



Invest NYC SDG: A Finance White Paper

Models for Financing the UN
Sustainable Development Goals

March 2021

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About NYU Stern Center for Sustainable Business

The NYU Stern Center for Sustainable Business' (CSB) mission is to prepare individuals and organizations with the knowledge, skills, and tools needed to embed social and environmental sustainability into core business strategy. In doing so, businesses reduce risk; create competitive advantage; develop innovative services, products, and processes; while improving financial performance and creating value for society. CSB implements its mission through activities in Education, Research, and Engagement. **To learn more, visit our website at stern.nyu.edu/sustainability or reach out at sustainablebusiness@stern.nyu.edu.**

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Executive Summary

Building a Sustainable and Resilient Society

In the last five years, countries and cities worldwide have been developing strategies and programs to implement the 2030 Agenda for achieving the United Nations' 17 Sustainable Development Goals (SDGs) and the Paris Climate Agreement. These goals address the most pressing global challenges of our time, from combating climate change to reducing hunger and eradicating poverty. While governments play an important role, both these international agreements call for partnerships between countries and the public and private sectors.

Achieving an ambitious 2030 Agenda requires us to rethink our practices and leverage new models of partnership between civil society, private sector, and the public sector, particularly when it comes to finance.

Our cities will become the laboratories of this needed innovation. New York City is at the forefront, both as the first city in the U.S. to align its sustainability goals with the UN SDGs, and as a city working to implement aggressive new State and City climate change legislation.

Of course, the Covid-19 pandemic of 2020 has created a deeper sense of urgency and further stressed the need to innovate and reimagine public and private sector solutions that can rebuild resilient and sustainable societies and economies. The pandemic landed dramatically in NYC, killing tens of thousands of people and grinding economic activity nearly to a halt.

Unemployment jumped from 4.1% to 14.2% in a matter of weeks,¹ and the number of food insecure citizens nearly doubled from 1.2 million to over 2 million people.² Covid-19 joins 9/11 and Superstorm Sandy as another harsh reminder of NYC's vulnerability. At such an important moment, we look for models essential to NYC's long-term sustainability and the well-being of its almost 8.3 million residents.

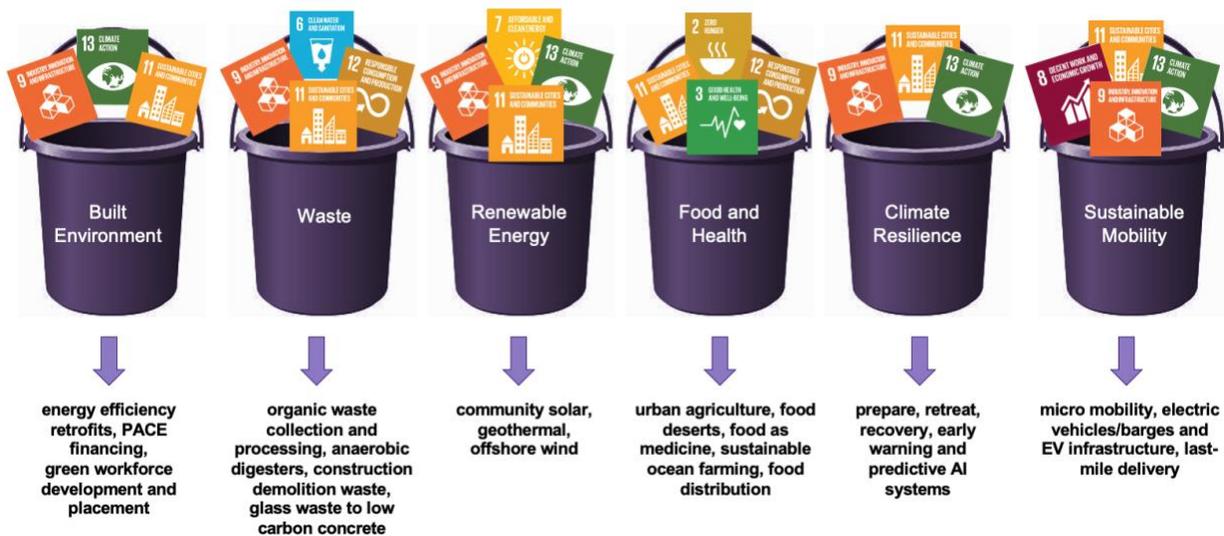
This White Paper seeks to accelerate the growth of sustainable finance by showcasing promising opportunities. It maps the landscape of stakeholders, promising partnership models, and both traditional and innovative financing mechanisms for six specific sectors: *Built Environment, Sustainable Mobility, Renewable Energy, Waste, Food and Health, and Climate Resilience*. Furthermore, it showcases innovative case studies of

¹ <https://www.syracuse.com/news/2020/05/new-yorks-unemployment-rate-jumps-to-14.5-as-job-losses-set-modern-record.html>

² <https://www.npr.org/sections/coronavirus-live-updates/2020/05/21/860312565/in-new-york-city-2-million-residents-face-food-insecurity-officials-say>

effective projects that may serve as models of inspiration for projects in New York City and globally, from financing affordable housing to investing in healthy communities and green infrastructure. We hope that the report will inspire new thinking and collaboration between the public and private sector.

Figure 1: Invest NYC SDG Focus Areas



Key Highlights: Models for Financing Sustainable Development Goals

A Broad Capital Spectrum: There are no turnkey solutions. A broad spectrum of capital is available from public, private, and philanthropic sources, which can be channeled towards sustainable development programs. Shaping successful financing models requires a deeper understanding of the types of capital, successful use cases, and the ability to match programs with the right kind of capital -- often requiring a mix of different kinds of capital. Often public and philanthropic "non-investment capital" can be used to catalyze funding from investors "investment capital." One of many examples is Grow-NY, which is among the nation's largest food and agriculture business competitions. Grow-NY distributes \$3 million in awards annually from the NYS Department of Agriculture and Resources to startups to fuel sustainable agricultural practices local to New York that can go on to raise investment capital from the private sector.

Figure 2: Capital Spectrum

Investment Capital			Other Capital	
<p>Commercial Investment Capital</p> <p>Seeks market rate risk-adjusted returns</p> <p>Example: Goldman Sachs Urban Investment Group, Equilibrium Capital, Citi</p>	<p>Blended Investment Capital</p> <p>Seeks market rate risk-adjusted returns, however the returns are subsidized by concessional capital providers</p> <p>Example: Low Income Investment Fund Sustainable Bond</p>	<p>Concessional Investment Capital</p> <p>Accepts below market rate returns</p> <p>Example: McConnell Foundation</p>	<p>Institutional grants</p> <p>Grants from philanthropic or corporate institutions</p> <p>Example: Rockefeller Foundation Zero Gap program</p>	<p>Government subsidy</p> <p>Financial assistance from the government that can take the form of tax credit, tax abatement, grant</p> <p>Example: Low Income Housing Tax Credits, Biomass Tax Credit</p>

Expansive Set of Financing Instruments for Capital to Make Impact: There are growing numbers of financial instruments in every asset class that can attract new capital sources or bring together different capital types in new ways. Before seeking to raise capital, it is essential to understand each asset class's specific characteristics and requirements, as these differ widely. For example, the New York City PACE program offers long-term lending (typically 20 to 30 years) created in 2019 by Local Law 96 in conjunction with Local Law 97 to provide building owners with low-cost funds to install renewable energy systems and make energy efficiency improvements. Under PACE programs, building owners get upfront capital to finance clean energy enhancements and these investments are repaid via property taxes over the project's lifetime. In contrast, investment from Venture Capital investors Unshackled Ventures and Monument Ventures in Pod Foods -- a tech-forward distribution and logistics platform -- comes with a much higher return expectation in a much shorter time-frame (typically less than ten years) through an expected exit.

Figure 3: Landscape of Financing Instruments

	Debt	Private Equity and VC	Other
Built Environment	Tax Exempt Bonds, e.g., Betances Residences	Accelerators e.g. The Urban Future Lab	Government subsidies/ Philanthropic Grants
Sustainable Mobility	Green Bonds, e.g., MTA Green Bond	New Business Models, e.g., Carma; Bay Area Rapid Transit (BART)	Capital Leasing; Public-Private Partnerships; Grants
Renewable Energy	Asset-Backed Securities; Property Assessed Clean Energy (PACE); Green Bonds	Power Purchase Agreements; Tax Equity Financing; Real Estate Investment Trusts (REITs)	Energy Services Agreements; Energy Performance Contracts
Waste	Variable Payment Obligations, e.g., ReFED	Venture Capital, Project Finance, Private Equity, e.g., Closed Loop Partners	Government subsidies/ Philanthropic Grants and "Venture Philanthropy," e.g., SEACEF
Food and Health	Microloans, e.g., Farm Service Agency (FSA)	Venture Capital, e.g., Pod Food	Crowd Funding e.g., Brooklyn Grange
Climate Resilience	Environmental Impact Bond e.g., DC EIB	Venture Capital, e.g., Quantified Ventures	Catastrophe Bond e.g., FEMA Catastrophe Bond

Building Models Beyond Climate Finance: Analyzing developments across the six sectors we see the greatest level of innovation and capital mobilization in renewable energy and the built environment sectors. Following the Covid-19 crisis, as policymakers increasingly shift their attention to mobilizing private capital for sectors such as food and health and sustainable mobility, there is dynamism and support to build on the lessons learnt from renewable energy and the built environment and expand into new markets. As a global financial hub, New York City can continue to lead and develop innovative financing solutions that will accelerate the transition to a low-carbon economy and align investments with the related climate, economic, and social challenges embodied in the UN SDGs.

About Invest NYC SDG

Invest NYC SDG is a two-year initiative launched by the Center for Sustainable Business (CSB) at NYU's Stern School of Business. The initiative focuses on aligning private sector business and finance opportunities with public policy initiatives and the UN Sustainable Development Goals (SDGs). *Invest NYC SDG's* purpose is to support NYC in its work to achieve the UN Sustainable Development Goals (SDGs) — "localizing the SDGs." As concrete demonstration projects are developed in NYC, it seeks to identify government policies and/or finance innovations needed to be

successful. The Invest NYC SDG initiative examines and recommends solutions for New York City across six areas that are essential to its long-term sustainability and the well-being of its almost 8.3 million residents: sustainable mobility, the built environment, climate resilience, renewable energy, food and health, and waste.

Invest NYC SDG is led by Tensie Whelan, CSB Director and Clinical Professor for Business and Society at NYU Stern, and Marianna Koval, Director, Invest NYC SDG, at the Center for Sustainable Business.

Introduction

The Center for Sustainable Business is pleased to present this finance white paper, authored by Cary Krosinsky and Ella Warshauer, and supported by a team of writers and researchers under their leadership. This work is an important component of the *Invest NYC SDG* initiative, which seeks to align private sector business and finance opportunities to advance the UN Sustainable Development Goals (SDGs) in six areas: built environment, sustainable mobility, renewable energy, waste, food & health, and resilience.

The white paper provides overviews for each area, discussing the current investment landscape, highlights key players, financing mechanisms and investment case studies, and identifies forward-looking trends. It also considers the role of philanthropy, as well as identifies the scope in each area for further research.

It becomes clear throughout this paper that there are varying levels of investment and innovative finance in each of the categories, ranging from public and private sources, which can be separated into three broad categories: 1) areas with sufficient innovative financing mechanisms that now require scaling up – the built environment and renewable energy; 2) areas with emerging investment solutions, but pathways to scalability that are yet unclear – food and health and waste; and 3) areas lacking sufficient financing, where a larger vision is required to make meaningful progress – sustainable mobility and climate resilience.

The initiative focuses on creating specific local solutions that represent significant business opportunities and support New York City's ambition of both achieving its sustainability goals and key SDGs. It takes the UN's very high-level goals and identifies ways that for-profit business opportunities can deliver meaningful progress toward those goals. In other words, *Invest NYC SDG* seeks to assemble some of the components of a thriving, just, and sustainable NYC economy, outline the business case for each one, and spur investment in them. It is hoped that successful component projects will have broader benefits as they spur further development.

The SDGs cover economic, social, physical, and environmental well-being for individuals, communities, cities, and the planet. The 17 SDGs -- and the 169 specific targets associated with them -- serve as a framework for putting the world on the path toward greater sustainability by 2030. If achieved, the goals would end poverty, protect the Earth's resources, and ensure greater shared prosperity. The vision, focused effort, collaboration, and innovation that it will take to achieve them is significant, but so is the opportunity that their achievement represents for humanity.

New York City has been at the forefront of urban sustainability planning since 2007, with then-Mayor Bloomberg's Plan NYC 2030. This long-term plan made explicit the link connecting New York City's population and economic growth with the health and viability of its natural and built environment and infrastructure. Mayor Bill de Blasio has taken this to the next level with his sustainable development plan, OneNYC 2050, and

his embrace of the UN SDGs, including the Paris Climate Accord commitments. New York City was also the first city in the world to systematically align its sustainability goals with the UN SDGs and launch voluntary reporting. OneNYC 2050 envisions a city that not only balances growth and prosperity with principles of equality, sustainability and resiliency, but builds a robust economy that draws its strength from its commitment to the SDGs.

More than setting ambitious policy *goals*, New York City and New York State have taken the lead nationally with new laws -- New York City's Climate Mobilization Act and New York State's Climate Leadership and Community Protection Act, both enacted in 2019, which constitute the most ambitious climate legislation in the United States. These new climate laws will spur major private sector investment.

The new State legislation requires New York to cut greenhouse gas emissions to 85% below 1990 levels by 2050, and offset the remaining 15% with measures such as planting forests and capturing carbon. The law will require that utilities obtain 70% of the state's electricity from renewable sources by 2030, compared with only 26.4% today. A 22-member New York State Climate Action Council will have three years to recommend mandates, regulations, incentives and other measures.

With its ambitious new climate legislation and strong commitment to the SDGs, New York City is a global leader in urban sustainability. NYC's aggressive new climate legislation will require energy-efficient building retrofits capable of reducing the carbon emissions of New York City's buildings by 80 percent in 2050. Connections need to be made, however, if an investing path is to be clear for the private sector. The knowledge, technology and financing resources to make significant progress toward the SDGs are available, but these resources are currently fragmented. As a consequence, productive collaboration does not occur naturally, opportunities are missed, and undesirable delays occur in the process of transformative change.

Invest NYC SDG is building on this work by using the SDGs as a framework to identify opportunities for private sector financing of community-supported initiatives. The initiative also aims to document the research and stakeholder engagement process to provide a model framework for other cities, in the United States and globally, to tackle sustainable development.

More than \$12 trillion in private investment is needed globally³ to meet the challenges of the SDGs. Financing projects that will materially help NYC achieve the SDGs will require engagement and collaboration between the private and public sectors. This will be no small feat, but the rewards are enormous, both in our future quality of life and in the evolution of a profitable and sustainable economy.

³ <http://report.businesscommission.org/>

The Built Environment

The built environment touches all aspects of city life -- it includes homes of all kinds, parks, roads, mass transit, public buildings, commercial and mixed-use buildings, and other infrastructure in which people live and work. Globally, buildings and construction account for 36% of final energy use, and 39% of energy-related carbon dioxide emissions, according to the UN.⁴ Today, 55% of people live in urban areas, and by 2050, the UN predicts this will be closer to 68%. Increased stress on the built environment means that sustainable development will be even more important as cities continue to urbanize.

While the built environment is much broader, this paper focuses on buildings. And in New York City specifically, buildings contribute approximately 66.7% of the City's total greenhouse gas emissions.⁵ Affordable housing, energy efficiency, and smart buildings provide solutions that can not only significantly reduce carbon emissions, but also help improve the lives of New Yorkers, make the city more livable, and align the city's development with the SDGs.

The sections that follow will detail the current state of play for each category: affordable housing, energy efficiency, and smart buildings, with a particular focus on finance. There are a number of innovative financing mechanisms – including property assessed clean energy (PACE) financing and energy performance contracting -- that have successfully helped to scale solutions. If NYC -- and the world -- is to remain on track to achieve the SDGs, a more energy-efficient and resilient, built environment is essential.

Affordable Housing

Overview

While some residents have debated leaving the city during COVID, New York City has become an increasingly desirable place to live in recent years. Aging older residents, younger families raising children, and empty-nesters who once moved out of the city are now staying. That said, the city has significant affordability issues.

Nationally, “too many people [in the U.S.] are paying too much of their income on housing,” according to a 2019 report by Harvard’s Joint Center for Housing Studies.⁶ The data shows that 31.5% of households are paying more than 30% of their incomes on housing. More than 18 million households – 1 in 6 – are paying more than half of their income on housing and are considered severely cost burdened. At the same time, the study notes that the country is “losing a staggering amount of low-cost rental homes – those renting for less than \$800 per month. Since 2011, says the study, “the stock of

⁴ <https://www.unenvironment.org/resources/publication/2019-global-status-report-buildings-and-construction-sector>

⁵ <https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/GHG%20Inventory%20Report%20Emission%20Year%202016.pdf>

⁶ <https://www.jchs.harvard.edu/state-nations-housing-2019>

low-cost rentals has shrunk by a remarkable 4 million units, including 1 million in 2017 alone.”

In New York City, those metrics are more severe. The Citizens Budget Commission⁷ analyzed 2018 data from the New York City Housing and Vacancy Survey,⁸ finding that 44% of all renters pay at least 30% of their income in rent, and more than half of those households are “considered severely rent burdened, which means they pay at least half their income in rent.”

In recent years the City of New York has launched a number of initiatives to create affordable housing, beginning with the 2014 plan⁹ to create 200,000 affordable homes over 10 years, followed by Housing New York 2.0,¹⁰ which promised to accelerate the original plan and create an additional 100,000 affordable homes by 2026.

These efforts are supported by numerous financing strategies.

Types of Financing

Multi-family housing is generally financed on a building-by-building basis, with building-specific revenues adequate to cover building-specific operating costs. Because debt service is typically the largest operating cost, strategies to reduce debt service are central to affordability.

The mix of financing ingredients typically includes:

- Tax-exempt bonds, issued by state and local housing finance agencies and purchased largely by institutional bond funds
- Tax credits, specifically Low-Income Housing Tax Credits (LIHTC), purchased by investors and put into the project as equity upon completion of construction and commencement of operation. Investors include banks and other corporations, as well as high net worth individuals seeking to reduce tax liability.
- Community Development Financial Institutions (CDFIs), which can provide construction period financing, as a bridge to tax credit equity and other permanent financing, acquisition and pre-development financing enabling affordable housing developers to purchase land, retain architects and engineers, and take other steps needed to put a project into construction
- Government or philanthropic grants
- Personal guarantees from owners of for-profit corporations

⁷ https://cbcny.org/research/think-your-rent-high?utm_source=Think+Your+Rent+Is+High%3F+Documenting+New+York+City%27s+Severest+Rent+Burdens&utm_campaign=Think+Your+Rent+Is+High%3F+Documenting+New+York+City%27s+Severest+Rent+Burdens&utm_medium=email

⁸ <https://www.census.gov/programs-surveys/nychvs.html>

⁹ <https://www1.nyc.gov/site/housing/index.page>

¹⁰ <https://www1.nyc.gov/assets/hpd/downloads/pdfs/about/housing-new-york-2-0.pdf>

- Pay for success contracts, which are often accompanied by social impact bonds to provide upfront capital through the service delivery period.¹¹
- Ongoing operating subsidies, such as federal rent vouchers or local property tax deductions

Because both tax-exempt bonds and tax credits result in tax expenditures, they are subject to annual volume caps by federal law. Using these tools to further ramp up production of affordable housing, therefore, would require changes to those laws. Other affordability tools, including rent vouchers and property tax reductions, similarly impact governmental budgets and are therefore subject to limits. Efforts to increase these limits are widespread and on-going, with support from public officials across the country, as well as advocacy groups such as the National Low Income Housing Coalition and locally based housing and community-oriented organizations.

Key Players Include:

- Federal Housing Administration (FHA)
- Goldman Sachs Urban Investment Group
- Residential Mortgage Insurance Corporation (REMIC)
- Citi
- Wells Fargo
- New York City Housing Authority

Specific Examples and Analysis:

Essex Crossing

One example of sustainable affordable housing development is the Essex Crossing project in NYC, in which Goldman Sachs led financing. In 2013, a mix of stakeholders with expertise in mixed income projects that serve non-profits convened to kickstart the project, including the Delancey Street Associates, BFC Partners, L+M Development Partners, Taconic Investment Partners, and the Prusik Group.¹²

Goldman Sachs' impact investing fund, the Urban Investment Group, which has committed over \$1.9 billion to more than 90 projects in NYC, invested nearly \$200 million in the 1.7 million square-foot project to revamp Essex Market, on New York's Lower East Side. With development costs totaling about \$1 billion, the project resulted in 1,000 housing units, 640,000 square feet of office and retail space, and 15,000 square feet of open space, and includes a mix of public uses and local services, including senior apartments, community facility space, a neighborhood medical clinic, a cafe to help youth develop work skills, parks and nature paths, grocery stores, a school, and a rooftop urban farm.

¹¹ <https://www.payforsuccess.org/learn/basics>

¹² <https://www.citylab.com/design/2019/09/essex-crossing-development-nyc-real-estate-lower-east-side/596818/>

The Role of Community Development Financial Institutions (CDFIs)

Community Development Financial Institutions (CDFIs) are community-based specialized financial institutions that serve low income people or businesses in economically distressed communities, often working in market niches that may be underserved by traditional financial institutions.¹³ Though CDFI projects often lack the scale required to interest Wall Street, they are the projects that define the poverty-fighting agenda of cities and towns, and they play an important role in financing affordable housing. CDFIs are focused on projects of economic opportunity and equality, and therefore, CDFI investments are almost always in support of the SDGs.

Betances Residence and CSH

One successful example of CDFI investment is a project managed by CSH, formerly known as the Corporation for Supportive Housing, to finance the Betances Residence affordable and supportive housing in NYC. The complex is one of the most carbon-efficient, passively designed apartment buildings in the world and will house low-income New Yorkers.¹⁴

The development was financed with \$58 million in tax-exempt bonds and subsidies from the NYC Housing Preservation and Development, \$23 million in Senior Affordable Rental Apartments Program funds from HPD, \$2.7 million in Homeless Housing, Assistance, and Prevention funding from the Office of Temporary Disability Assistance, and approximately \$39 million in equity generated from the sale of Low-Income Housing Tax Credits.

The CSH played a critical role in providing pre-development funds to kickstart the project, and perhaps there is an opportunity for CDFIs to play a larger role in financing and greening affordable housing development.

Blended Finance

Blended finance combines loans that are extended on more generous terms than market loans with commercial funding. It's one of the tools commonly used to facilitate financing for private sector-led projects that generate social benefits.¹⁵

The Low Income Investment Fund (LIIF) is a CDFI providing capital solutions to support healthy communities and families. In July 2019, it issued its first public debt offering with a \$100 million Sustainability Bond issuance to finance vital community development projects, representing the first public offering to align with the Sustainable Development Goals.¹⁶

This bond "blends" investment from CDFIs, foundations, commercial lenders, tax credit equity investors and muni bond investors at different stages in the life of the various projects underlying this bond issue. The offering was underwritten by Morgan Stanley

¹³ <https://nyscdfi.org/cdfi-definition/>

¹⁴ <https://rew-online.com/2019/09/affordable-building-meets-passive-rules/>

¹⁵ <https://ieg.worldbankgroup.org/blog/what-blended-finance-and-how-can-it-help-deliver-successful-high-impact-high-risk-projects>

¹⁶ <https://www.liifund.org/news/post/100-million-in-sustainable-bonds-for-social-impact-announcing-liifs-first-bond-issuance/>

and oversubscribed by a factor of ten. This bond has been considered largely successful.

Outlook

Recognizing the positive impact of decent housing on health, New York State has allocated state-only Medicaid funding toward supportive housing, which combines affordable housing with services such as healthcare, workforce development, and childcare.¹⁷

Mandatory Inclusionary Housing (MIH),¹⁸ enacted in 2016, is a NYC zoning tool which requires developers to include affordable housing in areas that are rezoned to allow for more development. It will require developers seeking to build taller, denser buildings to also include a percentage of units with caps on rent. The MIH will have long-term influence over how neighborhoods look and what benefits they provide to residents.

Further development of affordable housing will likely rely on a strong policy foundation.

Energy Efficiency in Buildings

McKinsey has identified energy efficiency as “the single most attractive and affordable component of the necessary shift in energy consumption.”¹⁹ The buildings sector is not, however, keeping up with population growth and the increased demand for energy. In many cities, New York included, the built environment is quite old, which leads to wasted heat and electricity, putting further demands on resource consumption. Approximately sixty-seven percent of total citywide greenhouse gas emissions come from NYC’s building stock.²⁰ This is not surprising, given that one of New York’s defining characteristics as a city is its buildings -- it is home to over one million buildings over 300 square miles. But the city needs to make an ambitious effort to improve energy efficiency in order to achieve its goals of 80% reduction in greenhouse gas emissions by 2050.²¹

¹⁷ <https://www.csh.org/supportive-housing-101/>

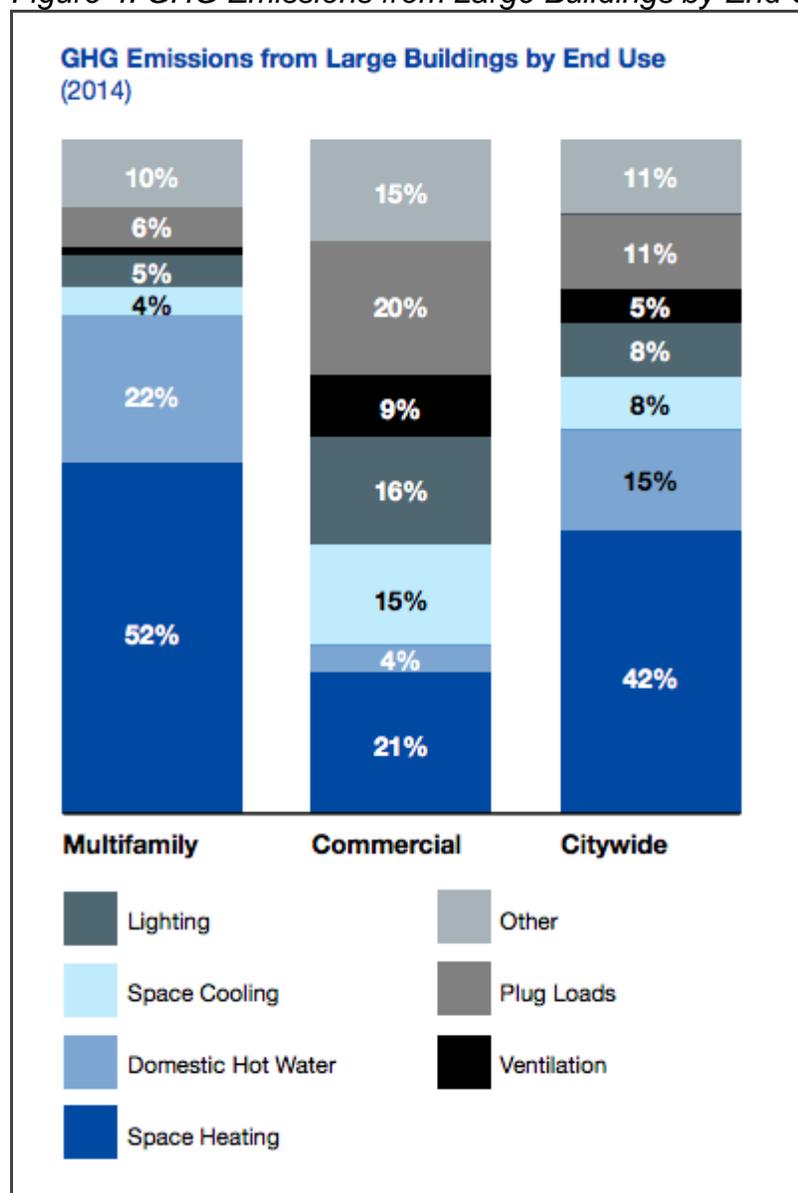
¹⁸ <https://www1.nyc.gov/site/planning/plans/mih/mandatory-inclusionary-housing.page>

¹⁹ <http://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/us-energy-savings-opportunities-and-challenges>

²⁰ <https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/GHG%20Inventory%20Report%20Emission%20Year%202016.pdf>

²¹ https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City's%20Roadmap%20to%2080%20x%202050_Final.pdf, pp. 73

Figure 4: GHG Emissions from Large Buildings by End Use (2014)



Source: New York City's Roadmap to 80 X 50, The City of New York Mayor Bill de Blasio, 2014.

NYC building energy use is highest for space heating and domestic hot water.²² This could be an opportunity for solar energy (see Smart Buildings section below for further information).

The Role of Policy

There is already a focus on energy efficiency in buildings in NYC. In 2019, the city passed the ground-breaking Local Law 97, which applies to approximately 35,000

²²<https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City's%20Roadmap%20to%2080%20x%2050%20Final.pdf>, pp. 73

buildings over 25,000 square feet and requires those buildings to reduce emissions or be subject to fines, based on the building's size and class.²³

Local Law 97 puts the pressure on building owners to take energy efficiency retrofit steps in preparation for the first deadline in 2024. To catalyze the transition, the city is supporting financing of these programs, and has put in place a new property assessed clean energy financing program (PACE) to provide low-interest loans for energy efficiency steps. The law notably also allows for deductions associated with the purchase of renewable energy credits, greenhouse gas offsets, clean distributed energy resources, and storage.²⁴ The law is estimated to unlock a significant market opportunity for building and energy efficiency retrofits in NYC -- the Urban Green Council estimates somewhere between \$16.6 billion and \$24.3 billion.²⁵ This legislation will play a significant role in driving building owners to accelerate the transition to more sustainable, climate resilient buildings.

Types of Financing:

- Property Assessed Clean Energy (PACE) financing
- Energy Performance Contracting
- Asset backed securities
- Energy services agreement
- Community Development Financial Institutions (CDFIs)

Key Financing Players:

- Goldman Sachs Urban Investment Group
- New York City Energy Efficiency Corporation (NYCEEC)
- New York Green Bank
- Citi
- Fannie Mae
- Center for NYC Neighborhoods

Specific Examples and Analysis:

Fannie Mae and Green ABS

Asset-backed securities (ABS) lend themselves well to energy efficiency financing. ABS are backed by financial assets, such as mortgages or lease receivables, which are then sold to investors who receive a return from the cash flows of the underlying assets.²⁶ ABS can be used to finance energy efficiency when the underlying assets consist of mortgages on certified energy efficient buildings (such as LEED or BREEAM certified

²³<https://www.ibtimes.com/local-law-97-how-nyc-law-can-change-way-we-look-emissions-2815577#targetText=Local%20Law%2097%20is%20applicable.a%20building's%20size%20and%20class.>

²⁴ *ibid*

²⁵ https://www.urbangreencouncil.org/sites/default/files/urban_green_retrofit_market_analysis.pdf

²⁶ *Green Securitization*, CBI, pp. 1

buildings), financing for energy efficiency upgrades, or loans for energy efficiency improvements.²⁷

Green ABS have been largely successful at scale. Fannie Mae was the largest issuer of green mortgage backed securities (MBS) in 2017, issuing \$26.4 billion. Its Multifamily Green Initiative, which targets mortgages to certified low-carbon buildings, and financing for energy and water efficiency improvements of at least 20%, has specifically driven this trend.²⁸ This program incentivizes best practices for investors in financing energy efficiency and certification for buildings and, over time, more stringent requirements for entering this program will help align building stock with the Paris Agreement and the SDGs.

