TRANSFORMING INFRASTRUCTURE IN NEW YORK CITY FOR SUSTAINABILITY: CRITICAL NEEDS AND OPPORTUNITIES WORKSHOP

APRIL 25, 2016

ROOSEVELT HOUSE, HUNTER COLLEGE

CITY UNIVERSITY OF NEW YORK

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Executive Summary Report

	Transforming Infrastructure in New York City for Sustainability: Critical Needs and Opportunities Workshop
Date	April 25, 2016
Location (city, state, country, facility):	New York, New York, USA, Roosevelt House, Hunter College, City University of New York
Co-Organizers	Peter Marcotullio (City University of New York) Cynthia Rosenzweig (NASA/GISS, Columbia University) William Solecki (City University of New York)
Sponsors	Électricité de France (EDF) UN Sustainable Development Solutions Network (SDSN) Urban Climate Change Research Network (UCCRN) – Columbia University CUNY Institute for Sustainable Cities (CISC) – City University of New York Consortium for Climate Risk in the Urban Northeast (CCRUN)

MODERATORS AND PANEL PARTICIPANTS:

Kate	Ascher	Columbia University
Michael	Bobker	City University of New York – City College of New York
Chris	Boone	Arizona State University
Juan	Camilo Osorio	New York City Environmental Justice Alliance
Elena	Crete	UN Sustainable Development Solutions Network
Projjal	Dutta	New York City Transportation Authority
Robert	Freudenberg	Regional Plan Association
Robin	Leichenko	Rutgers University
Peter	Marcotullio	City University of New York – Hunter College
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Douglas	Price	CUNY Institute for Sustainable Cities – City University of New York
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TRANSFORMING INFRASTRUCTURE IN NEW YORK CITY FOR SUSTAINABILITY:

CRITICAL NEEDS AND OPPORTUNITIES WORKSHOP

APRIL 25, 2016

AGENDA

9:30 AM – 9:40 AM	**Welcome and Introductions** *William Solecki, City University of New York – Hunter College;* *Peter Marcotullio, City University of New York – Hunter College;* *Cynthia Rosenzweig, NASA/GISS and Columbia University*
9:40 AM – 9:50 AM	**Review of the United Nations Sustainable Development Goals** *Cynthia Rosenzweig, NASA/GISS and Columbia University;* *Elena Crete, UN Sustainable Development Solutions Network*
9:50 AM – 11:10 AM	**Panel I: Conditions for Infrastructure Sustainability** *Moderator: Ernest Tollerson, Hudson River Foundation* *Panel Members:* *Nilda Mesa, New York City Mayor's Office of Sustainability;* *Robert Freudenberg, Regional Plan Association;* *Kate Ascher, Columbia University;* *Sandra M. Ruckstuhl, UN Sustainable Development Solutions Network*
11:10 AM – 12:30 PM	**Panel II: Economics of Infrastructure Transformation** *Moderator: Douglas Price, CUNY Institute for Sustainable Cities – City University of New York* *Panel Members:* *Projjal Dutta, New York City Transportation Authority;* *Rae Zimmerman, New York University;* *Michael Bobker, City College of New York – City University of New York*
12:30 PM – 1:10 PM	Lunch
1:00 PM – 2:20 PM	**Panel III: Social Equity of Infrastructure Transformation** *Moderator: Marta Vicarelli, University of Massachusetts – Amherst* *Panel Members:* *Juan Camilo Osorio, New York City Environmental Justice Alliance;* *Robin Leichenko, Rutgers University;* *Joel Towers, New School University; Chris Boone, Arizona State University*
2:20 PM – 3:30 PM	**Workshop Recommendations and Conclusions** *Cynthia Rosenzweig, NASA/GISS and Columbia University;* *William Solecki, Hunter College – City University of New York;* *Peter Marcotullio Hunter College – City University of New York*

WORKSHOP DESCRIPTION, STRUCTURE, AND OBJECTIVES

Cities have an extraordinary potential for transformational change due to their concentration of economic activity, dense social networks, human resource capacity, high levels of investment in infrastructure and buildings, relatively nimble local governments, close connection to surrounding rural and natural environments, and tradition of innovation. As a result, cities can become active players on the world's stage to respond to the new calls coming for enhanced movement toward sustainability. Indeed, cities are increasingly both the centers of investments and economic activities as well as the source of potential solutions to the global sustainability crisis.

