall as a Resource: A Resident's Guide to Green Roofs in Connecticut](#)

Readings on Blue Roofs

- [New Jersey Stormwater Best Management Practices Manual - 1.1 Blue Roofs](#)
- [Stormwater Management Practice Guidance - 4.6 Blue Roofs](#)
- [Blue-Green Systems: Impact of design variables on hydrologic and thermal performance of green, blue-green and blue roofs](#)

Readings on Solar Panels

- [Norwalk building opens among greenest in CT](#)
- [Solar Panels Keep Buildings Cool](#)

Contact

To learn more about CIRCA visit circa.uconn.edu and the Resilient Connecticut project for more climate resilience planning tools: resilientconnecticut.uconn.edu

University of Connecticut
Avery Point Campus
1080 Shennecossett Road
Groton, CT 06340
circa@uconn.edu

© 2021 University of Connecticut. The University of Connecticut supports all state and federal laws that promote equal opportunity and prohibit discrimination.

Photos sourced from CIRCA and courtesy of the City of Norwalk.



Funding for this project is provided by the U.S. Department of Housing and Urban Development through the Community Development Block Grant National Disaster Recovery Program, as administered by the Connecticut Department of Housing.