PACE Financing and the New York City Energy Efficiency Corporation

Property Assessed Clean Energy (PACE) financing is another innovative way to fund energy efficiency, and is unique in that it allows property owners to finance energy efficiency without making a large upfront payment. PACE is enabled by state and local legislation to allow private PACE originators to lend funding for energy efficiency improvements projects. PACE allows a property owner to finance the up-front costs, and then pay the costs back over time through a voluntary assessment.²⁹ The assessment is tied to the property rather than the owner, so in the event of a sale, the assessment stays with the property and remaining project costs are transferred to the new owner.³⁰

New York City created a PACE lending program in 2019 in conjunction with Local Law 97 to provide building owners with funds to install renewable energy systems and energy efficiency improvements.³¹ The program aims to help buildings comply with new emissions limits and will be administered by the New York City Energy Efficiency Corporation (NYCEEC), an independent financial services non-profit that has invested over \$28 million in energy and cost-savings projects across New York City.³² NYCEEC was created by the City of New York to promote and finance local energy efficiency projects, and offers financing via green mortgages, energy services agreements, and direct lending. The Corporation has enabled \$152 million in clean energy projects, which, it estimates, has eliminated 749 million tons of CO₂ and has created over 1,600 jobs.

²⁷ *ibid*

²⁸ *Green Securitization*, CBI, pp. 3

²⁹ <https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs>

³⁰ <https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs>

³¹ <https://energywatch-inc.com/pace-financing-program-to-help-property-owners-pay-for-complying-with-the-new-ghg-emissions-cap-on-nyc-buildings/>

³² *One City, Built to Last*, pp. 69

The Role of Green Banks

Green banks³³ can also play a role in closing the private sector financing gap by providing the expertise and financing mechanisms needed to scale up energy efficiency in buildings.

The New York Green Bank (NYGB), for example, was created as part of Governor Cuomo's Reforming the Energy Vision plan, and works to increase investment in clean energy in New York State. The NYGB not only provides financing for PACE and energy performance contracting, but also innovates with specific companies to come up with specially tailored solutions.³⁴ For example, NYGB provided a \$5 million revolving credit facility to enable Sealed, a company that provides energy efficiency installations, to finance energy efficiency through an energy savings agreement (ESA) where property owners make payments directly from energy savings back into the entity that procured and installs the equipment. Sealed aims to catalyze residential carbon savings equivalent to 10% of US 2020 carbon goals. NYGB's early financial investment helps establish a track record for residential energy efficiency financing, and pique the private sector's interest to bring more capital into the space.

Community Development Financial Institutions (CDFIs)

CDFIs can fill financing gaps in their local communities by offering specialized services to neighborhood residents, particularly in middle- and working-class communities. The Center for NYC Neighborhoods is one example of a certified CDFI that works with NYSERDA's Community Energy Advisors Program. It offers businesses and multifamily building owners advice on retrofitting their buildings to reduce energy use and energy costs.³⁵ The Center recently launched a program called HomeFix, which offers grants and loans, among other services, at favorable terms.^{36,37} This demonstrates how a CDFI can be a catalyst for investment when the project size for the private sector is too small or localized. There is room for this model to scale further to enable more retrofitting in NYC neighborhoods.

Outlook

The level of energy efficiency financing in New York is expected to increase rapidly in the near future. The passage of Local Law 97 mandating energy use reductions in larger buildings could drive demand for a credit trading system that is under development now and PACE financing and, in turn, spur growth in renewable energy generation.

In addition, while there may be many innovative financing mechanisms for energy efficiency, there are risks associated with installations. Homeowners and building owners seldom have experience with energy efficiency projects and are sometimes

³³ <https://greenbanknetwork.org/what-is-a-green-bank-2/>

³⁴ <http://ufl.nyc/case-studies/sealed>

³⁵ <https://www.nyserda.ny.gov/Contractors/Find-a-Contractor/Community-Energy-Resource>

³⁶ <https://cnycn.org/repairs-retrofits/>

³⁷ <https://www1.nyc.gov/site/hpd/about/press-releases/2019/06/hpd-announces-new-home-repair-program.page>

victims of shoddy work, leaving them saddled with the cost of the project, but inadequate energy savings to cover the cost. Problems with residential PACE installations have prompted the federal Consumer Financial Protection Board to look at new protections for homeowners.³⁸ There is likely scope for further research on scaling PACE and EPC, as well as business models that enable homeowners to scale residential energy efficiency.

Overall, energy efficiency financing is one of the more robust areas of finance that has the potential to scale the SDGs. To reach NYC's 80 x 50 goals, the challenge will be to implement these programs across all of NYC's building stock. Legislation such as Local Law 97 provides the foundation for accelerating the transition, but building owners and investors alike will likely require further education to evaluate contractors and to select and structure financing. Some resources are available, but there is also an opportunity for green banks and private capital to provide these advising services and further catalyze energy efficiency finance.

Smart Buildings

Overview

Smart buildings represent the next wave of opportunity for the built environment, helping to address resiliency, health and well-being, energy efficiency and renewables, and affordability. Smart buildings use the Internet of Things (IoT) to monitor and control building systems, improving their efficiency and sustainability, and in some cases, fixing a problem with no human intervention. Smart building technologies can include: water supply systems automated to detect leaks, monitor quality, and to automate heating and cooling; chiller plants optimized to incorporate outside weather data to reduce energy use while cooling the building; connected weather stations on the outside of buildings to optimize internal systems like temperature and air quality; and electricity, air conditioning and heating systems set up to turn on and off based on the occupancy of a room.

Key Players Include:

- Sidewalk Labs
- NYCEEC
- Demand Energy
- Enel
- Rocky Mountain Institute

³⁸ Lane, Ben; CFPB Plans to Issue Rules on PACE Loans; Housing Wire; Mar 4, 2019. Berry, K.; CFPB Moves One Step Closer to Regulating Clean Energy Loans; American Banker; Mar 4, 2019

Specific Examples and Analysis

Marcus Garvey Housing Complex

NYC Energy Efficiency Corporation (NYCEEC) is also active in financing smart buildings in NYC. In 2016, NYCEEC and ConEdison worked to finance battery storage for the nation's first affordable housing microgrid at the Marcus Garvey affordable housing complex.³⁹ The project was launched when Demand Energy, an energy storage company in NYC, wanted to install a battery system to take advantage of solar and fuel-cell generation at Marcus Garvey. Through a long-term energy services contract, NYCEEC developed a financing model that allowed a new business entity to own and operate the battery system profitably and also derive additional cash flow from demand response.⁴⁰ The system combines rooftop solar panels, electricity-generating fuel cells and large-scale battery storage to reduce the complex's demand on ConEdison's electricity grid while also lowering operating expenses, generating revenue as well as electricity, and cutting the facility's energy-related greenhouse gas emissions. The total cost of the project was \$1.79 million, with NYCEEC providing a loan of \$1.25 million and ConEdison contributing \$540,000 in incentives.⁴¹ Shortly after the battery system was installed at Marcus Garvey, it was acquired by Enel, a European energy company, which prepaid the loan to NYCEEC.⁴² This project has been considered largely successful and can be used as a model for financing battery storage and other distributed energy-generation projects.

Further, there is a burgeoning body of research on building electrification, which speaks to the opportunity for New York to meet its energy consumption needs from lower-carbon sources, reducing fossil fuel use in buildings.⁴³ Electrification presents a huge opportunity, as electric space and water heating can be intelligently managed to shift energy consumption in time to allow for cost-effective integration of renewable energy into the grid.⁴⁴ Unfortunately, there is still progress to be made before building electrification will scale. Research concludes that replacing natural gas furnaces and water heaters with electric pump devices is often not cost-effective.⁴⁵ But benefits include the reduction in homeowner costs over the lifetime of an appliance, and there are certain scenarios in which the economics of electrification are favorable, for example, for customers who bundle rooftop solar with electrification.⁴⁶

As variable renewable energy such as solar or wind increases in capacity, price spreads by time of day in electricity markets will increase. Intelligent devices that provide customers with the ability to earn the spread between capturing energy at low-cost periods and selling it to the grid during high-cost periods can help reduce the lifetime costs of electrification, which should help develop this market.⁴⁷ The potential

³⁹ <https://www.nyceec.com/wp-content/uploads/Marcus-Garvey-Apartments-NYCEEC-Case-Study-1.pdf>

⁴⁰ <https://www.nyceec.com/wp-content/uploads/Marcus-Garvey-Deal-Spotlight-Download.pdf>

⁴¹ <https://www.nyceec.com/wp-content/uploads/Marcus-Garvey-Apartments-NYCEEC-Case-Study-1.pdf>, pp. 5

⁴² <https://www.nyceec.com/wp-content/uploads/Marcus-Garvey-Apartments-NYCEEC-Case-Study-1.pdf>, pp. 9

⁴³ <https://rmi.org/insight/the-economics-of-electrifying-buildings/>

⁴⁴ Rocky Mountain Institute, *Economics of Electrifying Buildings*, pp. 6

⁴⁵ Rocky Mountain Institute, *Economics of Electrifying Buildings*, pp. 57

⁴⁶ Rocky Mountain Institute, *Economics of Electrifying Buildings*, pp. 6

⁴⁷ Rocky Mountain Institute, *Economics of Electrifying Buildings*, pp. 9

environmental impacts of electrification are significant - widespread electrification of buildings, ground transportation and industry, predicted to result in reductions of more than 70% of CO2 emissions if powered by zero-carbon electricity.⁴⁸ More research is needed, but financing to support electrification might come initially in the form of prioritizing electric heat pumps, since space heating and domestic hot water are responsible for the largest portion of emissions in large buildings in the city. This electricity segment is still young, however, and perhaps this indicates potential for building electrification from renewable sources in NYC. Today, NYC's electricity is partly generated by an infrastructure of fossil fuel burning power plants. In order to achieve longer term goals, adjustments will need to be made away from fossil fuel energy systems towards sustainable infrastructure that connects the city via transmission lines with clean energy generated upstate or offshore.

Cleantech Innovation

NYC is also dedicated to creating technology accelerators that focus on cleantech innovation. For example, the Innovative Demonstrations for Energy Adaptability program is working with the Urban Future Lab and other accelerators to identify energy-efficient technologies for implementation across the city's portfolio.⁴⁹ Projects and technologies included: innovations for building controls, including wireless pneumatic thermostats, self-powered wireless lighting controls, wireless space sensors, predictive building control software, wireless controllers for HVAC units, and building energy management systems.⁵⁰ The Urban Future Lab is home to a number of companies innovating in the smart building space. Buildee, and Urban Future Lab portfolio company, enables building operators and utilities to identify, prioritize, and realize energy efficiency investments through standardized data acquisition, modeling, and analytics.⁵¹ TagUp identifies system failures before they occur by monitoring equipment in real time from anywhere.⁵² Another example is Wavelength, an LED lighting and networked controls distributor and project company that serves the tristate New York area.⁵³

Outlook

Since 2012, total capital invested in the global smart building startup space reached \$18.8 billion with the highest level of investment over the last 4 years.⁵⁴ 2018 marked a record year for investment in smart building startups, with over \$2.4 billion invested globally, yet efficiency is still not being built into buildings today at the rate that it needs to be.⁵⁵ Building electrification may represent a promising opportunity, but the economics of implementation are lacking and the path forward for financing is still unclear. That being said, there is certainly an opportunity for venture capital and corporate accelerator programs to continue to finance companies focused on developing technology solutions to be applied to smart buildings.

⁴⁹ *One City, Built to Last*, pp. 53

⁵⁰ <https://www1.nyc.gov/site/dcas/agencies/energy-innovation.page>

⁵¹ <https://buildee.com/>

⁵² <https://www.tagup.io/about/>

⁵³ <http://ufl.nyc/members>

⁵⁴ <https://memoori.com/portfolio/startups-and-their-impact-on-smart-buildings-2021/>

⁵⁵ <https://memoori.com/who-is-investing-in-smart-building-startups/>

Further research to develop a blueprint for financing smart building technologies is needed to scale up innovations in the sector. As this is still an underdeveloped area, convening stakeholders across the public and private sectors might be useful in developing a broader vision for deep decarbonization of NYC's buildings.

Role of Philanthropy

The ClimateWorks Foundation is an NGO that works globally to strengthen philanthropy's response to climate change. The Foundation invests in a number of initiatives that are progressing the decarbonization of buildings through its Buildings and Industry portfolio, including in zero carbon buildings, decarbonizing supply chains, and deep decarbonization of the industrial sector, including cement, steel, and chemicals production.⁵⁶ In 2018, it made 13 grants to 10 grantees totaling \$2.3 million.⁵⁷ Grants have been invested directly in projects to accelerate the transition to more sustainable building materials. For example, the Foundation granted \$150,000 to the US Green Building Council in Los Angeles to support the Buy Clean Incentive Program, which incentivizes industrial manufacturers green supply chains, contributing to cleaner building materials.⁵⁸ In addition to directly financing incentives, ClimateWorks also provides grants to help grow thought leadership in the sector.

Another of its grantees is C40 Cities, a network of megacities committed to addressing climate change.⁵⁹ In 2019, ClimateWorks granted \$345,000 to C40 Cities toward its Energy and Buildings Technical Assistance Program, which develops guides, manuals, and case studies across the C40 network of over 90 global cities on the decarbonization of buildings.⁶⁰ C40 estimates that this program will directly save at least 76 MtCO₂ per year by 2030 – equivalent to nearly twice the annual emissions of Greater London.⁶¹ These examples illustrate how philanthropic grants can be used to finance change both directly through incentives, and also indirectly through research. Both are important for transitioning the building stock to be more efficient and meet the SDGs.

Conclusion

As we've seen, NYC is taking steps to catalyze action in the built environment sector to align with the SDGs and improve the city's resilience. As part of the Climate Mobilization Act, Local Law 97 provides an important policy foundation that will drive building owners, investors, and corporations to mitigate emissions. The large number of initiatives that NYC has to address climate resilience in the built environment -- including the *One City, Built to Last* plan, the *Greener, Greater Buildings* plan, and the commitment to reducing citywide emissions 80% by 2050, are all critical to outlining the path to a transition.

⁵⁶ <https://www.climateworks.org/programs/industry/>

⁵⁷ <https://www.climateworks.org/programs/industry/>

⁵⁸ <https://usgbc-la.org/programs/buy-clean-california/>

⁵⁹ <https://www.c40.org/about>

⁶⁰ <https://www.climateworks.org/portfolios/grants-database/>

⁶¹ <https://www.c40.org/programmes/building-energy-2020-programme>

The challenge that remains is scaling up financing across projects related to the built environment. Appropriate financing mechanisms to execute on these strategic plans exist -- PACE financing, green ABS, and energy performance contracting can be combined with energy benchmarking and implementation of smart building technology to accelerate the transition. To continue scaling these solutions, financial institutions and building owners that currently do not have much experience in energy efficiency or affordable housing projects need to become more active participants. The built environment is a particularly large component of NYC's overall footprint; it is therefore critical that the city invests rapidly and adequately in energy efficiency and renewables strategies across its entire building portfolio.

Scope for Further Research

The built environment represents a category that has a variety of innovative financing mechanisms, but requires scaling up. For mechanisms such as PPAs, PACE, and EPC, community development finance institutions and green banks can provide the guidance and expertise to implement energy efficiency improvements across building portfolios. Further research should be done on how NYC can utilize Qualified Opportunity Funds to finance improvements that particularly impact low- and middle-income communities. With policies such as Local Law 97 laying the foundation for widespread energy efficiency upgrades, perhaps there is scope for further research on financeable opportunities to develop technologies that streamline compliance and enable widespread adoption, as well as the impacts of a credit trading system, if adopted. In addition, a vision is needed for smart buildings. Sidewalk Labs can be looked to as a model ecosystem, and perhaps NYC could benefit from developing a playbook of possible solutions and subsequently acting as an incubator for testing. There is also an opportunity to explore the economics of building electrification as it relates to NYC as a solution to decarbonizing the city's buildings.

Sustainable Mobility

Overview

The transportation sector in New York City accounts for approximately 30% of NYC's total GHG emissions.⁶² In NYC's 2019 Mobility Report, Commissioner Polly Trottenberg cites recent mobility trends in New York City as unsustainable. Sustainable transport can help solve some of these challenges.⁶³

Sustainable mobility is defined as any form of transport that does not use or rely on dwindling natural resources, but instead relies on renewable or regenerated energy rather than fossil fuels that have a finite life expectancy.⁶⁴ Sustainable transport can have many positive downstream impacts, including reducing greenhouse gas emissions, improving road safety, increasing the efficiency of transport systems, or incentivizing people to switch from cars to more sustainable modes such as walking, cycling, public transport, and electric vehicles.

In this section, we will cover public transit, electric and hybrid vehicles, fuel efficiency, cycling, ride-sharing, and congestion management.

Public Transit

Overview

Public transit provides people with basic mobility services and access to employment, community resources, medical care, and other opportunities. It is key to creating economically healthy communities in that it creates a local hub of activity, which can improve safety, create a sense of community, and expand business opportunities. Public transit also offers the obvious environmental benefits -- it helps to reduce congestion and travel times, air pollution, and fossil fuel consumption.

Types of Financing:

- Revenue bonds issued directly by a transit authority or government
- Capital leasing
- Green bonds
- Debt service reserves
- Public-Private Partnerships (PPPs) Joint development projects in which various transit agencies coordinate share costs.⁶⁵
- State infrastructure banks that establish a revolving fund operated by the state, which can offer direct loans to fund infrastructure improvement projects

⁶²<https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/GHG%20Inventory%20Report%20Emission%20Year%202016.pdf>

⁶³ <https://www1.nyc.gov/html/dot/downloads/pdf/mobility-report-singlepage-2019.pdf>

⁶⁴ <http://www.earthtimes.org/encyclopaedia/environmental-issues/sustainable-transport/>

⁶⁵ <https://www.transit.dot.gov/funding/funding-finance-resources/state-infrastructure-banks/state-infrastructure-banks-sibs>

- Grants at the national, regional, and municipal levels -- for example, in financing e-buses in the U.S., grants from the Low or No Emissions Vehicle Program are often combined with state grants to cover the high upfront costs. However, these grants are irregular and in the case of buses, only cover a few vehicles at a time.

Key Financing Players:

- Metropolitan Transit Authority
- NYC Department of Transportation
- Port Authority of New York / New Jersey
- New York Metropolitan Transportation Council
- U.S. Department of Transportation's Federal Transit Administration

Specific Examples and Analysis:

MTA Green Bonds

The Metropolitan Transit Authority (MTA) is responsible for developing mass transit for the New York metropolitan area, serving approximately 14.6 million people spread over 5,000 square miles. The MTA manages commuter rails, subways, buses, and ferries. It has been a leader in green bonds, with 11 issues since its first in 2016.

Overall, green bonds can play an important role in funding the MTA's \$51.5 billion Capital Program, which outlines the updates needed for rebuilding New York's transportation from 2020 - 2024.⁶⁶ Projects would modernize line segments to speed up the system, and provide safer, more reliable access to subway riders. The Capital Plan provides \$3.5 billion to replace more than 2,200 buses, and to add more than 175 new buses to the system, funded partly by new congestion pricing fees assessed on vehicles entering Manhattan during prime business hours.⁶⁷

Additional funding strategies are paramount now more than ever as the MTA faces a 'five alarm fire'.⁶⁸ During the height of the pandemic in early 2020, there was a 95% commuter dropoff that stabilized at around a 75% dropoff in September 2020. Compare this to only the 12% dropoff that occurred after the stock market crash in 1929, the MTA is clearly facing its most desperate financial situation in history. After the original CARES Act funding was utilized, the MTA was losing an approximate \$200 Million per day.⁶⁹ Financing must evolve to support this essential infrastructure that allows NYC to operate everyday.

Park City, Utah, Electric Bus Battery Leasing

Some of the biggest challenges in financing sustainable transportation are the high upfront costs associated with implementing new technology. When it comes to buses in

⁶⁶ <https://ny.curbed.com/2019/9/16/20869063/mta-capital-plan-nyc-subway-improvements>

⁶⁷ <https://ny.curbed.com/2019/9/16/20869063/mta-capital-plan-nyc-subway-improvements>

⁶⁸ <https://www.nytimes.com/2020/09/01/opinion/new-york-subway-coronavirus.html>

⁶⁹ <https://www.thomsonreuters.com/en-us/posts/government/reuters-newsmaker-patrick-foye-mta/>

particular, one innovative business model that provides a way to decrease upfront costs is bus battery leasing. This allowed the Park City Transit Authority in Utah to purchase six fully electric buses.⁷⁰

King County, Washington, Consolidated Purchasing

Municipalities and bus operators can further reduce upfront costs by consolidating their orders to receive more favorable terms. For example, King County Metro in Washington State ordered 500 buses from Canada-based electric bus manufacturer, New Flyer. Then it granted San Francisco an option to purchase 333 of those buses at a better price than either could have negotiated alone.⁷¹

Guangzhou Metro Green Bond

China is one of the world's largest polluters and has quickly become a leader in green bond issuance. Guangzhou Metro is the largest issuer of green bonds in China, and in January 2019, issued a \$441.6 million green bond for an urban rail project.⁷² The deal is made up of six tranches, which will be spread across six rail projects for subway construction work, and is secured by subway ticket sale receivables. The deal meets the Climate Bonds Initiative definition of green, where the underlying cash flows must relate to low-carbon assets, and iGreenBank provided a second party opinion. While it's exciting that Guangzhou Metro is leading in green bond issuance, it's also important to note that by China's definition, up to 30% of the funds raised by a green asset-backed security can be used for non-green purposes as long as at least 50% of revenue securing the bond comes from green sectors. This brings up concerns around additionality and greenwashing -- meaning, green bonds should only be issued if projects truly contribute to an ongoing transition to a low-carbon future.

Outlook

Due to the variety of stakeholders involved and high capital costs, successfully financing public transit is heavily reliant on public-private partnerships. This can be difficult to coordinate successfully, as illustrated by Nashville's failure to pass *Let's Move Nashville*, the city's \$9 billion municipal transit plan. The plan would have launched five light-rail lines, one downtown tunnel, four bus rapid transit lines, four new crosstown buses, and more than a dozen transit centers around the city, but failed for a host of reasons, including the cost, the scale, the funding source, and the financing structure.⁷³

But while Nashville's plan may have failed, the outlook is more hopeful for a large-scale infrastructure project in Querétaro, Mexico. The high-speed passenger rail line between

⁷⁰https://c40-production-images.s3.amazonaws.com/other_uploads/images/1726_BNEF_C40_Electric_buses_in_cities_FINAL_APPROVED_%282%29.orial.pdf?1523363881, pp. 15

⁷¹https://c40-production-images.s3.amazonaws.com/other_uploads/images/1726_BNEF_C40_Electric_buses_in_cities_FINAL_APPROVED_%282%29.orial.pdf?1523363881, pp. 15

⁷² <https://www.climatebonds.net/files/files/2019-01%20CN%20Guangzhou%20Metro.pdf>

⁷³ <https://www.citylab.com/transportation/2018/05/what-went-wrong-with-nashvilles-transit-plan/559436/>

Mexico City and Querétaro was suspended in 2015, but a public-private partnership may provide the needed funds.⁷⁴

Electric / Hybrid Vehicles

Overview

As stated earlier, the transportation sector in New York City accounts for 30% of NYC's total GHG emissions. In order to align with the SDGs and NYC's goal of reducing GHG emissions 80% by 2050, the transportation sector will need to transition from fossil-fuel options toward electric vehicles (EVs). Some obstacles to EV adoption, such as high vehicle costs and low battery range, are being overcome by manufacturers. Others, like the lack of EV charging infrastructure, still require solutions.⁷⁵

Types of Financing:

- New York State Drive Clean Rebate - this rebate provides a \$2,000 rebate off the price of an electric car at the time of purchase⁷⁶
- New York State Truck Voucher Incentive - the NYTVI covers up to 80% of the difference in cost between an electric truck and a comparable diesel truck⁷⁷
- Grants - the Low or No Emissions Vehicle Program provides state and federal grants to purchase low emissions transit buses⁷⁸

Key Financing Players:

- US Department of Transportation
- New York State

Specific Examples and Analysis:

NYC has many initiatives in place to set the stage for a transition to EVs. It remains unclear, however, how these projects will be financed. For example, New York City is a leader in electric fleet vehicles, with 1,224 on-road EVs and plug-in hybrids in the city's fleet.⁷⁹ The MTA has budgeted \$1.1 billion for 500 electric buses. New York's Clean Fleet sustainability plan outlines the pathway to aggressively cut emissions, and transition to zero-emissions, clean, and renewable fleet vehicles, and EVs are now the cheapest option for NYC's fleet.⁸⁰

The NYC Mayor's Office of Sustainability is working with DOT, ConEdison, and private sector partners to establish a citywide network of EV charging infrastructure.⁸¹ NYC is

⁷⁴ <https://mexiconewsdaily.com/news/public-private-partnership-eyed-for-queretaro-train/>

⁷⁵ *The Future of the Electric Car*, Sustainable Innovation and Impact, pp. 251

⁷⁶ <https://www.nysderda.ny.gov/All%20Programs/Programs/Drive%20Clean%20Rebate>

⁷⁷ <https://www.nysderda.ny.gov/All%20Programs/Programs/Truck%20Voucher%20Program>

⁷⁸ <https://www.transit.dot.gov/funding/grants/lowno>

⁷⁹ <https://www1.nyc.gov/site/dcas/agencies/fleet-sustainability.page>

⁸⁰ <https://qz.com/1571956/new-york-city-says-electric-cars-cheapest-option-for-its-fleet/>

⁸¹ <http://1w3f31pzvdm485dou3dppkcg.wpengine.netdna-cdn.com/wp-content/uploads/2019/05/OneNYC-2050-Efficient-Mobility.pdf>, pp. 27

also launching the first-in-the-nation pilot program to outfit light-posts with chargers for accessible charging for city fleet vehicles.⁸² A similar initiative in Seattle was met with opposition because the charging infrastructure interfered with bike lanes proposed in the city's Bicycling Master Plan. This brings up the question of prioritizing modes of sustainable mobility, and illustrates an important lesson that New York can learn from.

Further, there is an opportunity for delivery vehicle fleets to convert to EVs to reduce emissions, particularly as ecommerce deliveries increase. For example, in 2017, UPS committed to convert their NYC truck fleet from diesel to electric.⁸³ The initiative was financed in part by a public-private-partnership with NYSERDA, which provided \$500,000 for the development and testing of the conversion system.⁸⁴

Green bonds have also been effective in financing EVs. Nationally, consider Toyota and Meidensha Corporation as examples. When it comes to increasing production of EVs and hybrids, Toyota stands out with its issuance of four green asset-backed securities, totaling \$5.3 billion, through which it finances new retail loan and lease contracts for Toyota and Lexus vehicles that meet the Green Bond framework criteria.^{85,86} This includes the Prius, Camry hybrid, and other hybrid or alternative fuel powertrain vehicles with a minimum of 35 mpg, and smog rating of 8 or better.⁸⁷

In Japan, the Meidensha Corporation (Meiden) has raised green bonds to fund the mass production of electric vehicle parts.⁸⁸ The bond was issued in July 2019, is Climate Bond Certified, and will mature in 5 years. The \$55 million raised will go towards funding EV motors and inverters, which are a growing focus for the power and electrical equipment manufacturer. Issuing this bond allows Meidensha to expand its range of procurement resources and allow a broader range of stakeholders to take part in Meidensha's efforts to invest sustainably.

Outlook

The EV market has been growing and shows no signs of slowing down. Bloomberg New Energy Finance expects annual passenger EV sales to increase to 10 million in 2025, and 56 million by 2040.⁸⁹ As battery prices continue to fall, price parity with internal combustion engines is expected by the mid-2020s, which means EVs will become increasingly affordable. Further, electrification is spreading from passenger vehicles to other segments, such as buses and commercial fleets. Policy and EV tax credits continue to play a role in incentivizing growth in this still-nascent market. New York's goal to green its fleet by 2024 and develop charging infrastructure is a step in the right direction, as this sets the stage for a long-term commitment to EVs.

⁸²<http://1w3f31pzvdm485dou3dppkq.wpengine.netdna-cdn.com/wp-content/uploads/2019/05/OneNYC-2050-Efficient-Mobility.pdf>, pp. 27

⁸³<https://futurism.com/ups-nyc-electric-trucks>

⁸⁴<https://futurism.com/ups-nyc-electric-trucks>

⁸⁵ Toyota website - https://www.toyotafinancial.com/us/en/investor_relations/green-bond-programs.html; Toyota Financial Services Supports Environmental Sustainability by Expanding Green Bond Program; May 13, 2016

⁸⁶<https://docs.google.com/document/d/0B-sDn8KL4G3YNI9pNXzNDdYOWdEM1VwM1o5WmJKOWxIU3g4/edit#>

⁸⁷<https://www.toyotafinancial.com/content/dam/tmcc-webcommons/toyotafinancial/documents/investor-relations/green-bond/TMCC%20Green%20Bond%20Framework%20-%20December%202017.pdf>

⁸⁸<https://cleantechnica.com/2019/07/26/japanese-company-sells-green-bonds-to-fund-ev-parts-production/>

⁸⁹<https://about.bnef.com/electric-vehicle-outlook/#toc-viewreport>

Fuel Efficiency

Overview

On-road vehicles are the largest source of emissions for the transport sector, accounting for 96%, and vehicles that consume gasoline account for 80% of transportation-based emissions.⁹⁰ Solutions to decreasing on-road transportation emissions include fuel-efficient vehicles and cleaner fuels.

NYC has been a leader in implementing the use of biofuels. In 2016, Mayor Bill de Blasio signed Local Law 119, which set the stage to transition all fuel used in heating to B20 - which is 20% biodiesel and 80% petroleum diesel - by 2034. This was widely considered one of the most aggressive biodiesel laws in the U.S. NYC has a strong policy foundation in place, and is doing its part to apply this foundation to green its fleet and use renewable fuels to decrease emissions, however, financing for fuel efficiency is still nascent.

Key Financing Players:

- Sprague Energy
- Renewable Energy Group

Specific Examples and Analysis:

NYC has dramatically improved the fuel efficiency of its municipal fleet through the purchase of electric and alternative fuel vehicles. The city is aiming for its fleet to be carbon neutral by 2040, driven primarily by the implementation of renewable diesel.⁹¹ NYC is in the process of bidding a multi-year contract for renewable diesel, produced by the Renewable Energy Group (REG), and distributed by Sprague Energy.⁹² Renewable diesel is made from non-petroleum, renewable resources such as plants, natural fats, vegetable oils, and greases.⁹³ One major benefit of renewable diesel is that it can be used in engines that are designed to run directly on conventional diesel fuel. The renewable diesel is expected to reduce greenhouse gas emissions by 60% compared to traditional petroleum-based fuel. NYC started testing renewable diesel in a pilot program in 2018, making it one of the first cities in the Northeast to use renewable diesel, and met the program's goals in 2019.^{94, 95}

Outlook

Currently, renewable diesel is more widespread across California due to good logistics and distribution. While the current supply of renewable diesel is low, interest from fleets across the country could increase demand and in turn, increase product availability.