The period 2015-2016 is a watershed moment for global sustainability efforts. During this time, a worldwide consensus has emerged that global climate change is now underway and the world's populations and ecosystems are experiencing the impacts of more frequent extreme events and gradual shifts in the everyday climate. Coupled with accelerating and globally significant biodiversity loss, and unprecedented levels of urbanization, human migration, and commerce, we have entered into what many have described as new geological epoch – the *Anthropocene*.

At the same time, several major global agreements put forward during the 2015-2016 period provide significant benchmarks and capacity for understanding the current trajectory and motivating forward action. In March 2015, the global community came together to ratify the Sendai Framework for Disaster Risk Reduction that provides protocols for addressing extreme events and threats to sustainability. And in October 2016, Habitat III defined pathways to promote sustainable urban development. In between, the world's countries authorized at least two other foundational pacts that will influence future prospects for sustainability. On September 25th 2015, countries of the world adopted the Sustainable Development Goals agenda designed to end poverty, protect the planet, and ensure prosperity for all. Each goal has specific targets to be achieved over the next 15 years. Less than 3 months later in December 2015, the UN and representatives from all of the world's countries ratified the comprehensive Paris Agreement on climate change.

One area where both global environmental change solutions and economic investments come together is in urban infrastructure. Sustainable urban infrastructure is a highly complex, heterogeneous, and interdependent mix of facilities that is resilient to a wide variety of threats, including extreme weather events, and helps to mitigate greenhouse gas emissions. At the same time, it is expected that sustainable urban infrastructure will promote economic development and enhance opportunities for increased social equity. Many cities around the world are now engaging in the crucial planning needed to define options for sustainable infrastructure and conditions for implementation.

Workshop Background

The objective of this workshop was to review and assess possible pathways for the transformation of New York City's infrastructure for sustainability. The workshop consisted of three discussion panels to investigate and assess different aspects of this issue. The panels were tasked with 1) Identifying key infrastructure systems and needs for New York City; 2) Scoping solutions to the needs and estimating the costs of transformation to sustainability; and 3) Defining the social equity and health issues of such a transformation. New York is in an excellent position to take a leadership role in discovering the opportunities for and meeting the challenges of fostering and developing sustainable infrastructure across a diversity of sectors, because it

is a global leader in sustainability planning and climate action (both adaptation and mitigation). The recent experience of Hurricane Sandy is also spurring transformative efforts.

Starting in 2012, a multi-stakeholder consultation was developed and executed in New York as part of the Sustainable Development Solutions Network that was designed to provide critical technical and operational support for the articulation and designation of the 17 UN-designated Sustainable Development Goals. With the adoption of the SDGs in September of 2015, especially SDG 11 'To make cities inclusive, safe, resilient, and sustainable,' much of the discussion has focused on how cities can move towards greater sustainability.

This consultation workshop was held to bring together city government representatives, infrastructure specialists, economists, environmental justice experts, and sustainability leaders. The one-day meeting consisted of facilitated discussions to elicit the most-pressing intersections of sustainability, infrastructure, and social equity issues. The workshop was designed to link directly to the goals of the *Deep Decarbonization Pathways Project* developed by the Sustainable Development Solutions Network (SDSN 2014 - http://unsdsn.org) for New York City.

Potential pathways and a conceptual framework for sustainable transformation for four critical urban infrastructure systems and their intersections will be developed from the discussions emerging from the workshop. The workshop discussion specifically focused on the energy, telecommunications, transportation, and water sectors, and their interactions. The framework to be developed will set forth methods and protocols for sustainability transformations in each of the infrastructure sectors and their interconnections, benefits of these infrastructure transformations to local public health conditions (i.e., air quality), and costs. The framework aims to reveal integrated mitigation and adaptation entry points in urban systems where enhanced greenhouse gas (GHG) mitigation could occur simultaneously with reduction in exposure and vulnerability of critical infrastructure to extreme weather and climate events, with sustainability as the overall goal.

Workshop Structure

The workshop included three panel sessions, each with four short presentations by workshop participants and a period of open discussion. Each panel addressed an overarching question and several more specific questions. The workshop concluded with an open discussion of the recommendations and conclusions from the workshop. The presentations and discussion from each panel have served as the foundation for this Executive Summary Report.

Workshop Objectives

The overall objective of this workshop was to review and assess possible pathways for the transformation of New York City's critical infrastructure for sustainability.