⁹⁰ <https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/GHG%20Inventory%20Report%20Emission%20Year%202016.pdf>

⁹¹ <http://1w3f31pzvdm485dou3dppkcq.wpengine.netdna-cdn.com/wp-content/uploads/2019/05/OneNYC-2050-Efficient-Mobility.pdf>, pp. 27

⁹² <https://www.government-fleet.com/301512/nyc-to-use-domestically-produced-renewable-diesel>

⁹³ <https://www.government-fleet.com/156621/what-you-need-to-know-about-renewable-diesel>

⁹⁴ <https://www.greenfleetmagazine.com/332292/new-york-city-says-renewable-diesel-pilot-met-its-goals>

⁹⁵ <https://www.government-fleet.com/332292/new-york-city-says-renewable-diesel-pilot-met-its-goals>

Overall, renewable diesel is a relatively turnkey solution, and is a particularly simple way for fleets that run on traditional diesel to convert to a more fuel-efficient option overnight. Further research into tradeoffs of adopting biofuels, however, should certainly be examined - the World Resources Institute cites that biofuels are much less productive than other forms of energy, and scaling adoption could come at the expense of exacerbating the food gap.⁹⁶ More work needs to be done on understanding the challenges associated with the production of renewable fuel before involving the private sector in investment opportunities to further scale efficiency.

Congestion Management

Overview

New York City has recently been seen as the fourteenth most congested city in the world -- drivers averaging 140 peak hours stuck in traffic per year⁹⁷ and the number of registered household vehicles has increased 8.8% since 2010.^{98,99} The number of for-hire vehicles increased 22.7% from 2016 to 2017, and the average number of daily deliveries to households in New York City tripled to more than 1.1 million shipments from 2009 to 2017. With delivery trucks double-parking across streets and the continued growth of Uber and Lyft, congestion has worsened.

Congestion also comes at an economic and environmental cost -- the city's Independent Budget Office estimates that congestion causes 300 million gallons of extra fuel to be consumed annually in NYC.^{100,101} Further, citywide bus speeds have declined to 7.58 mph, the lowest average speed recorded in decades. Overall travel speeds in Manhattan's Central Business District are down 22% since 2010.

There are, however, some encouraging statistics when it comes to improving congestion. The number of daily cycling trips has reached 30,000 and continues to grow, and the citywide ferry service has also increased by 4,000 trips per day, marking a 15% jump since 2010.

As population, employment, and tourism continue to increase, NYC must continue to implement solutions to manage congestion. Government is focused on increasing travel speeds, increasing walking trips, and reducing auto use, particularly in the Central Business District.

⁹⁶ *Creating a Sustainable Food Future*, World Resources Institute, pp. 18

⁹⁷ <https://inrix.com/scorecard-city/?city=New%20York%20City%2C%20NY&index=14>

⁹⁸ <https://ny.curbed.com/2018/2/6/16979696/new-york-city-traffic-congestion-second-worst#targetText=Additionally%2C%20New%20York%20drivers%20spent,being%20attributed%20to%20daytime%20traffic.&targetText=INRIX%20reports%20that%20on%20average,percent%20from%20the%20previous%20year.>

⁹⁹ <https://www1.nyc.gov/html/dot/downloads/pdf/mobility-report-2019-print.pdf>

¹⁰⁰ <https://ny.curbed.com/2018/1/18/16903152/nyc-traffic-congestion-cost-analysis>

¹⁰¹ <http://onenyc.cityofnewyork.us/initiatives/reduce-congestion-and-emissions/>

Types of Financing:

- Congestion pricing
- Green banks

Key Financing Players:

- MTA
- New York City Department of Transportation
- Port Authority of New York / New Jersey
- NYC Taxi and Limousine Commission
- NY Metropolitan Transportation Council
- U.S. Department of Transportation's Federal Transit Administration
- Federal Highway Administration
- The Centre for Public Impact¹⁰²

Specific Examples and Analysis:

NYC has plans to address congestion in Manhattan's Central Business District with the implementation of congestion pricing expected in 2021.¹⁰³ This program will electronically charge vehicles entering Manhattan for cashless tolling at bridges and tunnels. Fees are expected to be between \$11-14 for cars, and \$25 for trucks during prime business hours.¹⁰⁴ Fees will likely decrease at nights and on weekends. As the MTA's financial woes have worsened, congestion pricing has gained momentum in becoming a key revenue source for financing improvements to public transit. 80% of the revenue will go toward city improvements, particularly to improving the subway and the city's electric bus fleet. 10% of the revenues will go toward the major suburban commuter trains. This is an example of creating an additional revenue stream, and directing it toward continued green improvements.

London implemented a similar congestion charge in 2003, which has been considered largely successful. The number of vehicles driving into Central London is 25% lower than it was 10 years ago, and the pricing has been particularly successful in deterring personal use cars from entering the zone -- Central London saw a 39% decrease in private cars from 2010 to 2014.¹⁰⁵ Congestion pricing in New York is expected to have an immediate impact on the number of cars entering the Central Business District, and simultaneously provide a revenue stream that can be used for further improvements to transportation and mobility infrastructure.

In addition to decreasing the number of on-road vehicles, NYC is also supporting the use of sustainable forms of transportation, such as cycling. The City of New York's Bike Safety Plan outlines a number of improvements that will make biking safer and therefore encourage New Yorkers to take more frequent cycling trips. Some of these

¹⁰² <https://www.centreforpublicimpact.org/case-study/philadelphias-indego-bike-sharing-system/>

¹⁰³ <https://www1.nyc.gov/html/brt/downloads/pdf/better-buses-action-plan-2019.pdf>, pp. 7

¹⁰⁴ <https://www.nytimes.com/2019/04/24/nyregion/what-is-congestion-pricing.html>

¹⁰⁵ <https://www.citylab.com/transportation/2018/04/londons-congestion-charge-needs-updating/557699/>

improvements include expanding the bike lane network and growing Citi Bike.¹⁰⁶ Daily bike trips totaled 500,000 in 2017, more than three times 2010 levels.¹⁰⁷

While the Bike Safety Plan doesn't include financing specifics, the New York Green Bank has helped finance the expansion of Citi Bikes, providing a \$43.4 million term loan and a \$5 million seasonal variable funding note, which was critical to scaling the bike sharing program.¹⁰⁸ Citi Bike had previously encountered challenges accessing private capital that was structured and priced to reflect the strength of its business model, which was largely due to the nascent nature of the bike sharing asset class. The Green Bank used a replicable securitization structure to make this type of transaction scalable, with the goal of catalyzing further private investment in the space. Further, the Green Bank's investment has helped develop the bike-sharing asset class's track record, which will be critical for attracting private capital in the future. The New York Green Bank is leading the way in investing in sustainable infrastructure. Financing the SDGs will require a similar form of participation and innovation from more traditional financial institutions.

The proliferation of ecommerce also contributes to congestion. On average, 44.9 % of New Yorkers receive a delivery at home at least once a week.¹⁰⁹ FedEx, FreshDirect, Peapod and UPS are the most significant contributors -- these four companies accumulated over 515,000 summonses for parking violations in 2018, totaling \$27 million in fines.¹¹⁰ To address this, the NYC Department of Transportation launched an off-hours delivery initiative to encourage goods deliveries between 7pm and 6am.¹¹¹ Amazon has also launched last-mile warehouses which unlock opportunities for sustainable mobility options, such as bikes or scooters to complete last-mile delivery and decrease on-street congestion. These warehouses are typically bought by private equity firms -- for example, Amazon's warehouse in the Bronx was purchased by MRP Realty, and AEW Capital Management for \$26.5 million.¹¹² While these warehouses have brought local jobs to neighborhoods, residents are concerned about the environmental impacts of the warehouses and the impact that they will have on local congestion.

There are also new innovative business models being tested to increase mobility in urban areas. Consider the ridesharing app, Carma. Carma verifies that there are at least two passengers in an automobile which then qualifies the car for a 50% toll discount -- with three passengers, that discount increases to 100%. Carma has partnered with governments, such as the Bay Area Rapid Transit (BART) to provide incentives to aid in decongestion. The app estimates that it enables 250 daily carpool trips, whereas the alternative of constructing new lanes to provide the same capacity is estimated to cost anywhere from \$5.8 million to \$17.4 million.¹¹³ Identifying successful,

¹⁰⁶ <https://www1.nyc.gov/html/dot/downloads/pdf/bike-safety-plan.pdf>

¹⁰⁷ <https://www1.nyc.gov/html/dot/downloads/pdf/bike-safety-plan.pdf>

¹⁰⁸ NYGB Transaction Profile, *Expanding Urban Bike Sharing Program in NYC*, New York Green Bank, pp. 1

¹⁰⁹ <https://www1.nyc.gov/html/dot/downloads/pdf/mobility-report-2019-print.pdf>

¹¹⁰ <https://www.nytimes.com/2019/10/27/nyregion/nyc-amazon-delivery.html>

¹¹¹ <https://www1.nyc.gov/html/dot/html/motorist/offhoursdelivery.shtml>

¹¹² <https://www.welcome2thebronx.com/2019/01/16/amazon-is-coming-to-the-bronx-will-open-a-last-mile-warehouse-in-hunts-point/>

¹¹³ <https://www2.deloitte.com/us/en/pages/consulting/solutions/smart-mobility.html>

innovative business models, and scaling up these solutions represents another useful lever to pull in managing congestion.

Outlook

Congestion pricing and support for sustainable modes of transit, such as cycling, scooter-sharing, and walking are useful solutions for NYC to address congestion. Other solutions may include smart parking to provide drivers with real-time data for parking availability, and curbside management to enforce available curb space for parking. The emergence of new business models that address mobility issues signals an opportunity for green banks, private equity, and venture capital. As investors become more familiar with financing less-tested asset classes, the risk associated with these newer projects might decrease, and in turn, traditional private investors may become more interested in financing the transition.

Role of Philanthropy

Philanthropy has played a critical role in establishing the Shared-Use Mobility Center (SUMC), which is focused on providing research, strategic planning and implementation, and technical assistance for projects in the mobility space. For example, the Hewlett Foundation's sponsorship has spurred the Shared Electric and Mobility Initiative, which is helping to catalyze research development, host stakeholder workshops, and share successful case studies about the use of electric vehicles and sustainable mobility.¹¹⁴ Foundations play a key role in financing research initiatives, which identify existing challenges and gaps. Once these gaps have been identified, the private sector can step in to help fill the remaining unmet need. While funding knowledge sharing and research may not seem immediately investable, it does provide an important foundation for developing a broader vision around a sustainable mobility future, and can subsequently unlock further financing for city initiatives.

Conclusion

The need for sustainable urban transport is greater than ever before, yet financing is nowhere near enough to develop these sustainable transportation systems.¹¹⁵ Private investment in urban transport has fallen and is currently at a 10-year low. Governments are struggling to do their part in committing to infrastructure improvements, but face political headwinds for projects, as illustrated by New Jersey Governor Chris Christie cancelling the Gateway Project, which would have improved rail transportation and economic growth between New York and New Jersey. In New York City in particular, the MTA answers to New York State government, which has been resistant to new forms of financing, and the 2018 Capital Plan was criticized for funding expansion projects the government wanted, rather than updates that would benefit the system as a whole.¹¹⁶

¹¹⁴ https://sharedusemobilitycenter.org/wp-content/uploads/2019/10/SUMC_AnnualReport_09.26.19.pdf

¹¹⁵ <https://blogs.worldbank.org/transport/maximizing-finance-sustainable-urban-mobility>

¹¹⁶ <https://www.citylab.com/transportation/2019/01/fix-new-york-city-subway-mta-funding-congestion-pricing/579262/>

Additionally, investors may have concerns about mobility investment for any number of reasons -- urban transit often doesn't cover operating and maintenance costs, or capital expenses, and upgrading existing systems to sustainable transit (e.g. to light rail, e-buses, etc.) requires large up-front capital expenditures. Solutions such as reallocating funds away from fossil fuel-centric activities and toward sustainable transport options; turning to institutional investors, such as pension funds and insurance companies for long-term financing; and engaging local authorities, including state-owned enterprises or national governments to issue commercial municipal debt may help increase the flow of investment to mobility.

The future of mobility could look quite different from the crippled mobility infrastructure that is in place today. Improvements to public transportation infrastructure and the uptake of car sharing could reduce the number of on-road vehicles. Intelligent traffic systems could communicate with autonomous vehicles to map efficient routes and further reduce congestion and commute times. Electrification and renewable fuel sources could replace some of the fossil fuels that we use today, decreasing total emissions from the transport sector.

Scope for Further Research

A more ambitious project will be needed if New York City is to make meaningful progress toward mobility solutions. This will require bringing stakeholders together -- foundations, banks, and politicians -- in the tri-state area to develop regional solutions to drive the future of mobility. A better understanding of why public funding has fallen short, and a playbook for innovative financing solutions that involve the private sector helping to close this gap would be useful. Perhaps a coalition is needed to better understand the economic implications of failure to address sustainable mobility, and to continue to research and identify creative mechanisms for financing to quickly mobilize capital and implement solutions. Freshfields' Circular New York City initiative to bring together business leaders, financial institutions, academia, and think tanks to advise NYC on climate challenges might be looked to as a model.¹¹⁷

¹¹⁷ http://news.freshfields.com/r/Global/r/5543/freshfields_appoints_timothy_wilkins_as_global_partner

Renewable Energy

Overview

In 2015, New York State implemented one of the most aggressive climate goals in the country, passing the Clean Energy Standard (CES)¹¹⁸, which calls for 50% of New York State’s electricity to be produced by renewables by 2030. Recently, however, Governor Cuomo has called for the expansion of this standard from 50% to 70%, in support of his Reforming the Energy Vision (REV) of creating a “clean, resilient, and affordable energy system for all New Yorkers.”¹¹⁹

New York City has similarly set aggressive policy goals, enacting in 2019 the Climate Mobilization Act (CMA).¹²⁰ The CMA mandates carbon emission reductions through energy efficiency retrofits and transition to renewable energy sources.

This section details the landscape of renewable energy generation across wind, solar, and ground source heat. Additionally, we cover the Renewable Energy Credit (REC) markets that facilitate clean energy procurement, and describe some case studies of philanthropic capital being deployed to catalyze more renewable generation.

The General Finance Instruments

Some key financing structures and incentives apply across categories of renewable energy production. These include Power Purchase Agreements (PPAs), Investment Tax Credits (ITC), and Property Assessed Clean Energy (PACE) financing. Additionally, the concept of ‘de-risking’ and the various risk subcomponents guide the landscape of rates.

The Power Purchase Agreement

Under a PPA contract, a buyer agrees to purchase the energy generated from a clean energy project at a specific rate for a specific time (usually 10 to 25 years). This contract enables the clean energy producer to borrow against the contracted future cash flow. Commonly, PPAs are leveraged to offer building owners low or no upfront costs — in solar, for example, the energy developer owns and operates the panels, simply selling the energy back to the building owners as consumers or selling into the grid creating community solar.

Investment Tax Credits (ITC)

¹¹⁸ <http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b44C5D5B8-14C3-4F32-8399-F5487D6D8FE8%7d>

¹¹⁹ <https://static1.squarespace.com/static/576aad8437c5810820465107/t/5b43ab7570a6ad28d506172e/1531161461418/CES-ov-fs-1-v4.pdf>

¹²⁰ <https://council.nyc.gov/data/green/>

Investment Tax Credits are a longstanding federal policy wherein investors can deduct, depending on the type of technology, 30% of a renewable energy project's cost from their tax liabilities. This requires sufficiently large tax liabilities against which the incentive can be deducted. As a result, the field of renewable energy finance has developed around the concept of "Tax Equity Investors" — large institutions (such as Goldman Sachs, Citi, etc.) which can participate in a renewable project so that the project can reap the reward of the ITC. Complex financing structures have been engineered to the point of maturity to optimize risks and rewards among building owners, solar developers, equity financiers, and tax equity partners.

The federal ITC is expected to decline to 10% in 2022, and is slated to go away, unless Congress chooses to change the policy. Moreover, the supply of tax equity partners is decreasing; after the 2017 Tax bill lowered the federal corporate income tax from 35 to 21 percent, partners have fewer tax liabilities to write off.

Property Assessed Clean Energy (PACE) Financing

PACE is a finance mechanism to effect policy incentives for energy projects tied to buildings. Under PACE programs, building owners are given the upfront capital to finance clean energy enhancements with repayment as part of the building's tax bill. The upfront capital can come from private as well as public sources. PACE financing can be accessed by residential or commercial building owners directly in the form of a loan. Or, developers can leverage PACE financing to decrease the cost of lease or no-money-down PPA installations. It is also possible to wrap an Energy Savings Agreement (ESA) or PPA between a property owner and a third party, allowing PACE assessments to service these agreements alongside other debt vehicles.

PACE can be an attractive investment because PACE debt is senior to all other debt in a building. That said, debt obligation requirements complicate the PACE process for retrofitting existing buildings—as PACE financing requires permission from senior level lenders. Senior lenders in general are often unwilling to take an inferior position in the capital stack for existing buildings. Most mortgages are held by the largest banks in New York City¹²¹—providing an opportunity to reach an agreement with those banks that would allow for widespread use of PACE financing for retrofit projects.

De-risking

Most renewable projects face a combination of technology, project development, and pricing risk. Reductions in any of these risks reduce the cost of capital for clean energy.

Technology risk is the reliability of a given renewable technology to produce energy. While there are many innovative technologies, most financing centers on mature technologies with low risk. After decades of development and deployment, financial markets have good actuarial data on Photovoltaic (PV) solar panels and wind. Offshore wind and solar + storage can carry slightly more technological risk.

Project development risk is directly tied to siting, permitting, and transmission access.

¹²¹ <https://www.forbes.com/sites/greatspeculations/2018/06/27/a-breakdown-of-the-loan-portfolios-of-the-largest-u-s-banks-2/?sh=3a969a5126b2>

Siting risk has to do with the transference of land ownership, environmental and cultural risks, and even usage or safety hazards that might result from the project location or use for some facet of operations (ex: transmission lines through a forest). Siting challenges can postpone a project for years if there is no location that meets the various specifications of the projects, and the regulations of the jurisdiction. And, if a site is found, permitting can also bury a project in paperwork that could take years to process, depending on the complexity of regulations and the efficiency of permitting processes. Finally, transmission access can multiply the length of time the process takes. If there are no transmission lines readily accessible to a project site (which is often the case with large wind or solar farms), then an entirely new siting and permitting process must take place to decide where and how to place those transmission lines.

Pricing risk relates to the market for electricity. When the future market price for electricity is uncertain, so too are cash flows tied to the sale of electricity, though it's important to note that there are many commercial enterprises interested in buying power under long-term contracts (PPAs) at a fixed price. Reducing the spread of forecasted cash flows can make a tremendous difference in the viability of renewable energy projects. Many PPA agreements lock in a fixed price or schedule of prices in order to mitigate pricing risk.

Government programs can meaningfully affect pricing risk. Feed-in-tariff programs designate government entities as the renewable energy buyers at a government-guaranteed price schedule. In contrast to a PPA with a renewable energy buyer, government entities are less likely to risk defaulting on a contract. The German federal feed-in-tariff program, for example, is credited with driving solar production to above 30% of gross electricity production.

Wind

Overview

Wind energy is growing both in the U.S., and globally, and is expected to yield \$85 billion in economic activity from 2017 through 2020 from taxes, manufacturing, construction and operation.¹²² Wind projects hold many advantages over other energy sources -- projects can be constructed relatively quickly (especially when compared with larger power plants), and wind energy doesn't generate air pollution, greenhouse gas emissions, or waste byproducts. From small-scale and community projects, to larger offshore wind projects, wind energy provides investors of all sizes the opportunity to contribute to social and environmental causes while generating significant economic benefits. The U.S. Department of Energy's Wind Vision Report,¹²³ for instance, says that wind energy in the U.S. will potentially support 600,000 jobs by 2050. The report also anticipates it will save consumers \$280 billion by 2050.

¹²² <https://www.energy.gov/eere/articles/5-things-you-should-know-about-wind>

¹²³ <https://www.energy.gov/eere/wind/wind-vision>

That being said, there are challenges to investing in wind. Wind can be an unpredictable energy source, as wind speeds rise and fall. Turbines also create noise pollution and can have adverse biological and environmental impacts, disrupting the natural environment in which they are installed. In a project development sense, wind – like solar and geothermal – presents a tradeoff between high upfront costs to development, and low operating costs. Incentives are often needed to make financing wind energy competitive in the short run.¹²⁴

Additionally, New York City doesn't offer a lot of space for installing wind turbines. One solution is offshore wind, which is advantageous because offshore winds tend to be more powerful and more consistent than on land. NYS is committed to investing in offshore wind, and has provided a strong policy foundation upon which to do so. The New York State Climate Leadership and Community Protection Act “puts the state on a path to adopt measures to reduce statewide greenhouse gas emissions 85% by 2050, and achieve net zero emissions in all sectors of the economy.”¹²⁵ To reach this target, the State is supporting the development of 9,000 megawatts of offshore wind energy by 2035, enough to power up to 6 million homes.¹²⁶ In 2019, New York State entered into contracts for two large offshore wind projects that will generate nearly 1,700 megawatts of energy, enough energy to power over 1 million homes, create more than 1,600 jobs, and result in \$3.2 billion in economic activity.¹²⁷¹²⁸

The following section will detail some of the financing mechanisms that can be used for wind energy, and specific examples to highlight innovative financing for successful projects. Many contracts operate under a “take or pay” model, where if a project generates electricity, the PPA counterparty is required to buy the power at a fixed price. If the project is financed with a fixed-rate debt instrument, this leaves the developer or project owner long an annuity, but exposed to both counterparty credit risk and performance risk to the equipment. It is important for project owners and developers to obtain a guarantee or insurance against equipment failure.

Types of Financing:

- [Tax equity financing](#) -- where transactions involve one party agreeing to assign the rights to claim the tax credits to another party in exchange for an equity investment.
- Production Tax Credits - which provide rebates based on the amount of energy produced to incentivize investment in renewables. The PTC was the main contributor to the development of the wind industry, as it brought wind closer to cost competitiveness with the grid.¹²⁹ PTCs have been renewed for 2020.

¹²⁴ <https://www.renewableresourcescoalition.org/wind-energy-pros-cons/>

¹²⁵ <https://www.nysenate.gov/legislation/bills/2019/s6599>

¹²⁶ <https://www.nyserda.ny.gov/All%20Programs/Programs/Offshore%20Wind>

¹²⁷ <https://www.nyserda.ny.gov/About/Newsroom/2019-Announcements/2019-07-18-Governor-Cuomo-Executes-the-nations-largest-qs-w-agreements>

¹²⁸ <https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Focus-Areas/NY-Offshore-Wind-Projects>

¹²⁹ <http://www3.cec.org/islandora/en/item/2295-renewable-energy-financing-case-studies-lessons-be-learned-from-successful-initiatives-en>

- Project finance -- the long-term financing of infrastructure and industrial projects based upon the projected cash flows of the project rather than the balance sheets of its sponsors.
- Renewable Energy Credits (RECs) -- RECs play an important role in accounting, tracking, and assigning ownership to renewable electricity generation and use. RECs also have value because regulation requires certain entities to buy them, making them –an important source of revenue for an alternative energy project.
- Power Purchase Agreements (PPA) – An arrangement in which a third party installs, owns and operates an energy system on a customer’s property.¹³⁰
- Green bonds – A fixed-income instrument specifically earmarked to raise money for climate and environmental projects.¹³¹

Key Financing Players:

- Citi
- Société Générale
- ConEdison, a NYS electric utility
- Vestas, a wind-turbine manufacturer
- GE Renewable Energy
- Wells Fargo
- NY Green Bank
- Siemens
- US Bureau of Ocean Management (BOEM)
- New York State Energy Research and Development Agency (NYSERDA)
- New York State Department of Environmental Conservation

Specific Examples and Analysis:

Sunrise Wind and Empire Wind: State-sponsored Wind Farms

NYS has made the “single largest commitment to offshore wind by a state in U.S. history to grow our clean energy economy, combat climate change and achieve economy-wide carbon neutrality,” according to Alicia Barton, President of the New York State Energy Research and Development Agency (NYSERDA). In July 2019, the State awarded two offshore wind contracts for a combined capacity of almost 1,700 megawatts (MW) in waters off Long Island. For context, this is about 3x the amount of energy produced by the typical 600 MW coal plant.

The two projects are the Sunrise Wind project, which is an 880 MW project, and the Empire Wind Project, which is 816 MW. The Sunrise project was awarded as a 50-50 joint venture to Ørsted, a Danish company, and Eversource, New England’s largest utility company. The project will be located 30+ miles off the coast of Montauk.

¹³⁰ <https://betterbuildingssolutioncenter.energy.gov/financing-navigator/option/power-purchase-agreement>

¹³¹ <https://www.investopedia.com/terms/g/green-bond.asp>

Construction will begin in 2022, and operations are expected to begin in 2024.¹³² The second contract for Empire Wind was awarded to Norwegian energy company, Equinor. The Empire Wind project will cover an area of 80,000 acres and will sit to the southeast of Long Island. Total investment in the facility will be \$3 billion, and it will power more than 500,000 homes.¹³³ Ultimately, implied CO₂e based on electricity consumption and the resulting fines under Local Law 97 can only be reduced by purchasing clean energy if the project is connected to the Con Ed Service (zone J) – the Empire Wind Project is positioned to help reduce these emissions.

Middelgrunden: Community Cooperative Wind Farm

Community wind represents an innovative financing model. Denmark's Community Initiative in Middelgrunden is a good example. In 2001, it was the world's largest offshore wind farm and was cooperatively owned. In this model, a wind cooperative establishes a partnership with the electric utility, purchases turbines, selects the best site available, negotiates a PPA with the utility, and funds construction. Ultimately, it sells electricity to the utility under favorable conditions, and shares the revenue among the cooperative members.¹³⁴ The Cooperative purchased 20 turbines with 2 megawatts capacity each. The turbines are 50% owned by the ~10,000 investors in the Middelgrunden Wind Turbine Cooperative, and 50% owned by the municipal utility. The source of funding for the co-op is the sale of shares, which entitles the owner to an average annual production of 1 kilowatt. The co-op is not allowed to go into debt by its bylaws, so in the early days, it financed its work by selling pre-subscriptions. Nearly 30,000 of 45,000 total shares were sold in pre-subscriptions. What's also important is that the project risk was minimal because the first 12,000 full-load-hours were guaranteed at a price of 0.6 DKK/kWh by the Danish Electricity Act. The only direct contribution from the government was a loan to finance the project's feasibility study, provided by the Danish Energy Authority. Overall, community wind is more than an investment strategy -- it's also a stakeholder engagement / community support building strategy. That is, Middelgrunden had all the investors they needed, but they created a set-aside investment for the local community to allow them to share in the profits from their own renewably-generated energy needs.

Block Island / Vineyard Wind: Commercial Offshore Wind Farm¹³⁵

The Block Island Wind Farm was the first U.S. offshore wind project to reach financial close. In 2015, the project finalized a \$298 million round of financing to construct a 30MW wind farm that will sit off the coast of southern Rhode Island. The financing for the project was primarily handled by Société Générale, which underwrote 100% of the transaction and syndicated the debt after close, with the final financing consisting of a \$268 million construction/term loan, with \$30 million for letters of credit. In addition to this \$298 million, Deepwater (now Ørsted) also received \$70 million in equity funding from its owners with D.E. Shaw & Co. leading the way.^{136,137} Citi and GE Financial

¹³²NYSERDA Offshore Wind Open House Presentation, pp. 18 (<https://www.nyserda.ny.gov/All-Programs/Programs/Offshore-Wind/Contact/Events>)

¹³³ <https://www.cnn.com/2019/07/19/new-york-gives-green-light-for-two-huge-offshore-wind-projects.html>

¹³⁴ <https://www.chelseagreen.com/2009/a-case-study-in-community-wind-denmark/>

¹³⁵ <https://www.vineyardwind.com/projects>

¹³⁶ <https://www.societegenerale.com/en/sustainable-commitments/deepwater-wind>

Services were also investors in the project, taking out tax equity to provide capital.¹³⁸ The choice of low-risk tax equity investments for both Citi and GE Financial Services highlights an interesting example of large banks looking to participate in offshore development, but are only prepared to take certain risks—other financiers, such as D.E. Shaw in this case, will need to step in and accept construction risk and other risk.

The financial close and start of construction for Ørsted's Block Island wind farm has since spurred more projects along the coast of New England. Vineyard Wind's \$2.8 billion project aims to provide 800 MW of power to 400,000 homes in Massachusetts. Vineyard Wind's project is set to be the first large-scale offshore wind project in the United States. It has been delayed, however, by the federal government extending the project's environmental impact review. And it is currently facing intense uncertainty due to a federal roll back of the Investment Tax Credit (ITC) incentive for wind projects. Much of the project's pricing competitiveness rests on its success in qualifying for this ITC. Even though the project has already secured the 24% from its 2017 start date, the project needs to be completed by 2021—a year ahead of its contracted start date of 2022. Hence, the project is facing a two-sided dilemma of tight construction deadlines coupled with an elongated review process inhibiting the start of construction. Not only does this put a strain on the ability to construct the actual turbine arrays, but it also puts the project's ability to woo tax equity investors in jeopardy, an important source of funding for this project.

The tendency for the Trump administration to prioritize fossil fuels over renewables is one of the main factors in the challenges facing Vineyard Wind. As a result, there are concerns that companies might shy away from such projects in the future.¹³⁹ Industry confidence in the ability to gain and maintain permitting along with expected incentive programs will be a key factor to watch when considering ways to finance offshore wind for New York City.¹⁴⁰ Biden's election may be key in driving this confidence, especially considering his potentially aggressive Climate plan and specific focus on permitting processes that support sustainable energy projects.¹⁴¹ This is especially true with respect to Vineyard Wind's success. This project is expected to set the tone for the growth of the offshore wind industry—which is expected to reach \$70 billion over the next decade. Thus, in many ways, the growth rates of offshore wind and the speed at which such projects are developed is contingent on the confidence that such projects can be successfully completed in the face of community opposition to wind turbines along coastlines and current federal policy attempting to slow the transition from conventional energy generation.

¹³⁷ <http://dwwind.com/press/block-island-wind-farm-now-fully-financed/>

¹³⁸ <https://www.businesswire.com/news/home/20161011005413/en/GE-Energy-Financial-Services-Citi-Provide-Tax>

¹³⁹ <https://www.bostonglobe.com/business/2019/08/14/feds-delay-puts-crucial-tax-credit-jeopardy-for-vineyard-wind/TGqfGZeAY0uOb90KNcbomM/story.html>

¹⁴⁰ <https://www.bloomberg.com/news/articles/2019-08-09/u-s-is-said-to-extend-review-of-first-major-offshore-wind-farm>

¹⁴¹ <https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/>

Crow Lake Wind Project, South Dakota: Crowdfunded Wind Farm¹⁴²

Another interesting and innovative funding mechanism that has precedent in the United States is crowdfunding. The South Dakota Wind Partners Crow Lake wind project is the largest wind farm owned by a co-op, and was funded almost entirely by residents. The overall cost of the project was \$21.5 million, \$16 million of which was funded by residents in less than 60 days after 27 town halls. Notably, companies were barred from investing in the project, and residents who incorporated their farm and leveraged it as equity were the only companies allowed to partake in the investment round. In addition to resident-backed funding, the project also received \$80,000 in seed funding from East River Electrical Cooperative, as well as a \$6.7 million grant through a tax incentive funded by the American Recovery and Reinvestment Act (also called the 1603 program).

Shares in the wind farm were sold at \$15,000 per share, and many residents purchased multiple shares. These shares paid out dividends like a fixed-income investment, with a 7% return paid semi-annually, and proved to be a lucrative investment as the wind farm began operating at 9% above the initial projected capacity.

Community resistance to offshore wind is one of the more significant barriers to scaling the technology. Both the Block Island and Sunrise Wind projects faced immense community pressure that placed additional costs on the project and extended the timeline. Community investment and ownership through a crowdfunding platform can, however, help align interests between the community and the offshore industry.

As New York moves closer to implementing large-scale offshore wind, there remains a lot to learn from Europe's financing strategies. One interesting fact to note is that much of European offshore wind is owned by pension funds. In particular, Danish pension funds PFA and PKA committed over £300M in the Walney Extension offshore wind farm project—the largest direct commitment by either pension fund ever, and one that gives PFA and PKA each a 25% stake in the facility. PFA and PKA also issued investment-grade bonds to BlackRock, Aviva, and more.¹⁴³ Many UK Local Authority Pension plans also are invested in offshore wind, including Surrey Council, Southwark Council and East Riding Council.¹⁴⁴

Outlook

Overall, there are many investment vehicles that can be leveraged for wind financing. The Empire and Sunrise offshore wind projects represent a strong start in fulfilling NY State's long-term commitment to developing 9,000 megawatts of offshore wind, but the State will need to continue to work with industry leaders to develop wind energy capacity as offshore wind is still a relatively nascent industry. Large-scale wind projects come with high upfront capital costs and relatively low revenue during operational

¹⁴² *ibid*

¹⁴³ <https://www.ipe.com/news/investors/danish-pension-funds-invest-2bn-in-worlds-biggest-offshore-wind-farm/realassets.ipe.com/news/investors/danish-pension-funds-invest-2bn-in-worlds-biggest-offshore-wind-farm/10021508.fullarticle>

¹⁴⁴ <https://www.4coffshore.com/news/glennmont-raises-funds-for-european-wind-nid13759.html>

periods, leading to long payback periods. New York State currently has 20 wind projects throughout its upstate region, totaling over 1,800 MW in capacity.¹⁴⁵ New York State's wind resources have the potential to fulfill more than half of the state's electricity needs.¹⁴⁶

The other challenge facing New York wind has to do with overburdened transmission lines that struggle to transfer electricity generated by wind upstate to the downstate region. The New York Independent System Operator calls this problem the tale of two grids, as much of upstate New York's wind energy is not utilized to its fullest capacity.¹⁴⁷ Hence, in addition to further investing in wind technology, there also needs to be a focus on addressing the overwhelmed energy infrastructure in the state.¹⁴⁸ As New York begins to invest in offshore, however, more energy will be produced downstate, which will also decrease reliance on long transmission distances and increase local grid interconnection—though better integrating upstate and downstate energy production should be a top priority to improve energy efficiency grid-wide.

Solar

Overview

All it would take to power the USA with solar is 11.2 million acres, or 0.6% of the country's surface area.¹⁴⁹ If that conjures a mental image of vast deserts of solar arrays, therein lies the catch: getting the power from the source to the consumer, at the right time, at scale, is complicated.

To achieve New York State's ambitious goal of 70% renewable energy by 2030 and 100% clean energy sources by 2040, solar must grow exponentially. Currently, the State generates just 1.86% of its electricity from solar.¹⁵⁰ NY solar is projected to grow from about 500 MH capacity as of 2019 to about 3500 MH by 2030.¹⁵¹ In April 2020, the State announced an initiative to accelerate solar efforts, establishing an Office of Renewable Energy Siting to consolidate the environmental review of major renewable energy facilities.¹⁵²

¹⁴⁵ https://www.dec.ny.gov/docs/permits_ej_operations_pdf/windstatuscty.pdf

¹⁴⁶ <https://www.dec.ny.gov/energy/40966.html>

¹⁴⁷ https://www.syracuse.com/news/2017/05/tale_of_two_grids_upstate_wind_power_needs_more_extension_cords_to_nyc.html

¹⁴⁸ <https://www.politico.com/states/new-york/albany/story/2018/01/09/slow-progress-on-transmission-lines-worries-energy-industry-180023>

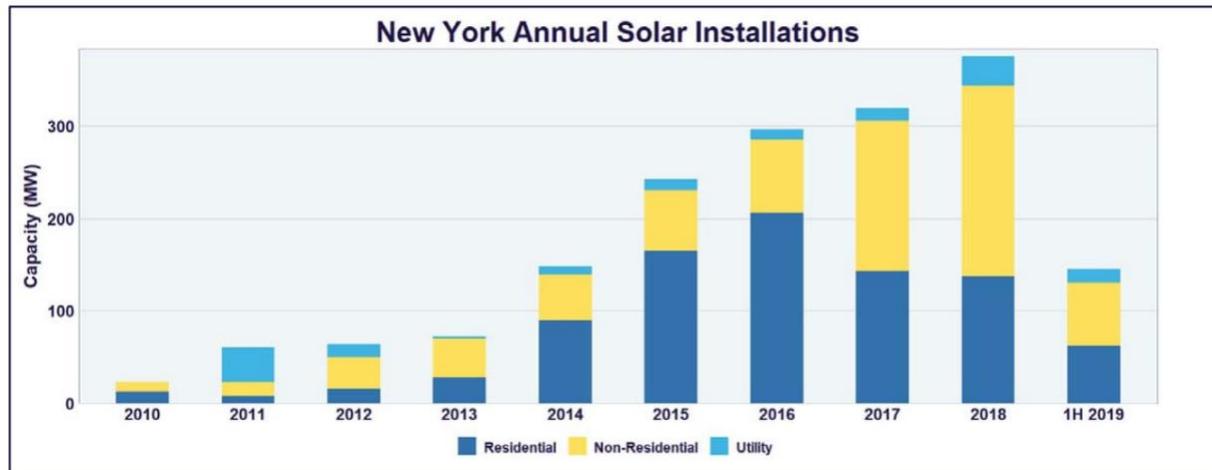
¹⁴⁹ <https://www.good.is/infographics/solar-power-all-of-america>

¹⁵⁰ <https://www.seia.org/sites/default/files/2020-03/New%20York.pdf>

¹⁵¹ <https://www.nyiso.com/documents/20142/2223020/2019-Power-Trends-Report.pdf/0e8d65ee-820c-a718-452c-6c59b2d4818b>

¹⁵² <https://www.nyserda.ny.gov/About/Newsroom/2020-Announcements/2020-04-03-NEW-YORK-STATE-ANNOUNCES-PASSAGE-OF-ACCELERATED-RENEWABLE-ENERGY-GROWTH-AND-COMMUNITY-BENEFIT-ACT-AS-PART-OF-2020-2021-ENACTED-STATE-BUDGET>

Figure 5: New York Annual Solar Installations



Source: [Solar Energy Industry Association of America](#)

During the past decade, solar panel financing has transformed from niche to mainstream, with many mature and scalable investment vehicles to choose from, and well-defined risk profiles for projects from residential to commercial to utility scale. Meanwhile, panel costs have been trending down for several years and are now cost-competitive with fossil fuels.¹⁵³

Over the next decade, the major financing innovation challenges will be for the less shiny but equally important components of a scalable solar electric grid -- energy storage and grid infrastructure.

This section will overview the main investment vehicles for solar production, highlight success stories, and explore upcoming vehicles for solar storage + smart grid.

Types of Financing:

- Investment Tax Credits
- Blended finance
- IPO
- Corporate loan
- YieldCos / REIT
- ABS
- PPA
- RECs
- Small commercial participation loans
- Small business, not for profit on-bill recovery loans

¹⁵³ [Solar Energy Industry Association of America](#)

Key Financing Players:

- NY Green Bank
- NYSERDA
- ConEdison
- Citi
- Connecticut Green Bank
- CDFIs, such as the New Hampshire Community Loan Fund, which has made revenue-based investments in solar across New England¹⁵⁴

Investment Tax Credits

The biggest policy incentive for renewables in the US has been, depending on the type of technology, 30% federal Investment Tax Credit (ITC) for renewable energy. The ITC is instrumental across the spectrum of project sizes, from residential, to community, to utility scale. New York State offers additional tax credits, such as a 25% personal tax credit for residential installations, up to \$5,000.

While the ITC is being gradually phased out, the ITC has been both a boon and a burden for solar developers. The substantial value is the difference between many projects being unviable and profitable. In order to claim the tax credit, however, the developer must have large enough tax liabilities. In practice, this has meant that solar developers need to develop relationships with the top 4-5 large banks, Citi, Goldman, Wells Fargo, large corporations or Ultra High Net Worth Individuals (UHNWI), and arrange complex project financing structures. As a result, it is common for solar projects to have shared ownership models, the percentages of which change over time (“flip”) in order to optimize tax credits. Tax equity partners, who are usually not in the solar industry, require time and energy to become comfortable with these complex structures (though it’s important to note that tax equity is a widely-used financing structure outside of the solar industry as well). As a result, relatively few of the potential tax equity partners choose to become involved. The high demand from solar developers means that tax equity partners command high leverage in negotiations.

PPA

PPA agreements commonly enable solar developers to offer projects to consumers with no upfront cost. Homeowners pledge to purchase future electricity from the developer at a specified rate for a fixed period of time, which can be more or less than the market rate for grid electricity. In exchange, the developer maintains the solar array throughout the lifetime of the contract.

For commercial- and utility-scale projects, PPAs can be employed to sell electricity into the grid or to large energy users. See “Identifying Renewable Energy Buyers” below for more details.

¹⁵⁴ <https://communityloanfund.org/>

Utility Solar

Overview

A utility-scale solar facility is one that generates solar power and feeds it into the grid, supplying a utility with energy. While a minority of New York State solar capacity comes from utility-scale projects, the utility scale is arguably the most mature segment. Utility scale projects have appeared since the early 1970s. Financing for utility solar is generally straightforward. The volume of assets is sufficient to merit direct attention by banks, in contrast to the need to aggregate pools of assets for smaller scale projects.

Commercial solar usually operates at a smaller scale and generates power for commercial organizations and/or industrial plants.¹⁵⁵ Technical and climate factors disadvantage New York utility solar relative to commercial and residential, as some of the most globally popular technologies for utility-scale solar do not work well in New York State. For example, concentrated solar power (CSP) is common across the western and southern U.S. In CSP, large arrays of reflective metal reflect the Sun's light and heat towards a small thermal collector in the center. The principle is as old as Archimedes' burning lens, and the simplicity allows for cheap construction and operation. Unfortunately, the temperate climate and inconsistent sunniness of New York are incompatible with CSP.¹⁵⁶ Lack of rooftop space also prevents larger adoption of solar, there just isn't enough space in the city, on rooftops or otherwise to install a utility scale solar array.

Additionally, aging grid infrastructure challenges the viability of utility solar, particularly in New York City. Transmission losses occur whenever power is generated by a large remote power plant rather than by smaller distributed generation infrastructure. Therefore, to minimize transmission losses, utility scale solar must be near a 3-phase transmission line, ideally less than 2,000 feet away, as well as near an electrical substation.¹⁵⁷ Even with optimal placement, transmission losses from upstate New York to NYC can be substantial.¹⁵⁸ Contrast this with traditional power plants, which are able to locate nearer to the city they are serving.

Residential Solar

Overview

Residential solar is a strong market in NYS and NYC, with a diversity of mature financing options and a bevy of government policies to encourage adoption. Installation

¹⁵⁵ <https://www.targray.com/media/articles/solar-project-types#:~:text=The%20most%20common%20types%20of,mounted%20and%20rooftop%20solar%20systems.&text=Utility%2Dscale%20projects%20primarily%20serve,corporate%20organizations%20and%20industrial%20plants.>

¹⁵⁶ Solar Energy in New York, NY Department of Environmental Conservation <https://www.dec.ny.gov/energy/43231.html>

spiked in 2016 as developers rushed to sign projects in advance of the expected expiry of the federal ITC (the ITC was extended at the last minute), and has leveled off since.

New York State has several key incentives for residential solar. In addition to the federal ITC, NYS offers 25% additional tax credit, up to \$5,000.

While New York City has potential for more residential solar, it has two key disadvantages that will limit its growth within the city. First, the majority of residents are not homeowners, with limited ability to participate in an installation. New innovations in Community Solar (see below), however, can mitigate these challenges.

Second, rooftop solar photovoltaics get hot. The panels are designed to absorb as much solar radiation as they can. This issue is magnified in New York City, where black pavement and tall buildings trap solar radiation. "Cool roofs," which utilize reflective white color, can substantially mitigate this Urban Heat Island effect.¹⁵⁹

Community Solar

Overview

Community Solar describes commercial-scale projects financed by retail investors. The idea is that individuals without rooftops, such as apartment-dwellers and renters, may subscribe to a community solar project or participate in solar elsewhere to offset their electricity use. Community solar is typically installed on farmland or commercial buildings. Because community solar is typically generated near consumers, it lessens demand on the grid for high-voltage inter-region transmission lines.

Early experiments in community solar leveraged crowdfunding models popularized by sites like Kickstarter. Mosaic, Inc. began offering crowdsourced solar investments in New York in 2013.¹⁶⁰ These early approaches were limited by uncertainty over securitization laws, and generally only accepted accredited individual investors. The SEC's finalization of the JOBS Act regulations in 2017 have emboldened a new wave of startup attempts to build a solar crowdfunding marketplace for retail investors. Raise Green is another new start up example that has been supported by Greentown Labs.^{161,162} SOLAR Crowdsourcing is an additional model that has gained traction – non-profits looking to finance solar energy projects are connected to crowdsourced sources of capital.¹⁶³

New York City's utility, Con Edison, is driving forward one of the most innovative and successful takes on community solar. Under their new program, individual electric consumers can "subscribe" to community solar projects within their utility service area, for free. The consumers pay for their share in the community solar project over time, while receiving credits to deduct from their electricity bill. Third-party capital is raised to

¹⁵⁹ <https://link.springer.com/article/10.1007/s10546-016-0160-y>

¹⁶⁰ <https://www.joinmosaic.com/>

¹⁶¹ <https://www.raisegreen.com/>

¹⁶² <https://greentownlabs.com/>

¹⁶³ <https://www.solarcrowdsourcing.com/>

pay for the panels and equipment, then the sale of the electricity to subscribers generates a return for the third parties in the form of equity, debt, and tax equity.

Another option that allows renters to purchase solar is a renters PPA. In this model, property owners include a Power Purchase Agreement (PPA) in the rental agreement that requires renters to purchase solar electricity at below retail rates, and enables property owners to create an additional revenue stream if electricity sales exceed borrowing costs.¹⁶⁴ This option is expected to perform best on single family home rental properties that contain only one meter, which simplifies the process of determining the end use of energy. Further research should be done on the potential for rental PPAs to be scaled up in NYC, as this is a financeable opportunity to accelerate the rate of the energy transition.

Case Study: Commercial Rooftop Solar in NYC

Overview

Problem: Solar Renewable Energy Generation

Solution: Large + Small Commercial Rooftop Solar

Size: \$59m

Key stakeholders: NYSERDA, Generate Capital Inc (GCI), NYC DCAS, Solar Energy Systems

Mechanism: Equity Financing + Debt

Project Start: January 2018

In 2014, NYC Department of Citywide Administrative Services (DCAS) awarded an RFP to a solar developer to cover a swath of commercial buildings across the five boroughs with solar panels. These 88 buildings had been pre-screened by DCAS. The RFP included the rights to the project as well as a series of incentives, to be disbursed according to project milestones.

Generate Capital Inc. (GCI) purchased the contract and provided construction financing and sponsor equity to the project. GCI took on the equity risk, arranged a tax equity partner, and took on responsibility for finding subcontractors and partners to fulfill the contract. GCI also became responsible for substituting project sites, should any roofing issues arise with the original 88 buildings.

Problem

Aggregate energy demand within NYC is among the highest in the nation, leading to relatively high energy prices. Moreover, NYC buildings typically have dark roofs that absorb sunlight, but which can be made more reflective through solar PV panels. While space in the boroughs is tight, many commercial buildings are amenable to installing solar panels on their rooftops. At the same time, however, the cost of installation in NYC is roughly three times the statewide average.

¹⁶⁴ Russell Heller et al., "Financing Rooftop Solar for Single-Family Rental Properties: The 'Renter's PPA,'" in *Sustainable Real Estate - Multidisciplinary Approaches to an Evolving System* (Palgrave Macmillan, 2019), pp. 1-452.

These ‘soft costs’ are particularly acute at commercial scale. Unlike residential solar, where installers can estimate credit quality of homeowners based on readily available FICO scores, the credit quality of each commercial entity must be assessed individually. Individual commercial projects are too large for the entity to finance on their own, and too small for most outside investors. Furthermore, origination remains a challenge; selling solar into these businesses is time and energy intensive. While homeowners may quickly deliberate alongside one or two family members, commercial solar sales must navigate hierarchies of business bureaucracy akin to enterprise organizations — for a smaller reward. As a result, few solar developers focus on the commercial space, and the firms with a commercial-scale presence typically treat it as a side-business to higher-margin enterprise-scale sales. Additionally, since the return on investment is comparatively low for these solar installations compared to selling NYC real estate, property owners are oftentimes skeptical of encumbering their buildings with a contract that may hinder their ability to sell the asset.

Solution

NYSERDA announced an RFP in 2014 based on the pool of buildings pre-screened by NYC DCAS. With a pool of buildings, the project size can attract investors as well as regional solar developers. By leveraging existing city processes to pre-screen buildings and confirm building owner interest, government agencies can mitigate the major costs that prevent solar developers from approaching commercial scale opportunities.

Generate Capital (GCI) proposed to aggregate a pool of commercial projects under one financing agreement. The whole effort is covered under a single PPA. Within that PPA, GCI maintains the discretion to substitute commercial rooftops for other, better candidates over the course of the project. In other words, GCI commits to the overall size of the installation, without locking themselves into any specific commercial buildings, to mitigate the risk that pre-screened buildings turn out not to meet final requirements.

Key Stakeholders

NYSERDA - the renewable energy authority for New York State, in charge of designing and administering incentives to advance renewable energy deployment. Their incentives are key to the financial viability of the project.

DCAS - a NYC government agency that manages and leases city-owned property. They were able to leverage their personnel, position, and existing relations to pre-screen 88 commercial buildings for solar installations.

Generate Capital - specialized renewable energy financier, with a reputation for innovative financing structures. They propose to administer and oversee the project.

Solar Energy Systems - the primary Energy Performance Certificate (EPC) contractor firm in charge of installations.

Process

The project is laid out in three equal-sized “blocks,” each with its own set of milestones. Each block includes a mix of large- and small-scale commercial projects. Construction on the first block commenced in 2018, and the last COD for the final block is expected to occur in late 2020.

Financing

GCI is the sole equity financier at this stage. GCI secured GAF Energy as a tax equity partner. In each time period, GCI would be responsible for ensuring the timely completion of the pair of blocks of small and large commercial buildings. Each pair of blocks totals roughly 17 MW.

Figure 6: Incentive Assumptions

<i>Incentive Assumptions</i>					
	<i>#of sites</i>	<i>MW</i>	<i>Current</i>	<i>-1</i>	<i>-2</i>
Large Commercial	35	10.3	Block2	Block3	Block4
Block Size (MW)			20	25	25
Capacity Used (MW)			3.2	0	0
PBI (\$/kWh)			0.17	0.17	0.16
\$/W			0.61	0.59	0.57
Incentive Amount @ COD			1.6	1.5	1.5
Incentive Amount @ Each Yr 1-3			1.6	1.5	1.5
Total Incentive amount			6.2	6.0	5.8
Small Commercial	53	6.8	Block4	Block5	Block6
Block Size (MW)			15	10	10
Capacity Used (MW)			9	0	0
\$/W first 50 KW			0.7	0.6	0.5
\$/W additional up to 200 KW			0.45	0.4	0.3
Incentive Amount @ COD			3.7	3.3	2.6
Total	88	17.1	10.0	9.3	8.4

Original estimates for the CAPEX were roughly \$3/W. GCI found that, in the early stages of the project, realized costs ran higher. About 1 in 5 of the pre-screened buildings turned out to be unsuitable. Finding buildings to substitute took effort. Furthermore, local workforces lacked experience with commercial-scale solar installations.

Figure 7: Project CAPEX

Project CAPEX	(\$mm)	(\$/W)
EPC Price	52.7	3.10
Transaction Costs - Legal & LC	1.4	0.07
Transaction Costs - IE	1.5	0.09
Transaction Costs - Appraisal	0.0	0.00
Total Project Capex	55.7	3.26

Over time, however, these issues improved, and GCI has since achieved the estimated ~\$3/W capital expenditure per project. In fact, they see the cost trend continuing to decrease. The overall project may end up reaching the estimated target. More importantly, the ecosystem improvements can be leveraged by future commercial solar projects in NYC in the years to come.

GCI plans to add debt to the project once the rollout is complete. This allows GCI to achieve favorable debt terms when the project has been de-risked past the construction stage.

Results

While the project is still in the construction phase, some outcomes are already encouraging. NYC has decided to replicate this program, and will be offering another RFP for a new pool of buildings, starting in 2020. The most exciting impacts, though, are in the local ecosystem.

Initially, workers were hard to find and poorly trained. GCI intended to offer contracts to at least five different firms for various aspects of the installation and maintenance. Due to a lack of local expertise, they ended up hiring a single firm to do the majority of the work to date. Two years into the project, more firms have emerged with adequate expertise, and GCI is in the process of awarding a portion of the contract to at least one more firm.

Over time, the efficiency of the local ecosystem has improved drastically. The very first installation in the project ended up costing roughly \$11/W, due to a combination of construction inefficiencies. Now, contractors' skills have improved to the point where the

most recent completed project cost ~\$3/W. Through additional training and optimization further improvements are possible to the point where the final project could come down to \$2/W, 80% less than the first project. Projects of this scale reduce 'soft costs' and ultimately can catalyze markets.

YieldCos / REITs

Overview

Real Estate Investment Trusts (REITs) are financial vehicles, often publicly traded, where investors can partake in the cash flows from income-generating properties. REITs are classified as a pass-through entity; at least 90% of the taxable income generated by the properties is distributed directly to the shareholders. The REIT holding company manages a portfolio of properties in exchange for a fee.

While REITs have flourished since the 19th century, and existed in modern form since 1960, the IRS has limited the ability of REITs to be used for solar. Under current regulations, solar is not allowed to be considered a standalone property to be managed under a REIT. Solar is allowed inasmuch as it is part of a larger building complex, and as long as the revenue produced from the sale of electricity back to the grid is less than the energy consumed from the grid. In other words, REITs can be used to increase the percentage of solar energy consumed by buildings, but not to replace or surpass grid consumption. Additionally, REITs have the ability to impact energy efficiency. Hannon Armstrong is an example of a REIT that is counterparty to hundreds of energy efficiency transactions.

Inspired by the REIT structure, solar developers invented the YieldCo in the early 2010s. Similar to the REIT, the YieldCo is a holding company, typically publicly traded, wherein the revenue stream from energy production is distributed to investors via dividends. YieldCos have successfully helped lower the cost of capital to solar, but face some key disadvantages as investment vehicles on their own.

Early on, YieldCos grew quickly due to their ability to attract capital from public markets below the rate of private markets. At the time, perceived risk by private markets meant that solar financing typically hovered around 13% rates for cost of capital. Eager public investors, however, brought that rate down to 9%. By offering YieldCos to the public, solar developers were able to build more projects more quickly.

Over time, the perceived and actual risk for solar converged, as did the public and private costs of capital. YieldCo asset growth slowed as the 'cost of capital arbitrage' opportunity between private and public markets diminished. While YieldCo investors had come to expect the rapid growth they exhibited in the early days, the market bottomed out as that growth slowed.¹⁶⁵ This risk was one of the factors which brought down the firm credited with pioneering the YieldCo, SunEdison.

¹⁶⁵ <https://www.greentechmedia.com/articles/read/the-yieldco-boom-and-bust-the-consequences-of-greed>

Nowadays, many of the YieldCos on the market have stabilized, but they do not exhibit the rampant growth in dividends that characterized the early excitement. More traditional investing structures are growing, which avoid the pitfalls of YieldCos by separating project origination from asset owners + management. Examples include the Hannon Armstrong Sustainable Infrastructure Fund, which invests \$1.3 billion per year into sustainable projects¹⁶⁶ and Brookfield Renewable Energy Partners.

Innovative Financial Vehicles

Overview

A couple of the most exciting new financing pathways are “the Morris Model” and solar + storage.

The Morris Model’s namesake is Morris County, New Jersey, where the local government entered into a mutually beneficial lease-purchase arrangement with a solar developer. Under this arrangement, the government issued a municipal bond at an attractive interest rate, leveraging their strong credit rating. Next, the government leases the solar panels to the developer. The government then buys electricity from the developer in the form of a PPA. Overall, this reduces costs because the developer would otherwise have to secure a loan for the panels at a higher cost of capital than the government can achieve through tax-free bond issuance. Additionally, this project made use of a robust local Solar Renewable Energy Certificates (SREC) market. The original “Morris Model” project amounted to \$22 million, and was successful. Subsequent attempts to replicate the Morris Model have failed due to other factors, including the decline of SREC markets. When this model fails, we should note, the government will be left holding the distressed assets.

Solar + Storage

Combinations of solar plus storage are typically used to either dissociate from the grid (‘off-grid’) or arbitrage the timing of energy sold back to the grid.

Off-grid systems can be useful in remote areas, but are typically not financially optimal. The amount of storage required to supply solar energy at all times is large, and storage remains expensive.

Grid-connected storage systems can be smaller than off-grid systems, and offer a variety of monetizable services back to the grid. Already, grid systems with high solar concentrations have experienced instability due to high-capacity generation during daylight with precipitous drop-offs at night. Storage addresses this problem by allowing system owners to sell back to the grid during peak demand or during nightly nadir of solar production, fetching higher prices from grid operators. Here, the storage increases the value of the overall solar system by increasing the value of its cash flows. Additionally, in many jurisdictions (typically “deregulated” utility areas), additional

¹⁶⁶ <https://www.hannonarmstrong.com/>

discrete grid services can be monetized. For example, Tesla Energy Packs offer participation in frequency regulation markets.¹⁶⁷

The NYC FDNY recently finalized rules for energy storage.¹⁶⁸ The rules specify sizes and locations for outdoor battery storage for now and indoor battery storage rules are under development for the future. By promulgating these regulations, FDNY expects to streamline the permitting process and safety concerns so as to encourage more building owners to participate in load shifting and demand response programs.

Distributed networks of solar plus storage can be connected into microgrids operating autonomously or semi-autonomously from larger grid systems. Such a microgrid operates in Brooklyn — the Brooklyn Microgrid handles distributed transactions using blockchain technology.¹⁶⁹ Other prominent microgrid projects have faced unexpected setbacks. Tesla made headlines when it pledged a microgrid system to Puerto Rico following Hurricane Maria, but incompatibilities with existing infrastructure rendered the new systems largely unusable following the installation process.¹⁷⁰

Outlook

Three trends characterize the solar horizon. First, ITCs are declining in importance. Second, panel costs and installation costs continue to decrease. Third, storage offers attractive new possibilities to monetize distributed generation.

The decline of the ITCs, both directly via phase-out and indirectly via the 2017 tax code's slashing of corporate tax liability, signals the end of the era of tax equity-focused financing models. Whether politicians can muster the will to institute new aggressive incentive policies as part of a Green New Deal remains to be seen. Absent new government incentives, solar will begin to truly face public energy markets on its own two feet.

The precipitous drops in panel and 'soft' costs over the last 10 years mean that in many jurisdictions, solar already has achieved cost parity with coal or other conventional electricity sources. While the decline in panel costs per KW show little sign of slowing, soft costs will approach their bottom as financing models and customer acquisition channels mature. The 'soft cost savings' seen over the last 10 years may evaporate if federal policy moves to restructure renewable incentives away from the ITC.

Storage, and the associated issues surrounding grid infrastructure, are important issues in their own right. As it pertains to solar, the increasing technological maturity of networked, distributed storage systems, provides important additional monetization avenues to increase solar project viability, from simple demand arbitrage to more nuanced grid-stability services. The pathways for solar plus storage remain in early days, with numerous competing technologies and models.

¹⁶⁷https://www.huffpost.com/entry/elon-musk-tesla-puerto-rico-renewable-energy_n_5ca51e99e4b082d775dfec35

¹⁶⁸https://rules.cityofnewyork.us/sites/default/files/adopted_rules_pdf/608-01_outdoor_stationary_battery_systems_8-13-19_promulgation_final.doc_pdf

¹⁶⁹ <https://www.brooklyn.energy/>

¹⁷⁰https://www.huffpost.com/entry/elon-musk-tesla-puerto-rico-renewable-energy_n_5ca51e99e4b082d775dfec35

Ground Source Heat

Overview

Ground source heat provides a variety of economic, environmental, and logistical benefits for heating and cooling buildings, which accounts for nearly 70% of New York City's emissions. In a city where limited real estate and subterranean characteristics don't lend themselves easily to large-scale geothermal electricity production ground source heat is promising. While the City is making great strides in improving the thermal envelope of its buildings, and increasing the energy efficiency of its built environment, the other side of this movement is reducing the emissions that come with the actual temperature regulation of an indoor space. As a result, ground source heat is becoming an increasingly critical renewable energy source for New York City's "80x50" plan. Ground source heat systems only consume 30% of the energy consumed by furnaces and natural gas-fueled boilers, and roughly 80% of the energy consumed by air- and water-cooled air conditioning systems.¹⁷¹

In addition to lowering the carbon footprint, geothermal and ground source heat provide an opportunity to insulate building owners from fluctuating energy prices, and reduce peak energy demand for the city. This allows for a more stable energy input than air-based HVAC systems, and allows for more efficient heating and cooling, as, throughout New York City, subterranean temperatures sit between 55 to 65 degrees Fahrenheit—the indoor design specification for buildings in the city.

Much like wind, ground source heat and geothermal require a substantial investment in installation of wells and the initial infrastructure. It also has low operating costs and easy maintenance, however, due to its simple design. Realized savings in energy usage over time often are expected to cover the high initial investment. Moreover, the increased savings from grid reliability and reduced peak load, and the added benefit of avoiding price risk, also come into play as more immediate benefits.