The workshop was designed to examine the following three issues through three focused discussion panels:

1) Identify critical infrastructure systems and needs for New York City
2) Scope solutions to the needs and estimate the costs of transformation to sustainability
3) Define the social equity and health issues of such a transformation

WELCOME AND INTRODUCTIONS

William Solecki, City University of New York – Hunter College
Peter Marcotullio, City University of New York – Hunter College
Cynthia Rosenzweig, NASA/GISS and Columbia University

Workshop co-organizers welcomed participants to the workshop and introductions were made. The main objective of the workshop was reviewed—to determine critical pathways for transformation in infrastructure in New York City with respect to sustainability and resilience to climate change.

William Solecki explained that urban transformation at the city level sets the broader context for considering the larger scale of how to address global questions of urban environments, climate change, and sustainable development pathways. For example, how can different city infrastructure transformation scenarios help to limit global warming to 2.0°C or 1.5°C as proposed under the United Nations Framework Convention on Climate Change (UNFCCC)?

Solecki noted that the infrastructure systems present in today's cities will evolve

such that the systems will be fundamentally different in how basic resources in the city are provided in the future. For example, some forms of advancement may include changes such as transportation automation and transition to more electronic alternatives to alleviate dependence on carbon-intensive fossil fuels.

Finally, workshop participants were asked to consider how sustainability could be promoted while also enhancing opportunity for equity and positive health outcomes for all peoples and communities in New York City.

REVIEW OF THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

Cynthia Rosenzweig, NASA/GISS and Columbia University
Elena Crete, UN Sustainable Development Solutions Network

Cynthia Rosenzweig and Elena Crete urged workshop participants to consider infrastructure transformation pathways for New York City that would take into account the United Nations Sustainable Development Goals as well as recent mitigation targets proposed under the 21st UNFCCC Conference of the Parties held in Paris in 2015. Cities are increasingly seen as critical to implementing sustainable development as well as climate change mitigation and adaptation.

SUSTAINABLE DEVELOPMENT GOALS (SDGS)[1]

Presenters noted that the aim was to define critical needs and opportunities for creating intertwined systems to meet the objectives of SDGs #11 and #13 as adopted by the UN General Assembly on September 25, 2015:

SDG 11: Sustainable Cities and Communities—Make cities and human settlements inclusive, safe, resilient and sustainable.

- For SDG 11, *resiliency* of cities is defined in the following way: Cities are deemed resilient in the context of climate change extremes but also resilient to any kind of shock to the urban system (e.g., social, political, economic, and other types of hazards)
- Mitigation of climate change impacts is key, but all three pillars of sustainability should be considered as well (economic, environmental, and social sustainability)

SDG 13: Climate Action—Take urgent action to combat climate change and its impacts[2]

- Presenters noted that climate action was embedded in the SDGs. Thus, sustainability is not possible without action on climate change and vice versa.

PARIS CLIMATE AGREEMENT—CONFERENCE OF THE PARTIES TO THE UNFCCC 21 (COP21)[3,4]

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[1] United Nations Development Program. 2015. Sustainable Development Goals. Accessed at: http://www.undp.org/content/undp/en/home/librarypage/corporate/sustainable-development-goals-booklet.html

[2]Acknowledging that the UNFCCC is the primary international, intergovernmental forum for negotiating the global response to climate change.

[3] United Nations Framework Convention on Climate Change. 2015. Paris Agreement. Accessed at: http://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf

[4] United Nations Framework Convention on Climate Change. 2015. Adoption of the Paris Agreement. Proposal by the President. Draft decision -/CP.21. Accessed at: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

Presenters highlighted the important role of cities in climate change transformations in the Paris Climate Agreement produced at COP21.

The preamble to the Paris Climate Agreement emphasizes that strategies to reduce GHG emissions should be aimed at limiting the global average temperature increases to well below 2°C above pre-industrial levels. However, in acknowledgement of the impacts of climate change on Small Island States, COP21 acknowledged that further mitigation actions should be pursued to keep global average temperature increases to no more than 1.5°C above pre-industrial levels.

Preamble to Paris Climate Agreement:

> "Emphasizing with serious concern the urgent need to address the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with holding the increase in the global average temperature to well below **2.0°C** above pre-industrial levels and pursuing efforts to limit the temperature increase to **1.5°C** above pre-industrial levels" (emphasis added).

Coming out of UNFCCC COP21 discussions, the Intergovernmental Panel on Climate Change (IPCC) has accepted a invitation to prepare a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.[5]

The challenge presented to workshop participants was to focus on two different levels of potential transformation in New York City that would meet the 2°C and 1.5°C targets, respectively.