Given the density of buildings in New York City, and the specific requirements needed for well drilling, retrofitting can often be extremely costly and may not be possible in some cases. On the other hand, installation during construction of a new building is much easier. Nevertheless, the city already has some examples of ground source heating, with over 100 projects in operation¹⁷² including at the Brooklyn Children's Museum, Staten Island Museum at Snug Harbor, Queen's Botanical Garden, and St. Patrick's Cathedral. Some examples of financing mechanisms used for these projects and others relevant for geothermal and ground source heating are detailed further.

Types of Financing:

- Senior debt
- Residential Loans
- Commercial Loans

¹⁷¹ http://www.nyc.gov/html/planyc/downloads/pdf/publications/2015_Geothermal.pdf

¹⁷² https://www.nytimes.com/2012/11/07/business/geothermal-energy-advocates-hope-systems-get-a-second-look.html?_r=0

- Rebate
- Federal Geothermal Heat Pump Tax Credit: Federal tax credits have been available since 2018.¹⁷³
- Federal Residential Renewable Energy Tax Credit: Homeowners can claim a federal tax credit for making certain improvements to their homes, including geothermal.¹⁷⁴
- Production Tax Credit (PTC): Provides operators with a tax credit per kilowatt hour of renewable electricity generation for the first 10 years a facility is in operation. The credit was extended in 2020.¹⁷⁵
- Investment Tax Credit (ITC): Installing a geothermal system could allow New York taxpayers to claim an energy tax credit.¹⁷⁶
- Treasury Cash Grant: The Treasury cash grant program was an economic stimulus measure in 2009 under section 1603 of the American Recovery and Reinvestment Tax Act to encourage construction of new renewable energy projects.¹⁷⁷
- Modified Accelerated Cost Recovery System ([MACRS](#)): Allows the capitalized cost of an asset to be recovered over a specified period via annual deductions.¹⁷⁸

Key Financing Players:

- NY Green Bank
- NYSERDA
- Energy Star
- HeatSmart CNY
- Dandelion

Ground Heat Pump

Ground heat pumps make use of the stable, year-round ~60 degree F temperatures of deep underground fluids, such as groundwater. They "pump" that stable heat upwards during winter, and "pull" hot air downwards during the summer. This greatly reduces both heating and cooling costs.

Ground source heat is typically captured via Ground-Source Heat Pumps (GHPs)—a rather simple technology that uses water or solution to either transfer thermal energy to a building from the ground beneath it, and vice versa. The benefit of using a GHP is that it has the capability to both heat and cool a building. Due to the temperate temperature range of groundwater, GHPs can capitalize on temperature differentials between air and underground, meaning that a GHP can either transfer ground source heat into a building, or transfer heat in a building and store it underground.

¹⁷³ <https://energystar.zendesk.com/hc/en-us/articles/212109447-Is-there-a-tax-credit-for-geothermal-heat-pumps->

¹⁷⁴ <https://www.thebalance.com/residential-energy-tax-credits-3193014>

¹⁷⁵ <https://www.congress.gov/bill/116th-congress/house-bill/1865>

¹⁷⁶ <https://www.irs.gov/pub/irs-prior/i5695--2018.pdf>

¹⁷⁷ <https://home.treasury.gov/policy-issues/financial-markets-financial-institutions-and-fiscal-service/1603-program>

¹⁷⁸ <https://www.investopedia.com/terms/m/macrs.asp>

GHPs come in three different forms: Open Loop System, Closed Loop System, and Standing Well System.

A closed loop system uses a series of enclosed pipes to cycle a solution of water and glycol-based fluid (antifreeze) continuously between a building and the ground beneath it, relying on the transference of energy based on the temperature differential between the fluid inside the pipes and outside the pipes to regulate the temperature for either heating or cooling purposes. Open loop systems rely on groundwater pumped from a nearby well to heat or cool a building. It then lets the used water diffuse back into the supply well once it has served its purpose. Standing well systems are similar to open loop in that they rely on intake from nearby groundwater supplies, except they require less intake and go deeper into the bedrock, which allows for more transference of heat. Of the 100 or more ground source heat projects currently in operation in New York City, over 90% of them are closed-loop systems.

Lack of Mature Financing Options

As highlighted in the types of financing list, most of the financing opportunities for ground source heat are centered around rebates and tax credits—an attempt to increase savings and incentivize more project development by easing the burden on high up-front costs. There are few financing mechanisms that allow for the procurement of capital to begin with, most are focused on savings under the expectation that it will pay for itself over the long run.

The State of New York is also proposing to include the social cost of carbon into its competitive wholesale energy markets—a move that could potentially lead to more innovative financing mechanisms.¹⁷⁹ The state has also started partnering with ground source heating designers and installers.

The lack of large-scale, revenue-producing geothermal is likely a key reason for the limited access to capital for ground source heat. This problem is perhaps more pertinent, however, for residential complexes which make up a majority of buildings in NYC. Larger ground source heating projects are stepping up to fill the gaps, including projects such as St. Patrick’s Cathedral, which required roughly \$35 million for GHP installation, the Brooklyn Children’s Museum, and The Bronx Botanical Garden. These projects are bringing in large sums of investment money.

Large Buildings / Projects

There are examples of large ground-source heating projects scattered throughout the city that have successfully received capital to assist with financing the high installation costs. For example, the Center for Architecture installed a 2-well, closed-loop system in 2003 at a cost of \$100,000. The project shut down three out of four lanes on LaGuardia

¹⁷⁹ <https://www.nyiso.com/carbonpricing>

Place for three weeks, with the well reaching 1,200 feet in depth. The Center for Architecture received \$85,000 in funding assistance from NYSERDA to help finance the project, which was \$40,000 more expensive than the alternative of installing a cooling tower on top of the building, and was projected at the time to pay for itself in three years.

More transparency in how these projects are financed is needed. Right now it is unclear if these projects were funded mostly by internal budgeting or if unique financing mechanisms were used such as project bonds or loans. In some cases, where project costs were less than \$100,000, it seems plausible that no unique financing strategies were employed and the institution simply paid the bill on its own accord. However, such an assumption is less likely in the case of a \$35 million project. It would be incredibly useful to have more information on how projects of this size gained access to capital and who the major players were in those transactions. Having this information can help guide the approaches for others looking to finance GHP installation.

Residential

Ground source heat installation can vary in cost depending on a variety of factors including how deep the wells need to go, logistical complications from existing underground infrastructure, and other site restrictions such as space for drilling equipment and lot size. In general, the average cost for a deep well needed for larger projects in Manhattan can be up to \$150,000 each. For a 500-unit multifamily building, for example, 10 to 15 wells may be needed, making the cost as much as \$2.25 million, while cutting the annual energy bill of the building by 30% to 60%.¹⁸⁰

For a single-family unit, much less capital is needed for installation, but it is still significant even for residences not in Manhattan. The cost of a well for a smaller well for one-family unit can be around \$9,000, and a single-family unit can need up to 3 wells depending on the size of the home, making the total cost close to \$30,000.

Currently, options for financing ground source heat are primarily focused on tax credits and rebates. Currently there are caps on the rebates allocated to a single building. A single-family home can receive, at most, \$15,000—roughly half of the installation cost, while on the other hand, no single building can receive more than \$500,000, which is only a fraction of the cost for the multifamily unit example mentioned above. Hence, when these limitations are put in conversation with the aforementioned costs of installation, it becomes clear that providing access to capital for residential projects is an area of opportunity for New York City. One example that could help in identifying ways to increase access to capital is through public loans. Mass Save HEAT Loans are interest-free energy-efficiency home improvement projects up to \$25,000.¹⁸¹

Access to upfront capital is especially a challenge for residential buildings that are predominantly low-income and might not have the ability to finance an overhaul of their heating and cooling system. This can be true for both large multifamily buildings as well

¹⁸⁰ https://www.nytimes.com/2012/11/07/business/geothermal-energy-advocates-hope-systems-get-a-second-look.html?_r=0

¹⁸¹ <https://www.masssave.com/en/saving/residential-rebates/heat-loan-program/>

as smaller 1-4 family units as currently rebates and tax credits can only cover about 50% of installation costs.

One key avenue currently being used to address this is New York City Housing Authority's (NYCHA) Better Building Showcase Project,¹⁸² which used a NYC capital grant and funding from the American Recovery and Reinvestment Act to finance a \$2.2 million overhaul of a low-income, 225-unit multifamily building. This renovation included the installation of a GHP that resulted in a 55% reduction in energy needed for heating water throughout the building.¹⁸³

GHP Systems and PACE Financing

Homeowners without access to upfront capital may qualify for PACE financing. Under the PACE program, NYCEEC will offer loans to finance the installation costs. In return, homeowners pay back the loan via increased property taxes. PACE can also be used to finance installing geothermal at a commercial building or nonprofit (which can elect to pay property tax). PACE financing pools are often raised through the issuance of municipal bonds.

PACE incentives can also be leveraged by developers who offer homeowners a no-money-down PPA or lease structure. In that scenario, the developers can finance their projects through the PACE program, and pass down the savings to homeowners in terms of lower periodic lease or PPA services payments.

The financing mechanism used is a long-term, fixed-rate loan for energy efficiency projects. What is interesting about this loan, however, is that it is tied to the property, and not to the borrower—meaning it is non-recourse capital using the property as collateral. The loan is repaid over 20-25 years via a long-term property tax assessment, which essentially means property taxes are higher during the payback period. Nonetheless, in many cases GHP projects experience a net gain in savings despite the higher property taxes due to the low operating costs and increased efficiency of the technology. Moreover, this financing mechanism can be combined with both simple capital structures and complex capital stacks, contributing to the cost of capital being rather inexpensive.¹⁸⁴ Hence, in some cases, PACE financing can be an interesting mechanism to fund gaps in a pay stack or even to entirely fund smaller sized projects.

PACE financing has been more effective for new buildings than for retrofits, however, as it requires permission from senior-level lenders. In general, senior lenders are not as inclined for existing buildings to take an inferior position in the capital stack. Most mortgages in New York City are owned by large New York City banks. These banks will need to be persuaded to agree on some programmatic criteria to accept PACE financing. This can include a prescribed debt-to-equity ratio, a minimum size loan, or passing on the cost to tenants (which would increase the market value of buildings and help the credit position).

¹⁸² <https://betterbuildingssolutioncenter.energy.gov/partners/new-york-city-housing-authority-nycha>

¹⁸³ <https://betterbuildingssolutioncenter.energy.gov/beat-blog/nycha-deploys-first-renewable-energy-solution-25-savings>

¹⁸⁴ <https://www.pace-equity.com/blog/the-better-way-to-finance-ground-source-heat-pump-systems-part-2>

Specific Examples and Analysis:

Thermal Grids in Iowa

Much as community solar is emerging as a means of bringing renewable electricity to dense urban areas, thermal grids are emerging as a means of bringing renewable heating and cooling to cities. Thermal grids allow commercial and residential buildings to connect to a ground source heat system that is shared by the community. Community-shared ground-source heat provides a unique opportunity for New York City buildings to engage in a symbiotic exchange of heating and cooling, as different buildings often are simultaneously pumping heat into the building, or into the ground. Buildings pumping heat into the ground can contribute to the heat that other buildings are bringing in—creating a phenomenon known as load diversity. Consequently, a shared thermal grid can be far more efficient than individual ground-source heat systems that are already more efficient than traditional HVAC systems.

Thermal grid installation costs as little as 25% of the cost of natural gas lines of similar scope. Moreover, since ground-source heat taps into groundwater, thermal grids can be installed concurrently with city wastewater and stormwater renovations. This could decrease initial costs substantially since most thermal grid costs are associated with drilling.

Thermal grids have worked in other places in the United States. In particular, West Union, Iowa, successfully installed a thermal grid system that was designed to connect at least 60 separate buildings, including the county courthouse. The project cost \$2.3 million and was financed with an EPA Climate Community Showcase Grant, HUD Community Development Block Grant, and some additional funding from the DOE. As for property owners looking to connect to the system, funding was provided in several ways, including a special low-interest loan that was supported by two local banks and utility rebates.

One key challenge this project faced, however, was building the business case for property owners to tap into the thermal grid instead of keeping their current HVAC systems or reinvesting in traditional technology. Many property owners were hesitant and delayed any sort of investment until the state and city could prove a business case for doing so. That prompted the Iowa Economic Development Authority and Main Street West Union to tap a USDA Renewable Energy Development Grant that allowed for the hiring of a mechanical and electrical engineering firm to make a business case for 20 properties.¹⁸⁵ These business cases included the following: Energy load analysis, sizing and location of heat pumps, opinion of probable cost, life-cycle cost analysis comparing district system use versus an alternative gas heating and DX cooling system, and an estimate of potential rebates and other available incentives. Ten property owners committed soon after the case was made.

¹⁸⁵<https://meetingoftheminds.org/how-the-town-of-west-union-built-a-transformational-geothermal-project-28753>

Cost Effective Retrofit -- Brooklyn Children's Museum

While retrofitting a building with ground-source heating technology can be extremely costly, there is precedent for it to pay for itself, such as with the Brooklyn Children's Museum.

In 2007, the museum invested approximately \$675,000 into an open-loop ground-source system with four wells. While the financing mechanism used is unclear, this investment came alongside an expansion of the building from 50,000 square feet, to 110,000 square feet. Initially, the 50,000 square feet was heated and cooled by conventional methods and cost the museum roughly \$200,000 annually. However, with the 60,000 square feet added to the building, the cost in heating, cooling, and electricity only rose by \$50,000. Hence, even though the space increased in square-footage by 120%, monthly costs associated with conditioning the space rose by only 25%.

Still, notwithstanding the value in understanding cost effectiveness and project costs overall for making the case for GHP installation at scale, there are still the aforementioned challenges of transparency around financing mechanisms.

St. Patrick's Cathedral: A Major Project Offers Long-Term Benefits

The biggest project to date in New York City has been St. Patrick's Cathedral, which now contains a standing column hybrid open loop system GHP system, launched in 2017. It has the capacity to generate 2.9 million BTU's per hour of air conditioning and 3.2 million BTU's per hour of heating, regulating the temperature through 76,000 square feet of space.¹⁸⁶ The geothermal plant will reduce the building's energy consumption by more than 30% and reduce CO2 emissions by approximately 94,000 kilograms, taking just 40% of the space of a conventional HVAC system.^{187 188}

The main renovation project of the cathedral cost \$200 million, of which \$35 million were dedicated to the GHP system that replaced the steam boiler and air conditioning system installed nearly 60 years ago. Monsignor Robert T. Ritchie, the director of St. Patrick's Cathedral, told the New York Times "It was not only the most sustainable, cost-effective, long-term energy option for the cathedral, but the option that best aligns with the greater good of New York, and not just today, but for generations to come."¹⁸⁹

Dandelion Affordable:

Dandelion is a private GHP designer and installer, and is one of the contractors listed under NYSERDA's \$15 million rebate program, which offers up to \$1 million for qualified installers, depending on the size of the project.¹⁹⁰ Born out of Alphabet's X division,

¹⁸⁶ <https://www.renewableenergymagazine.com/geothermal/new-york-s-iconic-st-patrick-s-20170222>

¹⁸⁷ <https://cleantechnica.com/2018/03/19/st-patricks-cathedral-new-york-city-goes-green-35-million-geothermal-installation/>

¹⁸⁸ <https://www.hpbmagazine.org/st-patricks-cathedral-new-york-new-york/>

¹⁸⁹ <http://www.rapidshift.net/st-patricks-cathedral-in-new-york-city-goes-green-with-35-million-geothermal-installation/>

¹⁹⁰ <https://www.nyserda.ny.gov/About/Newsroom/2017-Announcements/2017-05-30-NYSERDA-Launches-15-Million-Initiative-to-Spur-GSHP-Market>

which supports development in cutting-edge technology, Dandelion is focused on creating affordable access to GHP installation by reducing drilling costs and standardizing their heat pump product. The biggest reason for Dandelion's success is its innovative drilling technology that substantially decreases the cost of well creation. In general, Dandelion itself is not an innovator in financing as much as it is in cost reduction. When partnered with financing avenues, however, funding GHP installation becomes much more manageable, and allows for more accessible pricing mechanisms.

The company charges nothing up front, arguing that monthly payments in general are less than monthly bills for heating and cooling after application of the rebates and tax credits. They assert that even though Dandelion is making money for their services, customers are actually saving upwards of \$2,250 a year. Prices for Dandelion can be as much as of \$25,000 for a larger unit. However, the price can go up substantially if there are project-specific complications such as zoning, challenging bedrock, or if multiple wells are needed.

With that said, their focus is on shallow installation projects that are perhaps better suited for 1-4 unit residential buildings rather than large multifamily complexes or museums. This raises questions for the scalability of Dandelion's pricing model with larger projects. In particular, it may be difficult to do larger projects while charging no money up front, especially when they are at or above the \$100,000 mark. Nevertheless, this model has the potential to be a building block for future solutions to capital-intensive installation and lack of access to capital by building owners in this market segment.

Outlook

Overall, with the advent of firms like Dandelion, thermal grids, and the improvements in ground-source heating technology, GHPs are increasingly becoming more mainstream for integration in building design. Given the density of New York City's housing stock, especially in Manhattan, perhaps thermal grids can be explored to provide a bulk solution to GHP installation in one of the most expensive regions in the country. The price insulation coupled with the easy installation alongside regular water infrastructure maintenance can make implementing ground source heating low cost and scalable. Dandelion also provides an interesting solution for smaller developments that do not need deep wells to achieve heating and cooling needs. Moreover, GHPs provide both heating and cooling, as well as water heating, so comparing GHP performance to traditional heating technologies like natural gas furnaces misses an entire function of GHP technology.

In addition to the technological improvements in ground-source heat, NYSERDA's \$15 million rebate program is a good start to incentivizing installation of GHPs throughout the state. The state is also requiring all new public projects to consider installing GHPs based on cost effectiveness. The true challenge for New York City will be financing retrofits for already existing buildings, and for providing equal access to capital for projects in low-income buildings -- as the up-front cost of installation is the biggest barrier to wide-scale adoption of GHPs. PACE financing and other loan programs may serve as a jumping off point for providing cheap access to capital, so long as the large

banks (the mortgage owners) cede priority to PACE. However other innovative financing mechanisms are needed for the continued growth in GHP adoption throughout the city.

Identifying Renewable Energy Buyers

Overview

This section contains a large number of acronyms and jargon. Below is a list of key terms that will help.

Key Terms:

RECs — Renewable Energy Credits (Renewable Energy Certificate)

SRECs — Solar Renewable Energy Credits

RPS — Renewable Portfolio Standards

CES — Clean Energy Standard

ZEC — Zero Emissions Credit

RES — Renewable Energy Standard

LSE — Load Serving Entity

PPA — Power Purchasing Agreement

PACE Financing - Property Assessed Clean Energy Financing

In 2015, New York State implemented one of the most aggressive climate goals in the country. It passed the Clean Energy Standard (CES),¹⁹¹ which calls for 50% of New York's electricity to be produced by renewables by 2030. Recently, however, Governor Cuomo has called for increasing this standard to 70%, as part of his Reforming the Energy Vision (REV) of creating a "clean, resilient, and affordable energy system for all New Yorkers."¹⁹²

To achieve these goals, the CES implements two important mechanisms: the Renewable Energy Standard (RES), and the Zero Emissions Credit requirement (ZEC).¹⁹³

The Renewable Energy Standard has three components: Tier 1, Tier 2, and offshore wind.

Tier 1 requires that all LSEs (utilities or other power generating entities that supply electricity to the grid) within New York procure Renewable Energy Certificate (RECs) to cover a certain percentage of their total load every year, with the percentage increasing each year. A REC acts as proof that 1 MWh of renewable electricity made its way into the grid from an approved renewable energy source. If, in a given year, a certain LSE cannot comply with a percent of load requirement (meaning they cannot verify that they

¹⁹¹ <http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b44C5D5B8-14C3-4F32-8399-F5487D6D8FE8%7d>

¹⁹² <https://static1.squarespace.com/static/576aad8437c5810820465107/t/5b43ab7570a6ad28d506172e/1531161461418/CES-ov-fs-1-v4.pdf>

¹⁹³ <https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard>

supplied a certain amount of renewably-generated electricity to the grid), then they will be allowed to make an Alternative Compliance Payment (ACP) instead. Hence, LSEs have four options under the RES to maintain compliance. They can (1) purchase RECs from NYSERDA, (2) purchase RECs from a third party, (3) self-supply RECs, or (4) make the Alternative Compliance Payment. The first three options depend entirely on who owns the renewable generation plant that any given LSE is purchasing power from for the grid.

Tier 2 will serve as a maintenance program that is not yet fully implemented, as many of the provisions are premature or are already covered under maintenance programs. However, its function will be to provide support for the systems and processes covered by Tier 1 requirements.

The offshore wind element of the RES is essentially meant to promote the development of technology and early planning that will allow offshore wind to replace older power-generating plants over time. Recognizing the potential for offshore wind on New York's coastline, the CES calls for the state, developers, and other key players to pay special attention to finding the best ways for maximizing its potential fiscal and power-generating value.

The Zero Emissions Credit requirement is an additional factor meant to maintain the operation of New York's nuclear plants until other renewable energy sources achieve enough scale to allow for their phasing out. In 2019, 33% of New York State's utility-scale electricity generation came from nuclear power plants, compared to 29% coming from renewable sources.¹⁹⁴ The ZEC requirement, then, requires all LSEs to purchase ZECs from NYSERDA. The amount of ZECs an LSE is required to purchase is purely dependent on its proportional contribution to the statewide energy load.

Key Financing Players:

Certified renewable energy providers (either NYSERDA or a third party)
LSEs
Market Makers and Intermediaries
Renewable Energy Developers
Energy Buyers (corporations, institutions)

Clarifying RECs and Energy Buyers

Fundamental to the purpose of LSEs self-supplying RECs or buying from NYSERDA is the ability to transfer ownership and responsibility of renewable energy on the grid to end consumers. For example, corporate demand for renewable energy is growing as many companies are announcing their own sustainability and carbon emissions goals. Therefore, many are using RECs as a way to substantiate claims of low-emissions and progress toward carbon neutrality—adding to the incentives for LSEs to offer more and more RECs to end consumers.

¹⁹⁴ <https://www.eia.gov/state/?sid=NY>

Many of these companies procure large amounts of RECs through Power Purchase Agreements (PPAs). PPAs are commonly used by commercial, industrial, and institutional organizations to purchase renewable energy from the grid.¹⁹⁵ Corporations and institutions are leading the way in REC purchases. According to Bloomberg New Energy Finance, purchasing of RECs tripled between 2017 and 2018, with U.S. corporations purchasing 8.5 GW of renewable energy through long-term PPA contracts.¹⁹⁶ Moreover, the development of Virtual PPAs has further pushed the growth of REC purchasing. Borne out of constraints of land coupled with high energy demands by corporations, this new mechanism allows the purchasing of off-site renewable energy as a means of offsetting electricity use in a different region. Overall, demand for RECs is surging throughout the country, which bodes well for NYSERDA's long-term plans for more renewable energy projects.

Specific Examples and Analysis:

Citi and Intermediation Structures

An alternative to corporations locking themselves into long-term PPAs is to use an intermediary that can provide fixed-rate renewable electricity through wholesale—what is known as an intermediation structure. Through this mechanism, an intermediary, usually a market maker or a bank, signs into a PPA themselves and then resells a portion of that energy to an end user at a fixed rate. The intermediary will usually charge a premium above what normal energy prices are, but the benefit for an end user is the reliability of having a fixed-rate electricity bill.

In one example of this kind of transaction, Citibank procured 200 MW of wind power and sold part of it to QTS Realty Trust at a fixed rate for one of its data centers in Texas. This project covered 100% of energy use for the data center while also allowing QTS to avoid engaging in a long-term PPA agreement—an engagement Citibank claimed to be rather high-risk.¹⁹⁷

This transaction took place under the umbrella of Citibank's \$100 billion Environmental Finance Goal.¹⁹⁸ This goal is a 10-year commitment, beginning in 2015, to lend to, and invest in, activities that facilitate a transition to a low-carbon economy.

Collaborative PPAs

Typically, PPA purchases are made by large institutions that are creditworthy, comfortable with long-term contracts, and have high electricity consumption. A new customer segment of smaller buyers, or even larger buyers that want to finance smaller projects, is emerging. Collaborative PPA deals are on the rise among corporate renewable energy buyers, where multiple parties will enter into a contract of similar or smaller size than a traditional PPA with one seller. One such example is the Dutch Wind

¹⁹⁵ <https://www.urbangridsolar.com/the-growth-of-corporate-renewable-energy-procurement/>

¹⁹⁶ <https://about.bnef.com/blog/corporate-clean-energy-buying-surged-new-record-2018/>

¹⁹⁷ <https://www.businesswire.com/news/home/20180402005268/en/Citi-to-Power-QTS-Data-Center-in-Irving-TX-with-Clean-Renewable-Energy>

¹⁹⁸ <https://www.marketwatch.com/press-release/citi-to-power-qts-data-center-in-irving-tx-with-clean-renewable-energy-2018-04-02>

Consortium that brought together Google, DSM, AkzoNobel, and Royal Phillips into a joint wind PPA in 2016.¹⁹⁹

It is important to differentiate collaborative PPA deals from regular PPA deals that have an anchor tenant that opens up the contract to smaller buyers. Traditionally, if a smaller renewable energy buyer wanted to tap into a PPA contract, they would join a deal where a larger buyer already negotiated the terms. As a result, the smaller buyers experience less flexibility and have little say with respect to deal terms. The alternative to this is a collaborative PPA deal wherein all parties enter at the negotiation stage and have a more proportionate say in the terms of the contract. As a result, it is important in collaborative PPA deals that all parties share the same goals and risk tolerances, as well as tolerable exit agreements.

Outlook

The demand for renewable energy by consumers is growing significantly, and the market for RECs in New York is as vibrant as it has ever been. When coupled with the sense of urgency that New York State has toward building more renewable energy projects, there should be no shortage of options for the purchase of renewable energy. Even if there were fewer local options for renewable energy in a given quarter, NYSEERDA and other third-party REC suppliers can transfer unpurchased RECs from prior quarters. Off-site renewable energy purchases are also becoming increasingly viable. With the advent of Virtual Power Purchasing Agreements and alternative financing mechanisms for large-scale renewable purchasing agreements, New York City-based renewable energy buyers are getting increased access to both the national and international REC markets and have more tools at their disposal than ever before. New York City also has a vibrant investing community that has already shown interest in financing large-scale renewable projects (e.g. D.E. Shaw & Co. with Block Island Wind), as well in creating financing opportunities for the wholesale procurement of renewable energy (as with Citibank and QTS Realty, and its \$100 billion Environment Finance Goal).

Additionally, New York State's CES mandate for the additional procurement and offering of RECs by New York-based LSEs only furthers optimism around the increasing availability of renewable energy for purchase for New York City-based consumers. As the supply of RECs increases due to more and more renewable energy projects being developed in and around New York, projections for prices of these RECs are also expected to remain relatively affordable. Nonetheless, at current prices, demand is still high as consumers begin to value the environmental benefits.

¹⁹⁹<https://perspectives.se.com/latest-perspectives/joining-the-club-collaborative-offsite-ppa-structures-for-renewable-energy-buyers>

Role of Philanthropy

Specific Examples

Kresge

The Kresge Foundation,²⁰⁰ an organization working to uplift low-income families and individuals, provides a great example of how philanthropy can catalyze renewable energy development that otherwise would likely not happen. It also provides an excellent example of a philanthropic organization working hand in hand with green banks to finance clean energy projects. In May 2019, Kresge Foundation announced that it would provide a \$10 million guarantee and a \$300,000 multi-year operating grant to Inclusive Prosperity Capital (IPC)—a spin-out and strategic partner of the Connecticut Green Bank focused on bringing the benefits of clean energy to low-income communities.²⁰¹ This commitment by Kresge will provide IPC with the means to expand beyond Connecticut and launch its flagship national clean energy investment fund. Due to the philanthropic nature of its funding, IPC is able to deploy capital to traditionally underinvested communities and generate heretofore unrealized energy savings, community health improvements, and community economic development. Moreover, the institutional backing tied to the guarantee also allows IPC to operate using flexible capital stacks, further allowing for more clean energy development.

SEACEF

The South East Asia Clean Energy Facility (SEACEF)²⁰² provides another, perhaps more unique example of how philanthropy can seek to catalyze growth in clean energy markets. SEACEF is an amalgamation of philanthropic investments from groups such as Bloomberg Philanthropy, European Climate Foundation, and the Children's Investment Fund Foundation that totals \$20 million.²⁰³ Focused on “venture philanthropy,” the group is meant to catalyze the growth in renewable energy investment throughout Indonesia, Vietnam and the Philippines by providing early-stage renewable energy developers with capital—primarily for wind, solar, and storage. Developers looking to start new renewable projects can access anywhere from \$100,000 to \$1 million in early stage funding via SEACEF in order to scale enough to reduce risk and therefore achieve funding from other traditional sources. Any returns generated from a given investment are cycled back into the fund to use in future projects. With that said, SEACEF invests using three main vehicles: equity, recoverable grants, or convertible loans with repayment intended at financial close. Additionally, funding to developers is made over time based on previously agreed-upon milestones.

²⁰⁰ <https://kresge.org/>

²⁰¹ <https://www.inclusiveprosperitycapital.org/2019/05/07/ipc-10-million-kresge-guarantee/>

²⁰² <https://www.seacef.org/>

²⁰³ <https://www.eco-business.com/news/western-governments-and-philanthropists-pump-20m-into-southeast-asian-clean-energy/>

Scope for Future Research

Despite the progress in New York State and New York City with respect to renewables, a significant amount of work still needs to be done. More research is needed, nonetheless. The following can provide a good starting point.

Wind: Scope for wind research entails finding ways to avoid political lock-ups of major wind projects—this is highlighted by the challenges faced in the Vineyard Winds project. Moreover, storage is a major challenge that needs to be addressed, and will continue to be a key area for investment. The volatility of wind production requires storage to help create consistency and predictability within the broader grid system. Moreover, philanthropy efforts to spur wind markets could be a possible avenue, with the SEACEF framework being a good place to start.

Solar: Efforts surrounding community solar pose an interesting appeal to New York City, and can work well with micro-grid-style solutions. It is also already being explored as a solution in the city and can be an interesting investment opportunity. Much like wind, research surrounding storage at scale would be an enormous boost to the viability of solar implementation. Additionally, more research is needed into how cost savings might dissipate should ITCs be phased out, and how that will affect the appeal of solar.

Ground source heat: In particular, research surrounding ground-source heat and potential use of PACE financing and other vehicles to decrease cost of capital is needed. This would aid in the implementation of ground-source heat at scale and help decrease overall need for outdated boiler and furnace systems, while decreasing the city's reliance on traditional heating fuels like natural gas. Better understanding of how larger projects throughout the city were financed (such as the Brooklyn Children's Museum) would be useful here. Thermal grids are also an innovative way to achieve scalable ground-source heat, and is an approach that could work well in New York City given the density and interconnectivity of the city. This approach can decrease drilling costs on an individual basis by creating a system that only requires buildings to tap into it, rather than each building needing to tap into an individual source of ground-source heat. Moreover, research with respect to emerging technologies that would make ground-source heat cheaper would aid on the other side by decreasing overall costs and the need for extensive amounts of upfront investment. Dandelion is a good place to start with this as they are the leaders in reducing drilling costs, the most expensive part of ground-source heat installation.

Renewable Energy Buyers: One of the more interesting opportunities that has arisen in the past few years is the increase in smaller renewable energy buyers that want projects too small to justify a PPA. With this in mind, the rise and attractiveness of collaborative renewable-energy buyers' clubs is an interesting and important area that needs further study. Additionally, given New York City's relationship with the financial industry, the other key focus area is on the role of large financial institutions in brokering renewable contracts. In particular, Citi's commitment to sustainability and its role in creating intermediation structures could prove influential in the coming years.

Conclusion

As a whole, between the CES, Governor Cuomo's REV, various NYSERDA incentives, renewable-centric allocations by private financiers, such as Citibank, and impressive innovations by companies such as Dandelion, New York City is on its way to receiving a significant portion of energy from renewable sources. While there are numerous opportunities for renewable projects to receive financing, there are still uncertainties. In particular, concerns around the feasibility of offshore wind under current political constraints can pose material risks for future projects. Moreover, much like innovations in community solar, efforts to decrease the cost of capital for ground-source heat are just getting started.

Nevertheless, the future of renewables in NYC, and New York State more generally, is very promising. Many of the municipal and state conditions are trending toward a better investment environment around clean energy, and many opportunities for both private and public funding are sure to emerge and surge in the coming years. Overall, this area of focus will be paramount to New York achieving its 80X50 emissions goals, and hence is, and will continue to be, a definite area of focus both publicly and privately.

Food and Health

A core part of supporting mental and physical health is access to nutritious, healthy, affordable foods. To provide this, and a sustainable food infrastructure, is essential. On a global scale, as populations continue to grow and incomes across the world increase, overall food demand is also set to increase by more than 50%, and demand for animal-based foods by 70%.²⁰⁴ Meanwhile, as demand for calories increases, climate change is decreasing the number of arable acres, often in regions where agricultural production is most crucial to economic and social stability. Conventional, mechanized farming practices have substantially reduced topsoil depth and fertility, and agricultural opportunities often contribute to deforestation, especially in the environmentally critical Amazon basin. In a perverse positive feedback loop, the IPCC estimates that agriculture itself contributes up to 40% of global greenhouse gas emissions. At least 10% of global emissions, or one-quarter of agriculture's impact, results from food waste alone, not including water usage or the impacts of runoff from overfertilization and deforestation.

Solving the global food challenge will require a coordinated global strategy to increase the efficiency of food production. We need to produce more, healthier calories using less land and water while reducing carbon emissions substantially. Entrepreneurs across the world have risen to the challenge and delivered unprecedented levels of innovation all along the value chain, from production to distribution, improving access to nutritious and healthy foods. In the seeming blink of an eye, cultivated meats, biological fertilizers, and dual-sided marketplaces for regenerative farming practices have become the de facto new backbone of modern agriculture. The ag tech investment ecosystem is maturing to match; the past five consecutive years have brought “record breaking” levels of private funding both in terms of number of financed deals and total quantity of investment, surpassing \$17B+ across 1,500+ private investments as of 2018.²⁰⁵

Food Deserts

Overview

Food deserts are areas that provide insufficient access to affordable healthy food. These areas typically offer residents a meager selection of fresh produce, meat and other healthy but perishable whole foods – mainly due to a lack of grocery stores, farmers' markets, and healthy prepared food providers.²⁰⁶ Communities are considered food deserts if 33% of the population resides further than one mile from a large grocery store or supermarket.

People living in food deserts have an increased likelihood of suffering from obesity, diabetes and other diet-related health issues due to their dependence on the less-

²⁰⁴ *Creating a Sustainable Food Future*, World Resources Institute, pp. 2

²⁰⁵ *AgriFood Tech Investing Report - 2018*, AgFunder, <https://agfunder.com/research/agrifood-tech-investing-report-2018/>

²⁰⁶ <http://americannutritionassociation.org/newsletter/usda-defines-food-deserts>

healthy foods available near them. This can impact public health by putting a strain on healthcare systems.

A related issue is food insecurity. Food-insecure households don't have sufficient income to provide the food they need. One in seven (14.4%) NYC residents, or 1.2 million citizens were food insecure before the COVID-19 pandemic, and it is estimated that the health emergency has increased the number to 2 million, or about 24% of New Yorkers.

Food security is a local, multifaceted issue, where solutions and financing involve a wide range of participants including retail grocery, urban agriculture, healthcare, government, philanthropy, and the private sector. The following highlights some of the private and public ventures, nationally and in New York, intended to address this issue.

Key Financing Players:

- US Department of Agriculture
- Lyft
- Blue Cross Blue Shield
- Walmart
- New Venture Advisors
- Equilibrium (CEFF)

Specific Examples and Analysis:

One of the more obvious ways to address food insecurity is by building retail grocery stores with full fresh food selections in food insecure regions. New York City incentivizes the opening of food stores in food deserts with tax and zoning incentives under a program dubbed FRESH (Food Retail Expansion to Support Health). FRESH has made it possible for 18 new stores to open; however, this is far short of the need, which was said to be over 100 new stores when the program was launched in 2009. This shortfall points to the need for experimentation and innovation.

In 2011, as part of Michelle Obama's campaign to reduce childhood obesity, Walmart pledged to build or renovate up to 300 stores to serve food deserts in the U.S. But five years later, in 2016, it shuttered 154 of them.²⁰⁷ The company reported that closing these smaller stores would help it grow its ecommerce business.²⁰⁸ Building new stores is difficult because it can be capital intensive, and stores in lower-income areas produce lower margins. Further, retail owners are concerned about theft and crime.

Upstate NY has numerous programs and partnerships supporting sustainable food production. Grow-NY is one example of many, and among the nation's largest food and agriculture business competitions, with an explicit focus on the 20% of New York State that is farmland. Grow-NY distributes \$3 million in 7 awards annually from the NYS

²⁰⁷ <https://www.cbsnews.com/news/walmart-shutdowns-create-new-food-deserts/>

²⁰⁸ <https://abcnews.go.com/Business/walmart-shut-269-stores-globally-including-154-us/story?id=36315019>

Department of Agriculture and Resources to startups to fuel sustainable agricultural practices local to New York.²⁰⁹

On the private side, numerous food-focused incubators are available to support NYC entrepreneurs, including:

- Brooklyn Food Works focuses on training professional chefs.²¹⁰
- Bronx CookSpace offers affordable shared kitchen space for rent and personalized consulting services for small food businesses.²¹¹
- Food Future Co helps high-growth companies move from an established early product phase to mainstreaming their offerings.²¹²
- HBK Incubates helps food entrepreneurs to scale their business.²¹³
- WeWork Food Labs focuses on supporting startups across the sustainable food ecosystem from an urban perspective, including consumer packaged goods and hospitality, AI, robotics, and distribution software.²¹⁴

NYC has close ties to the overall NYS food ecosystem. The Chobani Food Incubator provides \$25,000 equity-free grants to select early-stage food and beverage startups with missions to make better food for more people, and manufacturing facilities in upstate New York.²¹⁵

A range of corporations have also started addressing food security issues. Lyft pledged \$1.5 million and piloted its Grocery Access Program in 2018, allowing qualified families to pay just \$2.50 for up to 50 rides to and from the nearest grocery stores.²¹⁶ Another innovative private sector solution can be found in the healthcare space, where Blue Cross Blue Shield has launched their foodQ program, an online delivery service to deliver prepared, healthy, affordable meals to people living in food deserts.²¹⁷ Funding for the program comes in part from the Health Care Service Corporation's \$1 billion Affordability Cures initiative, whose aim is not to address food security specifically, but rather the affordability of healthcare.²¹⁸ Further, healthcare organizations have started directly funding the development of sustainable food systems, as doctors start to prescribe fruits and vegetables to promote healthier diets,²¹⁹ hospitals build farms,²²⁰ and healthcare providers build grocery stores.²²¹ These promising experiments will all require innovative financing to develop longer-term for-profit or hybrid solutions.

²⁰⁹ <https://www.grow-ny.com/competition-details/>

²¹⁰ <http://thebrooklynfoodworks.com/>

²¹¹ <https://whedco.org/bronx-cookspace/>

²¹² <https://www.foodfuture.co/>

²¹³ <https://hotbreadkitchen.org/incubates/#.XuJ2wedN42w>

²¹⁴ <https://www.wework.com/promos/food-labs>

²¹⁵ <https://chobaniincubator.com/>

²¹⁶ <https://www.marketwatch.com/story/lyft-is-offering-250-rides-to-grocery-stores-for-people-living-in-food-deserts-2018-12-12>

²¹⁷ <https://www.smartcitiesdive.com/news/mitigating-americas-food-desert-dilemma/554087/>

²¹⁸ <https://medcitynews.com/2019/02/hcsc-and-blue-cross-blue-shield-institute-test-new-food-delivery-service/>

²¹⁹ <https://www.fastcompany.com/90323580/prescribing-fruits-and-veggies-would-save-100-billion-in-medical-costs>

²²⁰ <https://www.greenmatters.com/food/2017/11/02/fpayr/hospital-creates-largest-rooftop-farm-in-boston>

²²¹ <https://www.newventureadvisors.net/how-health-care-is-influencing-food-system-planning/>

Government programs and philanthropy are also a significant source of funding for addressing food deserts. In 2019, the U.S. Department of Agriculture committed \$45 million to Double Up Food Bucks, a program started in Detroit, Michigan, which New York State has also adopted²²². The program allows Supplemental Nutritional Assistance Program (SNAP) recipients to purchase fresh food at farmers markets with their SNAP debit card, and then matches the amount spent with Double Up Food Bucks, effectively allowing SNAP recipients to purchase twice the value of their SNAP benefit.²²³ The program is also funded by philanthropic grants from various community foundations, illustrating the important role that philanthropy plays in financing food security solutions regionally.

Types of Financing:

- Federal funding via entitlement programs, such as the Supplemental Nutritional Assistance Program (SNAP), supports the development of markets for healthy food in food deserts and among food-insecure populations.
- Philanthropic grants can be used for researching and developing solutions, or directly contribute funds to support healthy food purchases, such as Double Up Bonus Bucks.
- Corporate food retailers, such as Walmart, can build grocery stores in food deserts.
- Health insurance companies can fund internal programs to provide people experiencing food insecurity with healthy meals.

Outlook

Financing for food security issues has historically been limited to government benefits and philanthropic grants. It is, however, exciting to see a variety of private companies attempting to solve these issues. A food-secure future might involve mobile grocery stores that deliver fresh, healthy food to food insecure regions via electric vehicles, and enable residents to maximize their purchasing power with Double Up Food Bucks. Food on the Move is one such example in Providence, Rhode Island, of a mobile market that incentivizes the purchase of fresh produce by accepting SNAP.²²⁴ Developing viable business models to address food insecurity has been a challenge thus far, and more imagination is likely needed to provide a vision for a food-secure future in New York. This may enable investors to identify investment opportunities, and in turn, unlock additional private-sector financing. As an example, Equilibrium Capital Group has closed and deployed a Controlled Environment Food Fund focused on greenhouse-grown food.²²⁵ In 2018, Equilibrium made a substantial investment in the Minnesota-based greenhouse operations of Revol Greens and a case study follows below.

²²² <https://doubleupnys.com/>

²²³ <https://doubleupnys.com/how-it-works/>

²²⁴ <http://www.browndailyherald.com/2019/04/12/mobile-market-promotes-fresh-produce/>

²²⁵ <https://www.globalaginvesting.com/equilibrium-closes-controlled-environment-foods-fund-336m-fully-deployed/>

Food Transport and Logistics

Overview

One major challenge that food companies face is logistics. Food is a physical and perishable product, and the current system is built to move large amounts long distances to global markets.²²⁶ Distribution can often end up requiring more capital than anticipated, and if distribution systems don't run efficiently, it can be difficult for food companies to scale. Inefficient transportation also leads to more food waste due to spoilage, and is more susceptible to disruption in weather and health emergencies.

In the food industry, transport is often categorized under the umbrella of *midstream technologies*, which operate between the consumer and producer, and include food safety & traceability tech, logistics & transport, and processing tech.²²⁷ Midstream tech has gained popularity with venture capitalists, with 2018 funding estimated to be around \$1.35 billion across 167 deals.²²⁸ Given the perishable and localized nature of food transportation, application of midstream technologies from adjacent industries has high relevance and potential.

Types of Financing:

- Venture capital
- Private equity
- Corporate-sponsored incubators

Key Financing Players:

- TechStars
- Moment Ventures
- Greenhouse Capital
- S2G Ventures²²⁹
- AgFunder

Specific Examples and Analysis

Indigo Ag has applied the Uber sharing-economy model to agricultural transportation through its digital freight matching program. Indigo connects owners of expensive yet infrequently utilized ag shipping equipment with growers looking to bring their product to market within tight timelines. Indigo's take on midstream technologies for food transport will directly address sustainability concerns from the billions in losses from inefficient agricultural transportation.²³⁰

²²⁶ <https://foodtechconnect.com/2016/08/01/food-unwinnable-for-startups/>

²²⁷ AgFunder Agrifood Tech Investing Report 2018, pp. 5

²²⁸ AgFunder Agrifood Tech Investing Report 2018, pp. 23

²²⁹ AgFunder Agrifood Tech Investing Report 2018, pp. 55

²³⁰ <https://www.indigoag.com/indigo-transport>

Venture capital plays an important role for catalyzing and scaling technology development. For example, Pod Foods is a tech-forward distribution and logistics platform that helps emerging food brands get into grocery stores. Pod secured \$250,000 in pre-seed funding from Unshackled Ventures, and announced a \$3 million seed led by Monument Ventures in 2019.²³¹

It is widely agreed in New York that the popularity of online shopping and the on-demand economy result in stark social and environmental consequences in the form of pollution and gridlock as trucks and couriers struggle to deliver 1.5 million packages per day across the city. Food delivery is part of this emissions-intensive gridlock and reductions in transport emissions need to be part of a larger food sustainability strategy.²³² The food transport space therefore benefits from applying technology innovations that improve the efficiency of logistics more broadly, and enable simple supply chain management.

For example, Starship Technologies is a startup that has created autonomous robots to carry items, such as groceries, to solve last-mile delivery, and has raised \$25 million from Matrix Partners and Morpheus Ventures.²³³ Another example, Nuro, the autonomous delivery startup which makes self-driving vehicles for local goods transportation, has raised a whopping \$940 million from SoftBank's Vision Fund. Nuro seeks to improve efficiency in transport overall, and while not directly targeting food transport specifically, it will nonetheless naturally address food transport challenges.²³⁴

Beyond improving the speed of delivery from farm to plate, other startups are focused on extending the shipping and shelf life of food. Apeel Sciences and Cambridge Crops are utilizing naturally occurring and edible plant and silk-based coatings to the surface of perishable foods to reduce spoilage.^{235,236}

In addition to VC, corporations are also participating in early-stage financing of food transport supply chain solutions. Agricultural giant Cargill Inc. launched an accelerator program in 2017 in partnership with TechStars, which focuses on tech solutions across the value chain for food and agriculture.²³⁷ Traditional supply chain management companies, such as Americold, are also starting to make more of an effort to pursue sustainability. Americold is focused on improving energy efficiency and decreasing emissions via improved cold chain management.²³⁸

Outlook

Previously overlooked by traditional funders as a logistically challenging and low-margin industry, sustainable agricultural production and consumption are in the early innings of a high-growth game. As evidenced by the past five years of consecutive record-

²³¹ <https://techcrunch.com/2019/07/03/pod-foods/>

²³² <https://clf.jhsph.edu/sites/default/files/2019-01/Instituting-change.pdf>, pp. 13

²³³ <https://techcrunch.com/2018/06/07/self-driving-robot-delivery-startup-starship-technologies-raises-25-million/>

²³⁴ <https://techcrunch.com/2019/02/11/softbanks-next-bet-940m-into-autonomous-delivery-startup-nuro/>

²³⁵ <https://apeelsciences.com/>

²³⁶ <https://www.cambridgecrops.com/>

²³⁷ <https://www.foodlogistics.com/technology/news/20986659/cargill-goes-tech-with-food-startup-accelerator>

²³⁸ <https://www.americold.com/about-us/sustainability/>

breaking levels of private funding, ag tech innovation is heating up. At the intersection of massive legacy industries like transportation, healthcare, and manufacturing that are each undergoing their own transformations, the sector is poised to benefit from adopting new business models and technological innovation that has been proven in adjacent industries. Accordingly, venture capital and incubator programs will likely continue to play a key role in financing the early stages of technology development, with some involvement from corporate stakeholders and baseline government grant funding.

Urban Farming

Overview

Urban farming is defined as growing and selling food within cities.²³⁹ It can refer to rooftop farms, controlled environment agriculture (e.g. vertical farming), and community gardens, and is gaining popularity as people become more interested in where their food comes from. Urban farming has many benefits, including increasing access to fresh, locally sourced foods, improving public health, reducing the heat island effect and toxic inputs, and reducing GHG emissions from transportation and food waste. Urban farms can also serve as green stormwater capture systems.

Types of Financing:

- Venture capital
- Government grants, such as the NYC Department of Environmental Protection (DEP) Green Infrastructure Grant Program
- Private equity
- Microloans, as offered by the Farm Service Agency (FSA)²⁴⁰
- Crowdfunding

Key Financing Players:

- Equilibrium Capital
- Google Ventures
- Kickstarter
- Barnraiser
- NYC DEP
- Farm Service Agency

Specific Examples and Analysis

Continued interest in urban agriculture has led to the development of innovative financing. Brooklyn Grange is a commercial urban farm financed through a mix of methods, including crowdfunding via Kickstarter.²⁴¹ Crowdfunding as a financing

²³⁹ <https://www.greensgrow.org/urban-farm/what-is-urban-farming/>

²⁴⁰ https://www.fsa.usda.gov/Internet/FSA_File/microloans_facts_2014.pdf

²⁴¹ <https://www.brooklyngrangefarm.com/faq>

mechanism is actually more popular than one may imagine, with sites such as Barnraiser dedicated specifically to the “sustainable, healthy food community”.²⁴² For example, Top Leaf Farm, a for-profit company that operates two rooftop farms in Oakland, California, utilized Barnraiser to crowdfund more than \$15,000 to pay for its greenhouse, supplies, soil, and seeds in early stages of financing.²⁴³ While non-profit farms have access to grants dedicated to mission-driven projects, for-profits don’t have the same access to capital. Crowdfunding represents an innovative solution to accessing early-stage financing.

Urban agriculture is financed primarily by venture capital and private equity, like the broader food and health category. Startup Bowery Farms operates indoor farms using machine learning, proprietary technology and sensors to monitor crops. The company raised \$90 million in Series B funding from Google Ventures, which will help scale operations beyond its warehouse.²⁴⁴

Gotham Greens is another prominent example. This urban farm was founded in Brooklyn and is a multi-state indoor farming leader with five facilities across New York and Chicago. It’s the largest hydroponic leafy greens producer in North America and is powered from renewable energy sources to reduce its environmental footprint.²⁴⁵ Through three rounds of private equity investment, Gotham Greens has raised \$45 million to enable growth. It is quickly expanding, with over 150 employees across its five locations and the development of an additional 500,000 square feet of new greenhouse.²⁴⁶

More traditional investors are getting involved in the space as well. AeroFarms, based in Newark, New Jersey, is the largest indoor vertical farm in the world.²⁴⁷ Since 2004, it has received a total of \$238 million in funding from private equity groups and traditional asset managers, including Goldman Sachs’ Urban Investment Group, RBH Partners, Alliance Bernstein, and Prudential Financial.

Aside from large-scale operations like AeroFarms, Bowery, and Gotham Greens, urban farming embraces more localized forms of food production as well. Companies such as Farm.One, Infarm, Smallhold, and Square Roots have developed networked systems of small growing units in shipping containers, restaurants, and food markets. NYC supports over 700 community gardens as well. United Way NYC and the Food Bank for NYC, for example, offer \$25,000 grants to community-based nonprofit organizations for urban farming activities and other projects that meet the nutrition needs of low-income households.²⁴⁸ Beyond direct support for production, the NYC Economic Development

²⁴² <https://www.forbes.com/sites/robindschatz/2016/02/13/crowdfunding-site-barnraiser-weaves-a-growing-tapestry-of-stories-from-the-good-food-community/#6f49c41f1c7d>

²⁴³ <https://edibleeastbay.com/2016/08/12/the-rise-of-rooftop-farming/>

²⁴⁴ <https://www.businessinsider.com/bowery-farm-90-million-raise-food-google-2018-12>

²⁴⁵ <https://www.prnewswire.com/news-releases/gotham-greens-raises-29-million-in-growth-equity-funding-300669351.html>

²⁴⁶ Ibid

²⁴⁷ <https://aerofarms.com/2017/11/14/welcome-worlds-largest-indoor-vertical-farm/>

²⁴⁸ <http://www.unitedwaynyc.org/what-we-do/food-support>

Corporation funds urban tech hubs like New Lab, where young companies have generated more than 2,000 jobs developing local, sustainable solutions.²⁴⁹

Case Study: Equilibrium Capital and Revol Greens

Controlled Environment Foods Fund (CEFF I)

Overview

Problem: Increasingly frequent extreme weather events are disrupting the supply of fresh leafy greens and lettuces in the U.S., which is overwhelmingly concentrated in California, and to a lesser degree, Arizona.

Solution: Distributed controlled environment facilities to grow leafy greens and lettuces financed by Equilibrium's Controlled Environment Foods Fund I ("CEFF I")

Key stakeholders: Revol Greens, Equilibrium Capital

Total Controlled Environment Growing Area: 2.5 acres; expanding to 10 acres

Mechanism: Sale-leaseback and triple net lease financing

Project Start: 2016

Location: Medford, Minnesota

The supply of fresh leafy greens and lettuces in the U.S. is threatened by the increased frequency of extreme weather events, as well as increasing labor shortages and recurrent food safety recalls. To mitigate these risks, as well as grow a better, fresher product, Revol Greens grows leafy greens and lettuces in a greenhouse to supply consumers 365 days a year. However, greenhouses are extremely capital- and energy-intensive. Access to capital has heretofore hindered the growth of greenhouses as an alternative production option. Revol Greens worked with Equilibrium Capital to finance the expansion of a greenhouse facility in Medford, Minnesota, to increase production capacity and help achieve economies of scale. The project carries multiple environmental benefits, including reduced food transport miles, the creation of family-wage jobs in the area, produce that is free of pesticides and herbicides, and less water-intensive methods compared to traditional farming.

Field production of leafy greens (both organic and conventional) is under long-term pressure due to labor shortages and increasingly frequent extreme weather events. Continued disruptions in the supply chain for fresh leafy greens are expected in the coming years. Specifically, the geographic concentration of the US lettuce supply in California and Arizona, which produces nearly all of the US lettuce supply, is a material risk to the produce industry. Climate change and increasingly extreme weather (historic droughts, fires, and rain) in the Western U.S. create long-term questions about the resiliency of this supply chain, in addition to concerns about the effect of long-distance shipping on produce quality and freshness.

Moreover, California's increases to minimum wage -- \$12.00 in 2019 (and to \$15.00 by 2022) and the 2016 introduction of mandatory overtime pay for the farm sector -- are reducing the wage disparity between field and advanced greenhouse agriculture -- the

²⁴⁹ <https://edc.nyc/industry/smart-cities>

latter typically pays materially higher wages – and may affect the long-term competitiveness of field lettuces relative to facilities like Revol's in Minnesota.^{250,251}

These factors are likely to drive leafy green production to distributed, regional sources. These controlled environment facilities are a flexible solution. Equilibrium, therefore, believes there is a significant growth market in controlled environment leafy greens, but catalyzing this shift will require new forms of financing and investment structures that provide the industry a scalable, affordable model for growth.

Problem

The advanced greenhouse industry is capital intensive. Investment can exceed \$1.3 million per acre for vine crops and \$2.5 million per acre for lettuces, making it financially challenging to fund the growth needed to achieve economies of scale, especially given the limited capital sources currently available to operators of these assets. For this reason, advanced greenhouse operators have historically expanded gradually in small, internally funded increments. However, demand from buyers for ever-larger volumes and the economies of scale required to be a cost-competitive producer now increasingly require far larger investments on significantly faster timelines.

Solution

Equilibrium's CEFF I partnered with Revol Greens to finance expansion of their greenhouse to increase year-round production of lettuce. Through a sale-leaseback, CEFF I created important liquidity for Revol Greens to invest in its growth, while additional lease-based financing is being used for a fourfold expansion of the facility from 2.5 acres to 10 acres of production.

Key Stakeholders

Revol Greens financed the original facility, sold it to Equilibrium CEFF I, and is now the lessee. While Revol Greens is a relatively new entrant to the lettuce sector, the company hired a team made up of industry veterans with decades of greenhouse experience.

Equilibrium Capital is a Portland-based real assets firm that manages the Controlled Environment Foods Fund I (CEFF I), which owns the greenhouse facility and leases it to Revol Greens. CEFF I provided the financing that allows the facility to expand and take advantage of the underlying market trends; the fund was responsible for investigation, diligence, and capital formation for the project.

Financing

Phase 1

Revol Greens designed and built the original 2.5-acre greenhouse ("Phase 1") using its own balance sheet. Phase 1 was completed in early 2018, and included the necessary

packing, harvesting, and energy infrastructure to support an expansion to 10 acres. However, lettuce greenhouses are capital intensive and Revol Greens wanted a partner to help them scale.

Equilibrium had been engaged with the Revol partners since the project was conceived in 2016. CEFF I acquired Revol's existing greenhouse facility in December 2018, and leased it back to Revol Greens under a long-term triple-net lease (i.e., Revol is responsible for paying all taxes, insurance, and operating expenses on the property).

Phase 2

In the sale-leaseback transaction, CEFF I reserved the capital necessary to expand the greenhouse facility to its originally planned 10-acre size. Construction for the 7.5-acre expansion (Phase 2) began in 2019 and first harvest was planned for 2020. The long-term triple-net lease is structured to incorporate both Phase 1 and Phase 2. Lease payments for Phase 2 will begin on commissioning of the expansion.

Demand from buyers and economies of scale now increasingly favor facilities larger than 30 acres for high-wire facilities (tomatoes, peppers, and cucumbers), and greater than 10 acres for leafy greens. Even for the largest and most experienced operators, finding capital on acceptable terms has proved difficult. Meanwhile, increasingly large operations are raising the stakes and requiring larger capital investment for operators to be competitive.

Equilibrium's Controlled Environment Foods Fund brings together operations and capital markets expertise to efficiently deploy capital in the controlled environment foods markets. CEFF I offers the market a new financial capability that can help the controlled environment agriculture (CEA) industry expand and scale, through the application of long-term triple-net leases, a transaction tool often utilized in real estate markets. Furthermore, Equilibrium's growing experience and expertise in CEA will prove beneficial to the industry's development.

Distributions from the project are expected to come in the form of lease payments from the operator, refinancing proceeds, and liquidity event proceeds. Lease payments include a base rent based on capital costs for the facility, and a revenue share. Stable base rent payments are expected to make up the majority of lease payments over the life of the project. The project has already started making yield distributions, and is expected to reach net cash flow positive in several years.

By removing a significant barrier to entry – the cost of land and greenhouse facilities – Equilibrium's CEFF I makes it possible for greenhouse operators to establish themselves at economic scale relatively easily. For this project, CEFF I offered Revol attractive lease terms that included a base rent plus a revenue share, rather than a larger fixed lease payment.

Results

The project will result in an investment of \$30 million upon completion of Phase 2 and several other important upgrades to the facility. The project represents the first commercial-scale triple-net lease in the U.S. greenhouse space. It is expected to create a platform for institutional investors to access an emerging food infrastructure asset class and for leading operators to efficiently access capital in order to meet market demands. This helps to drive lettuce and leafy greens production toward distributed, regional, controlled-environment facilities in order to address long-term pressures in field lettuces due to labor shortages and increasing extreme weather events.

Several positive sustainability impacts stem from the project and drive economic performance. CEA-grown leafy greens and lettuces use less than 10% of the water required for traditional field farming.²⁵² In addition, CEA facilities often reduce food miles, increase freshness to the consumer, and reduce waste by selling most of their output in the surrounding region. The controlled environment eliminates the need for spraying harmful pesticides and herbicides, with the result that all lettuce grown at Revol Greens is clean, food-safe, and chemical free. Finally, the facility will create over 30 family-wage agricultural jobs in the local area. Base pay is \$20 per hour, far higher than average agricultural wages, and because the facility is equipped to grow 365 days a year, these jobs are year-round, as contrasted with the seasonal nature of most field agricultural employment.

Community gardens are another form of urban farming that focus on bringing healthy, affordable food to low-income communities. Community gardens are often financed via dues paid by garden members, small fundraisers, or through small philanthropic grants. For example, the Brooklyn Community Garden Fund allows gardeners to make improvements and host community activities. It's financed through a partnership with the Brooklyn Community Foundation and the Green Gorillas, a community garden organization.²⁵³ Philanthropic funding will likely remain the primary funding mechanism for community gardens as these projects don't create revenue streams, which private investors require.

Outlook

Urban farming not only represents a way for communities to grow their own healthy food, but also creates parallel benefits. Outdoor farms and rooftop gardens can double as green infrastructure, providing permeable surfaces to capture stormwater and decrease the heat island effect. Rooftop gardens can also improve building energy efficiency -- something particularly important for New York City's dense built environment. Growing, selling, and consuming locally grown food also drastically reduces the cost of transport, decreasing greenhouse gas emissions associated with food.

²⁵² Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods, Lages Barbosa, Guilherme et al., 2017.

²⁵³ <https://www.brooklyncommunityfoundation.org/programs-impact/special-initiatives/brooklyn-community-garden-fund>

Overall, two of the larger barriers when it comes to urban farming are cost of land and policy. Farmers must consider zoning laws that increase the availability of public land, height restrictions on greenhouses, and navigating legislation in organizing farm operations and logistics. Perhaps there is an opportunity for green banks to develop expertise in this area, streamline the development process, and provide financing for new farms. Urban farming has already rapidly increased in popularity -- the private sector should pay close attention to successful business models, such as Gotham Greens and AeroFarms, to learn more about the development process and what opportunities there are to create new innovative financing mechanisms that allow urban farming operations to scale more quickly.

Role of Philanthropy

In addition to providing the financing for individual projects, foundations play an important role in catalyzing research to identify new business methods, supporting pilot projects, and bringing innovative solutions to the table. The EAT Foundation in Stockholm was launched in 2016 with the goal of breaking down barriers between policy makers, industry leaders, researchers, and society to develop actionable solutions that can be put into practice. The Foundation's initiative was created to transform the way people around the world eat to align with the UN Sustainable Development Goals.²⁵⁴ The EAT Foundation is co-funded by the Wellcome Trust, the Stordalen Foundation, and the Stockholm Resilience Center. The Wellcome Trust and Stordalen will contribute £3 million to the EAT Foundation over the next three years to support policy and science.

In contrast to the EAT Foundation, the McConnell Foundation has acted as an investor in sustainable food systems. In addition to providing traditional grants,²⁵⁵ the foundation has committed \$340,000 to Alternative Land Use Services, a Canadian program that helps farmers and ranchers deliver ecosystems services in their communities, establishing a social innovation fund that will enable farmers to create financial tools and markets to undertake conservation practices on their land.²⁵⁶ It has also provided \$1 million to Invesco to be used for private equity investment in companies promoting sustainable food solutions.²⁵⁷

Conclusion

New York City continues to develop programs to support knowledge and access to healthy food. Many barriers to access remain, however, when it comes to healthy and affordable food options.²⁵⁸ Whereas sectors such as energy efficiency in buildings and renewable energy have already adopted and are now expanding innovative financing mechanisms, food financing is still in the early stages of development, primarily defined by venture capital, private equity, philanthropic funding, and government grant

²⁵⁴ https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf

²⁵⁵ <https://mccconnellfoundation.ca/initiative/sustainable-food-systems/>

²⁵⁶ <https://mccconnellfoundation.ca/initiative/sustainable-food-systems/>

²⁵⁷ <https://mccconnellfoundation.ca/grant/investeco-sustainable-food-trust/>

²⁵⁸ <http://onenyc.cityofnewyork.us/initiatives/15-of-30-make-healthy-lifestyles-easier-in-all-neighborhoods/>

programs.²⁵⁹ As investors continue to finance food projects such as urban farms, they will begin to better understand business models and challenges. This should lead to further development of innovative financing mechanisms that more traditional institutions can help develop.

Scope for Further Research

As a developing space, a broader vision is needed, and there is scope for further research when it comes to food and health. Health insurers and other corporations might be able to play a larger role in catalyzing food security through their own investments and initiatives -- such as by launching incubators, services, or benefits that promote healthy eating.²⁶⁰ There might also be scope for further research around improving food transport, particularly given companies such as Uber Eats, Postmates, and other new food delivery business models having recently entered the space. Further, financing can be difficult to do at scale for issues that are local and regional by nature. Perhaps there is an opportunity for community development financial institutions and green banks to play a larger role in financing, by funding the upfront costs of capital-intensive projects. Revenue-based financing may also present an investment opportunity to scale food and ag tech.²⁶¹ These methods might be useful for scaling urban farming and controlled environment agriculture, which requires expensive high-tech systems to improve growing conditions, and where energy costs of food production are particularly high.

²⁵⁹ *ReFED US Food and Waste Investment Report*, 2018, pp. 15

²⁶⁰ <https://www.anthropocenemagazine.org/2019/04/the-trouble-with-the-urban-farming-revolution/>

²⁶¹ <https://impactalpha.com/as-unicorns-stumble-investors-warm-to-revenue-based-financing-for-zebras-and-clydesdales/>

Waste

More than six million tons of waste are disposed of annually in New York City. Each week, New Yorkers throw away, on average, 15 pounds of waste at home, and another 9 pounds at work.²⁶² There are significant environmental consequences to inefficient waste management. The City of New York recognizes that waste management accounts for 1.66 million metric tons of greenhouse gas (GHG) emissions, or 3.5% of the city's total GHG emissions (85% of which are associated with methane emissions from organic waste).²⁶³ This number only takes into account "GHG emissions from wastewater treatment, and in-city landfills, and solid waste disposed of out of the city," and does not consider the link between global resource extraction, transportation, processing, and manufacturing. When we minimize waste, we reduce greenhouse gas emissions in sectors that together represent 36.7% of all U.S. greenhouse gas emissions.²⁶⁴

With the closing of Freshkills, NYC no longer has local landfills. Its waste is trucked increasingly further out of state – currently as far as Virginia – which comes at no small cost - around \$2.3 billion annually.^{265,266} Disposing of waste is costly, but waste is also an untapped resource from which we can produce biogas, compost, and recycled materials. Unlocking the value of that resource is a challenge that NYC and the world now take seriously.

An estimated 68% of NYC's solid waste could be either recycled or composted.²⁶⁷ For more than two decades, the City has provided curbside recycling programs to divert certain materials, including paper, metal, plastic, and glass, from the refuse stream. However, these programs divert only 15.4 percent of the waste collected by city workers.²⁶⁸

For many years much of our recyclable waste was exported at very low cost to China, which no longer accepts it. Ironically, this inexpensive export solution stunted the growth of a domestic recycling industry, and many cities are now throwing away all waste in lieu of paying a premium to recycle it.²⁶⁹

NYC is taking waste management seriously with the implementation of a number of initiatives. The city has piloted a curbside organics collection program, composting initiatives, reductions in the use of plastic bags, and has installed anaerobic digesters to collect and sell biogas in wastewater treatment plants.²⁷⁰ Underpinning all of this is the

²⁶² <http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf#page=178>

²⁶³ <https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/GHG%20Inventory%20Report%20Emission%20Year%202016.pdf>

²⁶⁴ https://ilsr.org/wp-content/uploads/2008/06/stoptrashingtheclimate_exsum_lowres.pdf

²⁶⁵ <https://www.theguardian.com/cities/2016/oct/27/new-york-rubbish-all-that-trash-city-waste-in-numbers>

²⁶⁶ <https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/GHG%20Inventory%20Report%20Emission%20Year%202016.pdf>

²⁶⁷ <https://dsny.cityofnewyork.us/wp-content/uploads/2018/04/2017WCSFieldProceduresManual.pdf>

²⁶⁸ <https://onenyc.cityofnewyork.us/wp-content/uploads/2018/04/OneNYC-1.pdf> (pg. 176)

²⁶⁹ <https://www.theatlantic.com/technology/archive/2019/03/china-has-stopped-accepting-our-trash/584131/>

²⁷⁰ <http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf#page=178>, pp. 179

city's Zero Waste goal, which aims to reduce waste sent to landfills 90% by 2030.²⁷¹ The proper tools and technologies exist for succeeding in waste management. The challenge that remains is finding a way to pay for necessary infrastructure improvements, fund demonstration projects of innovative techniques to make waste valuable, and coordinating across stakeholders to stimulate meaningful change.

Circular Solutions

Overview

Many business models today approach waste linearly, where a business will take resources to produce a product, sell the product, and at the end of the product's lifecycle the consumer will dispose of it as waste. Financing is often on a phase-by-phase basis, directed toward either waste prevention, discarding waste, or recycling.

Circular solutions take a different approach, and see waste materials having value that can be recaptured. These solutions focus on opportunities to reuse, share, repair, recycle, or disaggregate waste back into natural systems that provide renewable resources (for example, through composting or anaerobic digestion). These are closed-loop, regenerative systems where outputs from one process are used as inputs for another. A natural ecosystem makes use of all waste products. Circular solutions have high potential to decrease the overall creation of waste and its associated greenhouse gases, and increase the productivity of resources by keeping products in use for longer periods of time.

Types of Financing:

- Private equity
- Venture capital
- Corporations
- Crowdfunding
- Public-private partnerships
- Loans
- Producer responsibility, in which the product producer takes environmental responsibility for the product throughout its lifecycle

Key Financing Players:

- Closed Loop Partners: A New York-based investment firm that provides equity and project finance in support of the circular economy²⁷²
- Equilibrium Capital: A sustainable investment manager focused on agriculture and food, and water waste and energy²⁷³

²⁷¹ <http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf#page=178>

²⁷² <https://www.closedlooppartners.com/>

- Structure Capital, a VC focused on removing waste from the economy²⁷⁴
- Circulate Capital, an investment management firm focused on plastic waste in the ocean²⁷⁵
- The New York State Energy Research and Development Authority (NYSERDA)²⁷⁶
- Connecticut Green Bank, the nation's first green bank, designed to accelerate the growth of green energy²⁷⁷
- Subaru
- General Motors
- Rabobank
- European Investment Bank
- Goldman Sachs

Specific Examples and Analysis:

There is no turnkey solution to investing in the circular economy -- investment solutions will require a mix of different kinds of capital. The US is starting to see firms such as Closed Loop Partners address this. The fund has raised money from and works with large corporations, including PepsiCo, McDonalds, Danone, Unilever, and more. Closed Loop Partners has five investment platforms covering advisory services, venture capital, project finance, private equity, and an accelerator program.²⁷⁸ Its project finance platform, called the Closed Loop Fund, has made 21 investments in circular solutions since its inception in 2014, deploying \$50 million in capital to date.

²⁷³ <http://eq-cap.com/>

²⁷⁴ <https://structure.vc/#about>

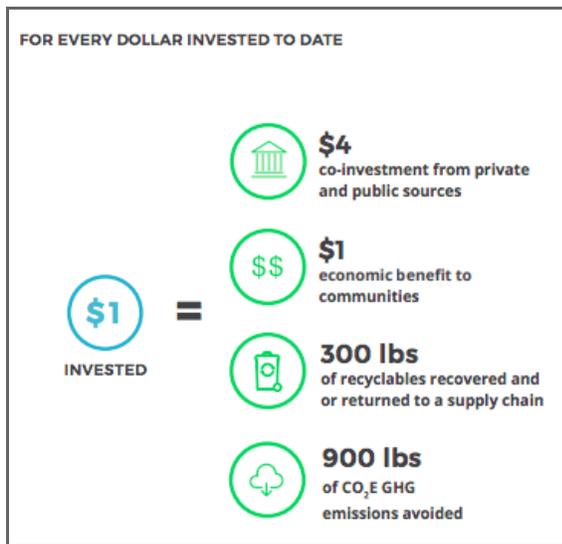
²⁷⁵ <https://www.circulatecapital.com/investments>

²⁷⁶ <https://www.nyserda.ny.gov/>

²⁷⁷ <https://www.hartfordbusiness.com/article/green-bank-invests-2m-in-southington-digester-project>

²⁷⁸ <https://www.closedlooppartners.com/wp-content/uploads/2019/03/Closed-Loop-Partners-Impact-Report-2018-1.pdf>, pp. 1

Figure 8: Closed Loop Partners estimates its impact per dollar invested is significant.²⁷⁹



Source: Closed Loop Partners

Case Study: Dairy Farm Anaerobic Digester

Private capital specifically is playing an increasingly important role in scaling circular economy projects. Portland, Oregon-based real assets investment management firm Equilibrium is a leader in this sector. For example, the firm invested in a joint venture to finance an upgrade and expansion of an anaerobic digester facility owned by a sustainable dairy farm. (Anaerobic digestion is a process in which microorganisms break down biodegradable material producing biogas, which is combusted to generate energy and heat.²⁸⁰)

Prior to Equilibrium's investment, the farm had been using anaerobic digestion to convert manure into three valuable products in a closed-loop system:

1. renewable electricity, which it generated by burning the biogas released in the anaerobic digester, and which it sold under a Power Purchase Agreement.
2. the remaining fiber from the anaerobic digestion process, which it used for cow bedding; and
3. the liquid effluent, which it used as organic fertilizer for crops.

To both accommodate future herd expansion and produce more value from the digester facility, the farm required additional infrastructure. It partnered with Equilibrium to increase the capacity of the digester facility, and to move from electricity generation to production of pipeline-quality conditioned renewable natural gas. This gas is a higher-value product that can be added to natural gas pipelines, displacing fossil fuel-derived gas. It thus serves climate goals twice: first when it replaces fossil fuel-sourced gas and

²⁷⁹ <https://www.closedlooppartners.com/wp-content/uploads/2019/03/Closed-Loop-Partners-Impact-Report-2018-1.pdf>, pp. 14

²⁸⁰ <https://americanbiogasCouncil.org/resources/what-is-anaerobic-digestion/>

second when it is burned, converting the methane it contains into carbon dioxide, which has roughly one-tenth the climate impact of methane.

The full project included the acquisition of the farm's existing digester and electricity-generating assets, a capacity increase for the facility, and the construction of gas-conditioning and interconnection facilities. Though the project was ultimately completed entirely with Equilibrium's equity capital (to closely control development, construction, and operations), the team evaluated multiple sources of financing, including traditional project financing and municipal tax-exempt financing.

The project monetizes every metric ton of carbon dioxide equivalent it captures. It benefits from monetizing the tax credits it receives through the Biomass Tax Credit program and sells the renewable natural gas it creates into the California transportation fuel market, where it generates both Renewable Identification Numbers (RINs) under the federal Renewable Fuel Standard, and credits under California's Low Carbon Fuel Standard (LCFS).

The success of the project highlights how closed-loop systems can turn waste into a source of revenue. The new facility will process 1,000 gallons per minute of manure from the farm's 33,000 milking cows, producing about 550,000 MMBtu per year, which will be sold via an offtake agreement to Fortune 500 companies. It is expected to capture approximately 134,000 metric tons of carbon dioxide equivalents annually.

Crowdfunding has also been used for funding circular economy solutions. For example, ReCircle Recycling is building the world's first closed-loop appliance, and in 2019 it launched a fundraising campaign on Crowdcube, a leading crowdfunding platform. The general public was able to invest as little as £10.²⁸¹ While still in the early stages of development, with the right investment incentives and a transparent, user-friendly investment process, crowdfunding has the potential to gain traction as the public becomes more familiar with the process.

Public-private partnerships for circular solutions have also been successfully implemented. For example, Germany turns 62% of its waste into new products or fuel.²⁸² After a spike in the use of single-use containers, the government passed a deposit law -- the Ordinance on the Avoidance of Packaging Waste -- that implemented a compulsory deposit on single use containers and made manufacturers responsible for taking back the packaging of their products. Containers were collected at grocery stores, shops, and independent collection centers, and customers were issued the refund owed for the deposits on the containers. The system is paid for by the beverage industry, and the industry keeps any unredeemed deposits. This approach was highly successful due to the refillable infrastructure previously set up in Germany. To replicate this in the U.S., however, could be difficult, with barriers that include FDA regulation and high costs to setting up refilling infrastructure. Nonetheless, this represents a successful example of a circular system solving waste challenges.

²⁸¹ <https://www.recirculerecycling.com/blog/recircle-is-crowdfunding-heres-how-it-works>

²⁸² *Germany's solution to waste challenges*, Sustainable Innovation and Impact, pp. 182

Large corporations have also started investing in the circular economy. For example, Subaru has been a long-time leader in zero waste, having not sent any waste to landfill since 2004. All of the company's manufacturing waste is either recycled or turned into electricity, saving the company \$1-2 million each year.^{283,284} General Motors, which aspires to zero-waste, has co-championed the Materials Marketplace, which matches traditional and non-traditional industrial waste streams with new product and revenue opportunities.²⁸⁵ PepsiCo also launched a \$1 billion green bond, the proceeds from which will help fund projects to reduce virgin plastic content across its beverage portfolio 35% by 2025.²⁸⁶ Because opportunities for circularity are often dependent on changes in production processes and supply chains, financing circular solutions will require further capital commitment from the corporate sector. That commitment can best be achieved through a combination of carrot (realizing the value of waste) and stick (regulation).

Outlook

To accelerate the transition to circular solutions, NYC needs a broader vision to help public and private institutions identify specific areas of opportunity. NYC can look to Europe as a leader in circular solutions. The Dutch government, for example, has adopted a goal of transitioning to a circular economy by 2050 and halving the use of raw materials by 2030.²⁸⁷

There is no silver bullet when it comes to financing the circular economy. While circular solutions are further evolving in the U.S., there remains a financing gap that will require a mix of capital to close. Many circular solutions involve upgrading supply chains, and there is certainly a larger role for corporations to play in spearheading the transition. Making zero waste an internal priority through its inclusion in company-wide sustainability plans is a start, and perhaps traditional corporate lending and bank finance can be scaled up to provide more robust financing if clear business models can deliver an adequate return.²⁸⁸ Public policies, support from public institutions, and subsidies would also accelerate the transition.²⁸⁹

Overall, many challenges still remain in developing circular business models, and investors need further education in order to provide effective financing and truly scale circular solutions. While academics and foundations, have developed case studies on various business models and opportunities, circular solutions are not yet fully organized in a cohesive framework. In-depth financing examples are also lacking. There is scope for further research to evaluate financing opportunities by sector -- perhaps preliminary

²⁸³ <https://www.treehugger.com/corporate-responsibility/subaru-celebrates-10-years-zero-landfill-manufacturing.html>

²⁸⁴ <https://www.scientificamerican.com/custom-media/scjohnson-transparent-by-design/zerowastefactory/>

²⁸⁵ <https://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2018/feb/0228-landfill-free.html>

²⁸⁶ <https://www.pepsico.com/news/press-release/pepsico-prices-us1-billion-green-bond-to-fund-key-sustainability-initiatives10072019>

²⁸⁷ <https://sustainablefinancelab.nl/en/how-the-dutch-government-can-accelerate-financing-the-circular-transition/>

²⁸⁸ <https://www.ingwb.com/media/1383724/rethinking-finance-in-a-circular-economy-report.pdf>, pp. 37

²⁸⁹ *Financial Resources for the Circular Economy: A Perspective from Businesses*, MDPI (file:///Users/ellawarshauer/Downloads/sustainability-11-00888-v2%20(1).pdf), pp. 16

categories could include segmenting solutions for plastics,²⁹⁰ glass,²⁹¹ construction materials, and textiles.^{292, 293}

The New York Circular City Initiative, a collaboration of New York City government, business, finance, and community, convened by Freshfields Bruckhaus Deringer LLP and supported by the Ellen MacArthur Foundation, released an important vision report in October 2020.²⁹⁴ The report intends to drive a circular urban economy in New York City and identifies 50 levers to create circularity, generate jobs, grow the economy, and help achieve New York City's goal of zero waste to landfill. Now is the time to press those levers and develop the roadmap to achieve the envisioned goals.

Food Waste

Overview

New York City sends four million tons of waste to landfills each year, and almost one-third of that is food waste.²⁹⁵ Restaurants account for the largest single stream of food waste on the commercial side -- they generate close to half a million tons of food waste per year, which is enough to fill over one hundred subway cars per day. Food waste comes at an economic cost - the U.S. spends \$218 billion annually growing, processing, transporting, and disposing of food that is never eaten.²⁹⁶ However, there is an opportunity here. For every \$1 invested in programs to reduce kitchen food waste, businesses save an average of \$7 in operating expenses.²⁹⁷ Food waste, and emissions from agriculture more broadly, have largely been identified as a climate issue, but more action is needed if we are to achieve solutions at scale.

Types of Financing:

- Venture capital
- Private equity
- Government grants
- Philanthropy
- Variable payment obligations

Key Financing Players:

- Equilibrium Capital

²⁹⁰ <https://www.ceguide.org/Strategies-and-examples/Dispose/Feedstock-recycling>

²⁹¹ <https://www.ellenmacarthurfoundation.org/assets/downloads/circular-economy/The-Circular-Economy-and-the-Promise-of-Glass-in-Concrete.pdf>

²⁹² https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report_Updated_1-12-17.pdf

²⁹³ See ING Rethinking Financing in a Circular Economy report for details on various circular business models -

<https://www.ingwb.com/media/1383724/rethinking-finance-in-a-circular-economy-report.pdf>,

²⁹⁴ <https://www.circularnyc.org/about-nyci>

²⁹⁵ http://www.nyc.gov/html/sbs/downloads/pdf/neighborhood_development/nddblog/FWC_overview.pdf

²⁹⁶ <https://foodtechconnect.com/2017/03/27/how-spoiler-alert-is-growing-its-food-waste-marketplace/>

²⁹⁷ <https://www.foodwastefair.nyc/>

- Venture Capital
- Accelerators, such as Urban X and Seed 2 Growth Ventures
- Generate Capital
- Rabobank
- Foundation for New York's Strongest
- ReFED

Specific Examples and Analysis

Philanthropic grants play a large role in supporting food waste reduction, particularly in food recovery. Funding reached \$134 million in 2016, a 70% increase over a five-year period.²⁹⁸ Feeding America is a major player in the food recovery space, which receives funding from the Morgan Stanley Foundation and Bank of America Charitable Foundation. It redistributed \$56 million to member food banks in 2016.²⁹⁹ Foundations have also helped fund small-scale composting systems. For example, the Department of Sanitation's Foundation for New York's Strongest launched a program to provide small businesses with \$2,000 grants and technical assistance to begin or expand food waste efforts.³⁰⁰

In 2018, venture capital and private equity funding for food waste totaled more than \$125 million, with many food waste startups joining incubator programs.³⁰¹ Some innovative examples include:

- Wasteless, an Israeli startup that aims to prevent food waste by using AI-driven variable pricing that incentivizes buying food when it is closer to its expiration date;
- ReGrained, which raised \$2.5 million in seed financing in 2018 to further develop and scale the technology it uses to transform food manufacturing byproducts into superfoods³⁰²;
- Imperfect Produce, founded in 2015 and valued three years later at \$180 million, which delivers flawed produce directly to customers' homes; and
- YWaste, a South African startup that allows retailers to post and sell surplus food at the end of the day at discounted prices.

Investment manager Equilibrium Capital is also investing in the beneficial processing of food waste. In another 50/50 joint venture, this firm invested in a project to repurpose a regional sludge management facility for anaerobic digestion of source-separated organics. This upgrade will allow the facility to produce biogas for the generation of renewable electricity. Revenue sources will include tip fees paid for accepting organic

²⁹⁸ ReFED US Food and Waste Investment Report, 2018, pp. 22

²⁹⁹ ReFED US Food and Waste Investment Report, 2018, pp. 27

³⁰⁰ http://dsny.cityofnewyork.us/wp-content/uploads/2018/04/RLS_Microgrant_Awardees_Foundation-.pdf

³⁰¹ ReFED US Food and Waste Investment Report, 2018, pp. 10

³⁰² <https://www.pnewswire.com/news-releases/regrained-closes-2-5m-strategic-financing-round-led-by-griffith-foods-300718234.html>

waste, electricity sales, and sales of fertilizer by-products from the anaerobic digestion process. The project has been designed to process an average of 350 tons per day of source-separated organics, generate 3.3 MW of renewable electricity, and yield approximately 39,000 tons per year of compost.

Financing included a combination of equity, grants, and traditional project financing, including a construction loan that will be later converted to a 12-year term loan and an export credit guarantee. In addition, the project qualifies for Investment Tax Credits as a renewable electricity generator and is a qualified Opportunity Zone³⁰³ business -- that is, it is located in an economically distressed community and qualifies for preferential tax treatment. The project is the first of its kind in New Jersey and represents a progressive step forward in addressing climate change and food waste in the region.

Variable payment obligations are a new financial mechanism developed by Santa Clara University's Miller Center for Entrepreneurship. They have the potential to support investment in food waste. ReFED, a non-profit that focuses on food waste data and economics, identifies variable payment obligations as the type of "patient, development-style financing that is needed to support testing and scaling innovations".³⁰⁴ ReFED provides growth capital for entrepreneurs while generating returns for investors, providing social enterprises with a capital infusion to achieve positive cashflow, where investors agree to a gradual payback mechanism that suits both parties' needs.³⁰⁵

Food and beverage corporations also contribute significantly to food waste, and some are now developing mitigation programs in response. PepsiCo is diverting 95% of its food waste from landfill,³⁰⁶ part of its larger effort to eliminate virtually all the waste it sends to landfills by 2025.³⁰⁷ Since establishing an organics recycling program in 2009, Walmart has recycled the equivalent of over 25,000 truckloads of inedible food for animal feed, commercial composting, and anaerobic digestion.³⁰⁸ While funding from corporations represents a small portion of deals, corporate interest in acquiring food startups strengthens the overall ecosystem, and can encourage entrepreneurs to continue developing solutions in the space.

Large philanthropies are also involved. For example, The Kroger Company's Zero Hunger | Zero Waste Foundation was established to support entrepreneurs with solutions to improve food security and prevent food waste.³⁰⁹

Outlook

While technology and innovative financing for food waste are still developing, the amount of public, private, and philanthropic capital committed to solving food waste is

³⁰³ <https://www.eda.gov/opportunity-zones/>

³⁰⁴ *2018 US Food and Waste Investment Report*, ReFED, pp. 13

³⁰⁵ https://consciouscompanymedia.com/sustainable-business/finance-capital/everything-entrepreneurs-need-to-know-about-variable-payment-obligations-vpo/?mc_cid=0d9102b7cf&mc_eid=411fa807ad

³⁰⁶ <https://www.environmentalleader.com/2018/07/pepsico-waste-diversion-packaging/>

³⁰⁷ https://www.pepsico.com/docs/album/esg-topics-policies/waste.pdf?sfvrsn=32345f87_6

³⁰⁸ <https://www.uschamberfoundation.org/look-walmart-s-food-waste-reduction-program>

³⁰⁹ <https://thekrogercozerohungerzerowastefoundation.com/about.html>

not commensurate with the scale of the challenge.³¹⁰ Philanthropy can play an important role in providing de-risked capital to kickstart research and innovation. Venture capital and private equity can provide the financing to scale these solutions. There may also be opportunities for financial institutions to host roundtables to provide a forum for financiers and entrepreneurs to exchange ideas and secure financing, and for private institutions to launch blended finance funds to invest in early stage technologies.³¹¹

Overall, private investors are certainly taking a greater interest in food waste, with over 450 investors making bets in the space in 2018.³¹² While there aren't many examples of financing mature technologies or scalable solutions yet, it's promising to see institutional investors such as Equilibrium Capital leading the way.

Wastewater for Energy Production

Overview

As governments are under pressure to address climate change and mitigate greenhouse gas emissions, biogas represents an opportunity for further investment. Project economics are still largely dependent, however, on the price at which producers can sell biogas.

Anaerobic digesters are the technology solution to creating revenue from wastewater. Digesters break down sludge into (a) biogas, a methane-rich gas that can be used to power renewable energy sources, (b) nutrient-rich solid waste, which can enrich soil and boost agricultural productivity, and (c) wastewater. While established wastewater treatment plants are aging and inefficient, significant improvements could come from upgrading existing digesters that are used to treat wastewater solids.³¹³

Readily available data on market trends and case studies that illustrate the business case for financing anaerobic digesters could make this space more approachable for private capital.³¹⁴

Types of Financing:

- Public-private partnerships
- Energy performance contracting, where investors would provide the capital for an energy services company to build and design water-conservation solutions³¹⁵

³¹⁰ https://wriorg.s3.amazonaws.com/s3fs-public/reducing-food-loss-waste-global-action-agenda_0.pdf, pp. 102

³¹¹ https://wriorg.s3.amazonaws.com/s3fs-public/reducing-food-loss-waste-global-action-agenda_0.pdf, pp. 102

³¹³ <https://nylcv.org/news/improving-new-york-citys-wastewater-treatment-infrastructure/>

³¹⁴ http://www.kleanindustries.com/s/environmental_market_industry_news.asp?ReportID=344449

³¹⁵ <https://www.epa.gov/sites/production/files/2015-08/documents/wastewater-guide.pdf>, pp. 25

- Government grants, such as Water Conservation and Reuse Grants, which can be applied to wastewater projects and provide incentives to install retrofits or other waste efficiency technologies³¹⁶
- Transition bonds³¹⁷

Key Financing Players:

- U.S. Department of Energy
- New York City Department of Environmental Protection³¹⁸
- Anaergia³¹⁹
- PNC Energy Capital

Specific Examples and Analysis

Most Wastewater systems are owned by municipalities and therefore such projects are usually spearheaded by the public sector. This speaks to the nature of water as a public resource.³²⁰ Government grants and incentives are common for catalyzing financing in this industry. The Department of Energy offers an Energy Efficiency and Conservation block grant program that wastewater facilities may be able to use for installing energy efficiency upgrades.³²¹ There also may be opportunities for municipalities to sell biogas under the federal Renewable Fuel Standards program.³²² Further, in 2019, the Department of Energy announced \$79 million in funding for bioenergy research and development, which included “developing anaerobic processes to enhance carbon conversion efficiency and lower costs of smaller-scale wet waste systems”.³²³ Government incentives, however, are subject to political risk. NYSERDA, for example, used to offer incentives of up to \$30,000 per year for energy efficiency measures through its Existing Facilities Program, but these have since been repealed. Lack of a supportive political environment can make it difficult to scale a young industry.

Public-private partnerships are critical in wastewater-to-energy projects. The treatment process requires large-scale infrastructure, which is expensive to both develop and retrofit. Typically, water utilities have relied on their own capabilities to design and build capital projects in-house, but projects are becoming more frequent and complicated, and the need for innovative solutions is strong.³²⁴

One successful example can be seen in a partnership between the City of Riverside, California, and FuelCell Energy. FuelCell installed, operates, and maintains a biogas-fueled power plant via a Power Purchase Agreement, which allows the City of Riverside

³¹⁶ <https://www1.nyc.gov/site/dep/water/water-conservation-reuse-grants.page>

³¹⁷ <https://www.lw.com/thoughtLeadership/lw-transition-bonds-guidelines-may-expand-sustainable-finance>

³¹⁸ http://www.nyc.gov/html/nyw/pdf/fy09_consulting_engineers.pdf

³¹⁹ <https://www.anaergia.com/anaergia-announces-successful-bond-financing-for-north-america-s-largest-organic-waste-to-energy-facility-its-rialto-bioenergy-facility-in-california>

³²⁰ https://ww2.energy.ca.gov/reports/efficiency_handbooks/400-00-001A.PDF

³²¹ <https://www.energy.gov/eere/wipo/energy-efficiency-and-conservation-block-grant-program>

³²² <https://www.wef.org/globalassets/assets-wef/3---resources/topics/a-n/biosolids/technical-resources/intro-to-funding-opportunities-fact-sheet.pdf>, pp. 1

³²³ <https://www.energy.gov/articles/doe-announces-79-million-bioenergy-research-and-development>

³²⁴ <https://waterfm.com/crossroads-procurement-delivery-capital-projects/>

to avoid upfront investment and instead purchase power as it is produced.³²⁵ PNC Energy Capital financed the deal through a sale-leaseback transaction.

Outlook

New York City is already making progress on harvesting energy from wastewater. All 14 of the city's wastewater treatment plants produce methane, which if captured and sold, can be turned into revenue. National Grid is building a \$30 million system at the Newtown Creek Wastewater Treatment Plant to process excess biogas, which currently is flared off. The city will receive half the profits from selling the biogas.³²⁶ The city also predicts that three additional plants have the potential to be a worthwhile investment, which could generate about \$2 million per year from biogas sales while reducing the city's methane emissions.³²⁷

There may be potential for anaerobic digesters outside of NYC, in areas with high rates of agricultural activity. Further guidelines to streamline installment might increase technology adoption on farms. Readily available data on market trends and case studies that illustrate the business case for financing anaerobic digesters could make this space more approachable for private capital.³²⁸

Role of Philanthropy

Foundations, which are less limited by financial risks, can stimulate growth in developing waste solutions. This is particularly the case for food waste. For example, the Food Cowboy Foundation,³²⁹ which addresses food waste by connecting food donors and logistics partners with local nonprofits to accept surplus inventory, launched the No Waste Promise and the Food Waste Innovation Fund, which will invest up to \$75 million a year to address solutions to food waste. The Closed Loop Foundation³³⁰ also offers grants and program-related investments for addressing food waste, through its Food Waste Solutions Search initiative.³³¹

Further, the Ellen MacArthur Foundation is a leader in championing circular solutions. The Foundation works with businesses, institutions, governments, and cities to accelerate the transition to an economy that is restorative and regenerative by design.³³² Notably, the Foundation has partnered with BlackRock to launch a circular

³²⁵ <https://bioenergyinternational.com/technology-suppliers/fuelcell-energy-announces-commercial-start-up-of-wastewater-power-project>

³²⁶ <https://www.ibo.nyc.ny.us/iboreports/fares-tolls-and-other-revenue-generators-options-2018.pdf>

³²⁷ *ibid*

³²⁸ http://www.kleanindustries.com/s/environmental_market_industry_news.asp?ReportID=344449

³²⁹ <https://sustainablebrands.com/read/waste-not/food-cowboy-launches-new-alliance-innovation-fund-to-spur-post-food-waste-economy>

³³⁰ <https://sustainablebrands.com/read/defining-the-next-economy/calling-all-food-waste-fighters-new-funding-for-closed-loop-solutions>

³³¹ <https://sustainablebrands.com/read/waste-not/food-cowboy-launches-new-alliance-innovation-fund-to-spur-post-food-waste-economy>

³³² <https://www.ellenmacarthurfoundation.org/>

economy fund,³³³ the BGF Circular Economy Fund,³³⁴ and will provide expert advisory on circular economy principles that will inform the fund's investment methodology.³³⁵ The Foundation supported the New York Circular City Initiative, convened by Freshfields Bruckhaus Deringer LL, a crucial report issued in October 2020 to advance circularity in NYC.³³⁶ The Foundation has also published its New Plastics Economy report, which has prompted others in the industry, including The Recycling Partnership, to commission further research and investment.³³⁷ By providing a conceptual framework for circular solutions, outlining the business case, and its active partnerships with large corporations, the Foundation is mobilizing private investment toward circular solutions.

Conclusion

There is no single technology solution or business model that will address waste. Finance for food waste, circular solutions, and wastewater for energy is young and largely dependent on the stakeholders involved. Large infrastructure projects for wastewater will require capital to finance large up-front costs, while venture capital funding might be sufficient for developing new technologies and business models addressing food waste.

Circular solutions provide a framework that can inform the systematic development of food waste and wastewater systems. The Circular Economy Lab suggests that focusing on the delivery of designs rather than physical product could be a starting point.³³⁸

Here's a simple explanation: Instead of buying a product, we would purchase the 3-D blueprint, go to a neighborhood lab that uses locally generated waste material as feedstock, and print our custom product. Once the useful life of the product was over, the material in the product would be processed back into feedstock for the community to re-utilize. This would create a closed loop system for not just physical material but also for local wealth creation.³³⁹

Transitioning to a circular economy will require a significant shift in behavior. New business models and ways of thinking about converting waste into revenue have emerged from circular systems, but to reach zero-waste goals, businesses, government entities, and private investors will need to understand the business case. Every successful project, like those cited above, bolsters the case for circularity.

³³³ <https://www.ellenmacarthurfoundation.org/news/the-ellen-macarthur-foundation-partners-with-blackrock-to-accelerate-the-transition-towards-a-circular-economy>

³³⁴ <https://www.blackrock.com/americas-offshore/products/310173/blackrock-circular-economy-fund>

³³⁵ <https://www.ellenmacarthurfoundation.org/news/the-ellen-macarthur-foundation-partners-with-blackrock-to-accelerate-the-transition-towards-a-circular-economy>

³³⁶ <https://www.circularnyc.org/about-nycci>

³³⁷ <https://www.wastedive.com/news/recycling-partnership-500m-circular-economy-2025-ellen-macarthur/565422/>

³³⁸ *The State of the Circular Economy in America*, pp. 52

³³⁹ *The State of the Circular Economy in America*, pp. 52

Scope for Further Research

There is scope for further research to evaluate financing opportunities for the circular economy by sector. Categories for segmentation might include plastics,³⁴⁰ glass,³⁴¹ paper, construction materials, and textiles, to start.^{342,343} Financing for food waste solutions is nascent, and the space might benefit from convening stakeholders from the public, private, and philanthropic sectors to identify industry needs and develop creative financing mechanisms to scale new technologies such as pyrolysis and biochar.³⁴⁴ Further research should be done on potential impacts of implementing these technologies in New York City and financing mechanisms, such as transition bonds, which support the *transition* to a more sustainable economy, that might enable scale.³⁴⁵ Overall, all stakeholders eventually pay for waste, and a better understanding of bottlenecks at specific points in the supply chain could aid in the development of appropriate finance mechanisms, and scale up NYC's zero waste goals and initiatives outlined in the City's OneNYC strategic plan.³⁴⁶

³⁴⁰ https://www.closedlooppartners.com/wp-content/uploads/2019/04/CLP_Circular_Supply_Chains_for_Plastics.pdf

³⁴¹ <https://www.ellenmacarthurfoundation.org/assets/downloads/circular-economy/The-Circular-Economy-and-the-Promise-of-Glass-in-Concrete.pdf>

³⁴² https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report_Updated_1-12-17.pdf

³⁴³ See ING Rethinking Financing in a Circular Economy report for details on various circular business models - <https://www.ingwb.com/media/1383724/rethinking-finance-in-a-circular-economy-report.pdf>,

³⁴⁴ <https://gecaenviro.com/>

³⁴⁵ <https://www.lw.com/thoughtLeadership/lw-transition-bonds-guidelines-may-expand-sustainable-finance>

³⁴⁶ <http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf#page=178>, pp. 178-87

The Resilience of New York City

Overview

Resilience is a particularly challenging issue in that it places extraordinary demands on numerous systems at once. Catastrophic weather events, for example, stress a city's transportation, communications, water and food distribution systems. Extreme heat and drought burden the energy systems. All of these issues expose gaps in financing, and are spurring innovative solutions for funding recovery efforts or – even better – developing ways to finance efforts to mitigate these issues and make a city more resilient and better prepared.

This section will focus primarily on two of the acute issues facing New York City – sea-level rise and storm-related issues – while citing several promising finance solutions.

New York is widely considered to be one of the 10 global cities most vulnerable to coastal flooding, second only to Miami in assets physically and financially exposed.³⁴⁷ This creates an urgent need for infrastructure changes and adequate financial protection.

Even if global climate mitigation efforts accelerate rapidly throughout the course of the 2020s and 2030s, climate scientists fully expect an increase in medium-term damaging effects from sea-level rise as well as an increasing frequency of extreme storms likely to affect the NYC region.³⁴⁸ Estimates of the economic damage from this future reality continue to increase³⁴⁹ as sea level rise is expected to significantly affect the northeastern United States.³⁵⁰

Micro Resilience Issues: New York City

Resilience issues in NYC can be categorized as either micro issues, such as managing stormwater runoff, or macro issues like finance.

Managing stormwater offers several opportunities. Creative finance is emerging in cities such as Washington, D.C. and Philadelphia to address a variety of issues, from flood mitigation to increasing the economic value of fisheries and tourism to reducing the cost of water treatment facilities.³⁵¹

Macro issues pertain more to the ability to finance recovery from environmental catastrophes through the issuance of catastrophe bonds, as well as finding ways to fund the greater overall resilience of cities like New York.

³⁴⁷ https://www.giss.nasa.gov/research/briefs/rosenzweig_03/

³⁴⁸ <https://amp-theguardian-com.cdn.ampproject.org/c/s/amp.theguardian.com/environment/2019/nov/06/sea-level-rise-centuries-climate-crisis>

³⁴⁹ <https://assets.floodiq.com/2019/02/784113f9d16323db82f696b9c3b0874e-First-Street-Foundation-Mid-Atlantic-Press-Release-Immediate-Release.pdf>

³⁵⁰ https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter13_FINAL.pdf

³⁵¹ <https://doee.dc.gov/service/why-stormwater-problem>

Stormwater Runoff

As with many northeastern US cities, NYC's sewer system is older, with segments of it constructed more than 140 years ago. Over 60 percent of the sewer system is "combined," where wastewater and sewage from sinks, tubs, and toilets is combined with surface runoff from rain storms and flows to wastewater treatment facilities. Heavy rainfall increases stormwater runoff and can exceed the capacity of older waste water treatment plants, causing combined sewer overflows (CSOs), where toxic, untreated sewage is dumped into rivers and surrounding waters. CSOs cause a wide range of economic and environmental damage and are expected to increase with future sea-level rise and extreme weather.

Case Study: DC Water \$25 million Environmental Impact Bond

Overview

Problem: Combined sewer overflows

Solution: Green infrastructure

Size: \$25 million

Key stakeholders:

- *DC Water*, the water and sewer authority that serves over 672,000 residential, commercial, and governmental customers in the District of Columbia.
- *Goldman Sachs' Urban Investment Group*, which was formed to lead the firm's impact investing efforts, acted as an investor and purchased \$23 million of the EIB.
- *Calvert Foundation*, a global impact investing institution that focuses on social and environmental good.
- *Quantified Ventures* guided DC Water through the process of structuring and executing the country's first EIB.

Mechanism: Municipal bond utilizing a pay-for-success model

Project Start: October 2016.

In 2015, DC Water needed financing to install green infrastructure in the form of 20 acres of permeable paving surfaces to capture stormwater and mitigate CSOs. The company issued a \$25 million Environmental Impact Bond (EIB) – the first of its kind – with an innovative payment structure: a tax-free municipal bond with a pay-for-success model tied to specific environmental outcomes. This project serves as a model for water authorities and other municipal departments to leverage private capital to finance innovative solutions to environmental and resilience issues.

Positive outcomes of the project, beyond improved water quality, include a local job program, enhanced air quality, increased property values, beautified neighborhoods, cooler summer temperatures, thriving natural habitats, and enhanced public space.

Problem

Like hundreds of other cities, Washington DC uses a combined sewer system. When rainfall exceeds the system's capacity, it is designed to bypass the treatment facility and empty untreated waste water into local rivers.³⁵² It is estimated that two billion gallons of untreated sewage flowed into the Chesapeake Bay Watershed annually in violation of the federal Clean Water Act. Initially, the District of Columbia attempted to manage the problem and meet water-quality standards through a CSO Long Term Control Plan and later a Consent Decree with the EPA in 2005,³⁵³ where DC Water agreed to build a \$2.6 billion storage tunnel system to capture CSOs and prevent them from entering the watershed.

In the subsequent years, DC Water began to investigate the potential for green infrastructure to play a role in mitigating sewer overflows. Green infrastructure would include rain gardens, permeable pavement, green roofs, and rain barrels, all designed to mimic the absorption and filtering processes found in nature, reducing storm water runoff and sewer overflows. The EPA agreed to an amended Consent Order to include green with the grey infrastructure. At the time, these forms of green infrastructure had not been widely tested or proven to be effective, so there were a number of risks associated with the implementation of the green infrastructure projects. Risks included evidence risk (how well supported is an intervention in the literature?), implementation risk (how likely will an intervention be implemented with fidelity to the model?), evaluation risk (how likely is it that the evaluation will produce an accurate result?), and appropriations risk (how likely is it that the government will be able to re-pay the loan?).³⁵⁴

Solution

DC Water and Quantified Ventures structured a \$25-million, pay-for-success (PFS) municipal bond to implement the green infrastructure projects. In the PFS model, private funders provide capital to expand social services and the government pays for the program given a measurable achievement. PFS projects are also called Impact Bonds, and often combine expertise from nonprofits, the private sector, and government to fund and help solve social problems.³⁵⁵

The DC Water impact bond is unique in that it was the first *environmental* impact bond, meaning it was one of the first bonds to address environmental outcomes. The structure of the bond made it possible to share performance risk with investors by linking their returns to project success.

Process

DC Water conducted a three-step program to evaluate the effectiveness of the project's green infrastructure. The first phase included pre-construction monitoring to measure the existing stormwater runoff without green infrastructure. Construction then lasted for

³⁵² *The Story Behind the World's First Environmental Impact Bond*, Living Cities, pp. 1

³⁵³ <https://www.dwater.com/sites/default/files/documents/Long%20Term%20Control%20Plan.pdf>

³⁵⁴ *DC Water, Environmental Impact Bond*, Harvard Kennedy School, pp. 4

³⁵⁵ <https://www.brookings.edu/product/impact-bonds/>

two years. In the second phase, DC Water installed flow meters to measure baseline runoff levels, and modeled outcome ranges predicting the expected reduction in stormwater runoff as a result of implementing the green infrastructure. The expected range of reduction was 18.6% to 41.3%. Phase 3 included post-construction monitoring to measure the actual stormwater runoff with green infrastructure.

Financing

This impact bond is structured as a municipal bond. Other PFS projects are often structured as operating loans. The bond was privately placed with Goldman Sachs' Urban Investment Group and the Calvert Foundation. Investors receive a 3.43% coupon payment while the five-year bond is outstanding. Then, at the mandatory tender date, investors may receive a payment or be required to make a repayment to the issuer, based on the project's outcomes.

If the installed green infrastructure reduces runoff more effectively than expected (defined as a reduction of more than 41.3%), bondholders will receive a contingent payment of \$3.3 million at maturity. This represents a substantial bonus on the \$25 million bond, increasing its effective return by more than half. On the other hand, if the green infrastructure performs poorly (a runoff reduction of less than 18.6%), bondholders will be obligated to make a "risk-share payment" to DC Water of \$3.3 million, effectively reducing the bond's return to just slightly more than 1% annually over the five-year term.

Figure 9:

Performance Tier	Outcome Ranges	Contingent Payment
1	Runoff Reduction > 41.3%	DC Water will make an Outcome Payment to Investors of \$3.3mn
2	18.6% <= Runoff Reduction <= 41.3%	No contingent payment due
3	Runoff Reduction < 18.6%	Investors will make a Risk Share Payment to DC Water of \$3.3mn

Source: Goldman Sachs Urban Investment Group³⁵⁶

The pay-for-success environmental impact bond is unique in that it allows DC Water to manage or hedge a portion of the risk in developing innovative, unproven green infrastructure. At the same time, it forces DC Water to focus on outcomes to actually reduce stormwater runoff.

Figure 10:

³⁵⁶ DC Water Case Studies, Goldman Sachs Urban Investment Group, pp. 4

Transaction Details

Par Amount:	\$25 million
Use of Proceeds:	Construction of green infrastructure for Rock Creek Project A
Tax Status:	Tax-Exempt
Bond Structure:	Multimodal variable rate bonds, initially issued in a term mode at a fixed rate through the mandatory tender date
Contingent Payment:	Payable (if due) at mandatory tender date
Security Pledge:	Subordinate lien pledge of Net Revenues
Final Maturity:	October 1, 2046
Mandatory Tender:	April 1, 2021
Initial Term Rate:	3.43%
Investors	Goldman Sachs Urban Investment Group Calvert Foundation

Source: Goldman Sachs, Urban Investment Group³⁵⁷

Additionally, the bond is tax-exempt. The US Treasury has specific regulations for assigning tax-exempt status for municipal bonds with contingent payments. To be tax-exempt, one outcome must be significantly more likely to occur. The DC Water project was able to meet this requirement.

Results

The DC Water project aims to serve as a model for a pay-for-success environmental impact bond, and there are a number of key learnings to be derived. The use of a municipal bond in particular is key because the supporting stakeholders were already familiar with these bonds. Neighborly, an online platform for issuing municipal bonds, facilitated some of these processes, which enabled DC Water to save on transaction costs. However, there were other parts of the EIB that were more customized, and the project still took two years to launch.

The project garnered significant community support as it made green infrastructure and social impact projects visible. DC Water's general manager, George Hawkins, championed the EIB by ensuring its public promotion, which further contributed to the project's success.

Another key component is the transfer of risk from the government agency issuer to investors – as well as the sharing of unexpected benefits via the bond's contingent payment structure. For this reason, it can be important to partner with skilled

³⁵⁷ *DC Water Case Studies*, Goldman Sachs Urban Investment Group, pp. 4

contractors, and sometimes it can be useful to transfer management of construction to investors themselves.

Future PFS EIBs might also include a performance contract that incentivizes maintenance. For example, DC Water's project requires upkeep that impacts its performance, such as weeding and ensuring that silt and debris don't clog permeable pavements.

Macro Resilience Issues: New York City

Background

Superstorm Sandy

Coastal cities like New York City face the risks of increased storm intensity and potentially dangerous sea-level rise from a changing global climate. Superstorm Sandy in 2012 demonstrated how NYC in particular is vulnerable to extreme weather.

Sandy damaged or destroyed about 300,000 housing units in New York State.³⁵⁸ At least 106 people died³⁵⁹ and one estimate found over \$70 billion of damage caused by this one storm in the greater region – almost \$20 billion in NYC.^{360,361}

Sandy wasn't a single storm, but rather a unique convergence of multiple major systems that created an extraordinary event. It might have been a historic anomaly, but the world has seen an increase in destructive weather events in subsequent years affecting coastlines from Africa to India to the Philippines.

Catastrophe Bonds

Catastrophe bonds are high-yield debt instruments issued by insurance companies.³⁶² When specific events insured by the bond occur, the obligation to pay interest and repay the principal is either deferred or forgiven. Insurance companies use these bonds as an alternative to conventional reinsurance.

Catastrophe bonds typically have short maturities, often three to five years, and investors in these securities are typically hedge funds who can hedge their exposure to related risks.

³⁵⁸ <https://www.governor.ny.gov/news/governor-cuomo-releases-report-states-recovery-superstorm-sandy>

³⁵⁹ https://www.huffingtonpost.com/2013/10/29/hurricane-sandy-impact-infographic_n_4171243.html

³⁶⁰ <https://www.thebalance.com/hurricane-sandy-damage-facts-3305501>

³⁶¹ <https://edc.nyc/project/lower-manhattan-coastal-resiliency>

³⁶² <https://www.nasdaq.com/glossary/c/catastrophe-bond>

Pension funds and other institutional investors buy such bonds both for the higher interest rate and for the diversification they provide, since the value of these bonds is not linked to the state of the economy or the financial markets.

When such bonds are issued, the proceeds are usually deposited in a secure collateral account, where the funds might be invested in other securities. Interest payments to investors come from the secure collateral account.

A catastrophe bond might be structured so that the payout only occurs if total natural disaster costs exceed a specific dollar amount over a specified coverage period. Bonds may also be pegged to the strength of a storm or earthquake or the number of events that strike a specific region: after a minimum number of which occur, a payout to the insurance company is triggered.

Catastrophe Bond Risks

As sea-level rise and extreme weather events increase, the interest rates demanded by investors will probably rise. And as investors come to see the impacts of climate change as inevitable, rather than as a possible risk, the market for climate-related catastrophe bonds may disappear altogether.

Example of a Catastrophe Bond

An insurance company issues a catastrophe bond with a face value of \$1000 and which matures in two years, paying a 6.5% interest rate each year to investors. Investors will be paid \$65 each year, while the principal is returned at maturity. Proceeds raised from the overall issuance hypothetically total \$100 million and are placed in a special account.

The bond is structured so that a payout to the insurance company occurs only if total natural disaster costs exceed \$300 million over the two years in question with remaining funds returned to investors at the bond's maturity, making this both a risky proposition for investors if natural disaster costs occur at scale, but also one with higher interest rate payments. Questions also remain on who measures the total damage that occurs in such instances.

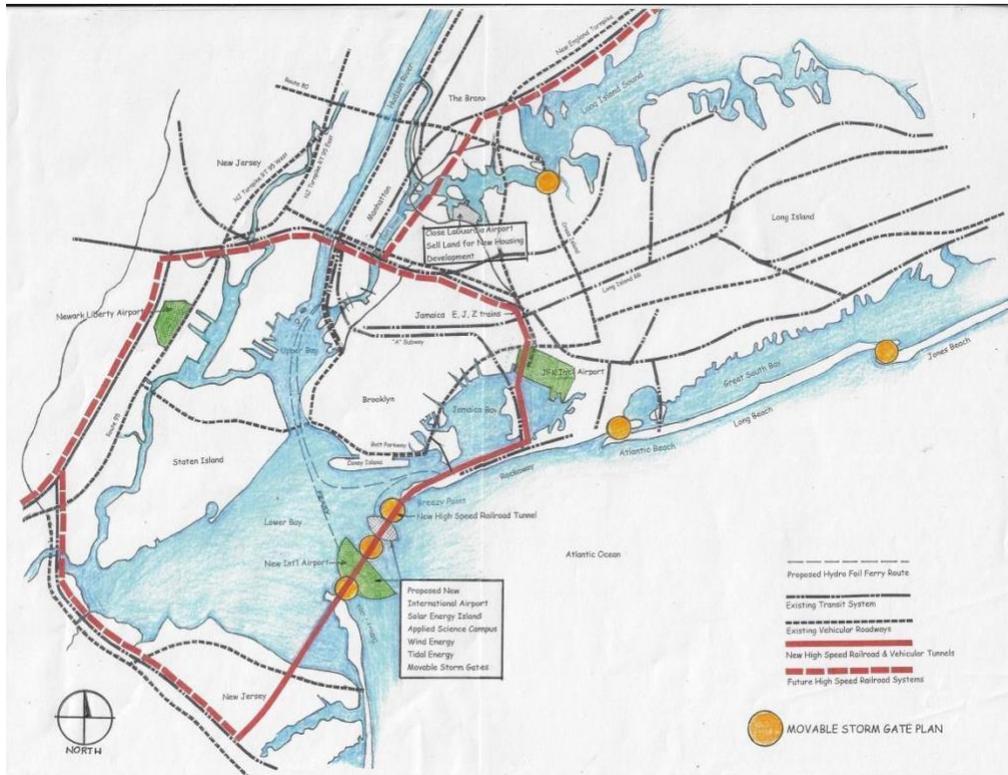
The Federal Emergency Management Agency (FEMA) issued its first catastrophe bond in 2018 as a way to recover losses from flood events. The strategy, according to a report on the transaction, is to enable FEMA to access greater market capacity and spread its risk across a more diverse pool of companies and investors.³⁶³

³⁶³ <https://www.fema.gov/hfip-reinsurance-program>

Building and Financing Storm Barriers

Most of the damage from Sandy occurred around New York's upper and lower bays, around Long Island's Great South Bay, and along New Jersey bays including Navesink, Manasquan and Barnegat. Each of these bays has a relatively narrow opening to the open ocean, which could be closed by a combination of permanent and movable barriers.

Figure 11 – A Grand Vision for the Future of New York City³⁶⁴



Source: Sustainable Innovation and Impact, Krosinsky, Cort (Routledge, 2018)

There may be an opportunity to combine barrier construction at inlets with income-generating projects. For example, demand for transportation and related facilities in the NYC area has outgrown current capacity, creating a need for a major new international airport. Perhaps an offshore airport facility, built as part of a coastal barrier protecting NYC, could generate enough income to repay the barrier's long-term development bonds. Such bonds could be offered as Green City Bonds or another form of tax-advantaged municipal finance, or enhanced through public-private partnerships.

³⁶⁴ Sustainable Innovation and Impact, Krosinsky, Cort (Routledge, 2018)

Potential revenue-generating projects associated with a coastal barrier include:

1. A new international airport strategically sited to narrow the gap between Sandy Hook on the New Jersey side and Breezy Point on the Long Island side of the entry to Lower New York Bay (Figure 11).
2. The inclusion of a waterfront barrier consisting of engineered sand dunes, inlet gates, sheet piling water barriers under the boardwalk (see City of Long Beach's new boardwalk), as well as new raised highways and rail lines, marine growth, shellfish beds and fishing reefs which will stop, slow and absorb the flow of flood waters.
3. A rail system and road work connecting JFK Airport to Newark Liberty Airport, eliminating the existing connection to LaGuardia Airport (which could instead be shut down and sold to developers to help fund the new airport).
4. A bypass, toll highway to reduce ongoing heavy traffic on the Verrazano Bridge and the Belt Parkway and related high-speed rail for connections and helping resolve the decaying, threatened single train tunnel between New Jersey and NYC for which the economy of the region remains heavily reliant.
5. The airport could be powered by distributed energy systems, such as solar, offshore wind, tidal generation and geothermal, with excess energy production sold back to local utilities.
6. 100% recycling of trash and sewage, with waste turned to revenue and the development of fishing and oyster reefs which would help control tidal action, purify coastal ocean water and provide recreational fishing grounds and protect existing wetlands.
7. Possible development of a college, museum and/or working science laboratory to stimulate similar developments.

An economic study could be undertaken by both Federal and regional government agencies to investigate the best way to proceed. This study would include establishing a longer-term schedule for planning, construction and financing the project as quickly as possible. The risks of another Sandy are rising. Other regions, given expected sea level rise in the decades to come, could learn from this example, creating new sources of revenue for all categories of organization involved.

Green bonds could be issued, at significant and necessary scale over time, to help finance any of these larger infrastructure plans, with proceeds paying back bondholders coming from a variety of revenue sources.

For more on Green Bonds, see earlier sections of this report as well as the Climate Bonds Initiative website³⁶⁵ for reports on the state of this growing global asset class.

³⁶⁵ <https://www.climatebonds.net/>

Also, former Secretary of State John Kerry's World War Zero³⁶⁶ has been a new bipartisan coalition calling for a scaling up of climate responses and solutions up until his recent appointment to the National Security Council involving financial thought leaders such as Hank Paulson, who served as Secretary of the Treasury. Such coalitions, including leaders from the financial sector, and involving academic institutions, have the opportunity to collaborate to develop methods and an overall plan for both properly funding the necessary low-carbon transition and ensuring cities such as New York can be fully resilient to a climate-affected future.

Role of Philanthropy

Philanthropy plays an important role in catalyzing SDG aligned investments. For example, the DC Water environmental impact bond would not have been possible without the Rockefeller Foundation and Calvert Impact Partners. The DC Water project is part of a much larger initiative by the Rockefeller Foundation, called Zero Gap, which is committed to the SDGs. It uses philanthropic risk capital, through both grants and program-related investments (PRIs), to develop and scale the next generation of innovative finance solutions that are needed to close the gap between global development funding needs and the resources that are currently available. In this scenario, the Rockefeller Foundation plays the critical role of providing capital for research and development of projects that could benefit from innovative financing. Calvert acted as an investor, providing \$2 million in capital to the project. This represents a perfect example of foundations taking on a leading role in identifying innovative opportunities, and providing the financing to turn them into reality.

Scope for Further Research

Priorities are also necessary for protecting buildings located on or near shorelines and in exposed bays which will face more frequent and stronger potential damage from wind, waves and high-water surges in order to address ongoing economic vibrancy and to avoid disruption.

³⁶⁶ <https://www.theatlantic.com/science/archive/2019/12/john-kerry-interview-climate-catastrophic-world-war-zero/602833/>

Summary

From combating climate change to reducing hunger and eradicating poverty, the United Nations' 17 Sustainable Development Goals respond to the pressing global challenges of our time. As it becomes more apparent that these challenges are fundamental threats to the global economy, governments and businesses around the world are starting to take them seriously. Some of the largest financial institutions, exemplified below, have started to commit to mobilizing capital to align with the UN Sustainable Development Goals.

Institution	Commitment to sustainable finance
Bank of America	\$445 billion by 2030 to low-carbon, sustainable business through its Environmental Business initiative, sustainability bonds, and more
Wells Fargo	\$200 billion through 2030, and \$65 million in philanthropic capital
Goldman Sachs	\$750 billion by 2030 for sustainable finance, investing, and advisory activities
JP Morgan	\$750 billion in sustainable financing by 2030
Morgan Stanley	\$250 billion to finance low carbon solutions by 2030
Citi	\$250 billion to finance activities that reduce the impacts of climate change by 2025

As we've seen throughout this report, there are many technologies, stakeholders, statistics, and frameworks that can be applied to each challenge.

The Business and Sustainable Development Commission estimates that achieving the sustainable development goals opens up at least \$12 trillion investment opportunity for the private sector.³⁶⁷ Creative financing mechanisms are certainly a means to scale up solutions and increase the rate at which we transition to a low-carbon economy, though challenges remain.

Innovative financing mechanisms have been developed and applied to the built environment and renewables, with energy performance contracts, PACE financing, power purchase agreements, and credit trading at the forefront of the space. New York already has implemented a strong policy foundation to catalyze energy efficiency upgrades. How can it continue to retrofit buildings at a scaled up, appropriate rate, and how can it best determine what is most appropriate? What processes and finance mechanisms can further de-risk what are often capital-intensive projects?

³⁶⁷ http://report.businesscommission.org/uploads/BetterBiz-BetterWorld_170215_012417.pdf

These two sectors, the built environment and renewable energy, represent the most developed of the segments covered in this report, but there is still room to figure out how to best scale up appropriate levels of financing.

The story is different for waste and food & health.

Investors have recently begun to take a greater interest in these sectors, yet the landscape is largely defined by early-stage financing and technology solutions that are still largely in development.

Circular systems and robotics technologies to improve waste sorting are being tested, but with China shutting its doors to recyclable U.S. waste, the scope of the problem is only increasing.³⁶⁸ In food & health, urban farms are starting to gain traction and unlikely stakeholders such as health insurance companies have started to invest in solutions. In addition to VC and corporate finance, revenue-based financing and transition bonds may also be useful in these sectors. While progress is encouraging, there is more work to be done to coordinate efforts across finance, government and businesses to scale up for necessary change.

When it comes to sustainable mobility and resilience, there is clearly more work to be done. Public transit has particularly suffered in light of COVID, and metropolitan areas have started implementing “slow streets” and have seen a rise in cycling popularity. In addition, there is much excitement about scaling up of EV charging infrastructure and related software tools to more efficiently manage EV charging. The few available finance mechanisms that have been implemented for resilience include catastrophe bonds, green bonds, and environmental impact bonds, but instead of mitigating climate change, these options are often reactive. How can the city update its infrastructure and avoid locking into inefficient structures for decades to come? As the portion of the population living in urban areas increases along with the frequency of extreme weather events -- dangerous storm surges, for example, are now 20 times more likely to overwhelm the Manhattan seawall than they were 170 years ago³⁶⁹ -- a grand vision coupled with further creativity in finance is almost certainly required.

Companies also potentially stand to benefit from an increased response by cities to ensure they build properly for full and true future resilience. An example list of such companies would be members of the MSCI ACWI Smart Cities Index,³⁷⁰ which has financially outperformed its benchmark for both the past one and three years, as well as since inception. And of course, global city efforts at adaptation are just getting started.

While implementing lasting change may seem like a monumental task, municipalities have the opportunity to take action on a local level to make an impact. New York has done an enormous amount of planning and aligning its city initiatives with the UN

³⁶⁸ <https://www.theguardian.com/us-news/2019/jun/21/us-plastic-recycling-landfills>

³⁶⁹ <https://www.businessinsider.com/new-york-city-flood-sea-level-rise-2017-5>

³⁷⁰ <https://www.msci.com/documents/10199/d1a1ee84-b78e-019c-97f9-a75bb2cd5cee>

Sustainable Development Goals through the *OneNYC* strategic plan, the *One City: Built to Last* sustainable development plan, and *Plan NYC 2030*.

While there is still work to be done in transitioning to a low-carbon economy, and achieving the Sustainable Development Goals, the technologies and capital exist to tackle these challenges. As a global financial hub with an ambitious sustainability plan, New York City is well-positioned to serve as an incubator for creative finance. The *Invest NYC SDG* initiative presents a compelling opportunity to identify and trial best-in-class projects, technologies, and finance mechanisms, and serve as a regional case study and blueprint for other metropolitan areas to tackle climate change.