Finally, the role of cities in climate change was one of 31 different topics proposed for special reports from the IPCC during their 43rd session held in Nairobi in April 2016. In acknowledgement of the importance of cities in climate change mitigation and adaptation, a focus on enhanced engagement with urban practitioners, city networks, and urban stakeholders is planned for the upcoming Sixth Assessment Report (AR6) cycle.[6] Moreover, a Special Report on Climate Change and Cities is now planned as part of the Seventh Assessment Report (AR7) cycle.[7]

WORKSHOP DISCUSSION

- One participant asked how many cities have created Nationally Determine Contributions (NDCs) goals at the city level.

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[5] Intergovernmental Panel on Climate Change. April 14, 2016. Press Release. Accessed at: https://www.ipcc.ch/news_and_events/pdf/press/160414_pr_p43.pdf.
[6] Intergovernmental Panel on Climate Change. 2016. Press Release. IPCC agrees special reports, AR6 workplan. Accessed at: https://www.ipcc.ch/news_and_events/pdf/press/160414_pr_p43.pdf
[7] Intergovernmental Panel on Climate Change. Forth-third session of the IPCC. Nairobi, Kenya, 11-13 April 2016. ANNEX 25. South Africa Proposal for Special Report on Cities and Climate Change. Accessed at: http://ipcc.ch/apps/eventmanager/documents/37/140320160519-INF.7_ThemesSRAR6.pdf

  - Another participant responded that the inspiration for every country determining NDCs for themselves was actually inspired by and based on how cities had already been determining their own contribution goals.
  - Another participant highlighted how goals to achieve 80% GHG reductions by 2050 is a city level proposal, but another participant noted that commitment to reducing emissions by 80% by 2050 is also a United Nations goal.[8]
  - The United States has also committed to the 80% reduction by 2050 in its NDC.[9]

- Pinpointing the relationship between the 80% emissions reductions by 2050 target and temperature reductions is important, said one participant.
  - Other participants noted that Representative Concentration Pathways (RCPs) from the IPCC 5th Assessment Report (AR5) link emissions with temperature increases (e.g., in RCP 2.6 1000 Gt of CO_2 between 2012-2100 will lead to global average temperature increases of 1.0°C and RCP 4.5 is about 2020 GT between 2012-2100. There is a need to reduce to only 10Gt/year, which means a 1/3 decrease from current pathways.[10]
- One participant speculated on how much of the last year's relatively lower emissions were a function of oil priced at $140/barrel and wondered what $36/barrel would mean for future scenarios.
  - Another participant responded that a lot of the scenarios are a product of market fluctuations. A reduction in the price of oil of two-thirds can make policies put in place in the present less impactful for future emissions scenarios.
- Another participant asked what energy mixes would be needed to make city targets doable under a transformation scenario that targets no more than 1.5°C global average temperature increases above pre-industrial levels.
  - Other participants noted that the city is heavily focused on reducing emissions from the built environment.

[8] Intergovernmental Panel on Climate Change. 2011. Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN). Accessed at: http://www.ipcc.ch/pdf/special-reports/srren/SRREN_Full_Report.pdf
[9] United Nations Framework Convention on Climate Change. 2015. United States Intended Nationally Determine Contribution. Accessed at: http://www4.unfccc.int/Submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf
[10] Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Mitigation of Climate Change. Accessed at: http://www.ipcc.ch/report/ar5/wg3/

PANEL I: CONDITIONS FOR INFRASTRUCTURE SUSTAINABILITY

Moderator

- ***Ernest Tollerson, Hudson River Foundation***

Panel Members

- ***Nilda Mesa, New York City Mayor's Office of Sustainability***
- ***Robert Freudenberg, Regional Plan Association***
- ***Kate Ascher, Columbia University***
- ***Sandra M. Ruckstuhl, UN Sustainable Development Solutions Network***

The discussion in Panel I revolved around the overarching question: What are critical infrastructure features (including energy, water, transportation, food, and communication systems) for a large city like New York and what are the primary needs to make the infrastructure more sustainable? Three specific questions were also posed: 1) How might the primary needs change over time? 2) What are the relationships between critical infrastructure and sustainability and the promotion of a low-carbon economy development pathway? 3) What are the best opportunities for the City of New York to have influence or control over the transformation of its critical infrastructure, what are the barriers, and how can they be overcome?

Nilda Mesa opened the panel discussion with an update on actions to reduce GHG emission in NYC and how use of renewable resources factor into GHG emissions mitigation actions and plans. Robert Freudenberg then discussed the history and current state of regional planning in the broader New York City region. Finally, workshop participants engaged in a discussion on the importance of multilevel governance and need for greater collaboration among city, state, and federal governments.

ACTIONS IN NEW YORK CITY TO REDUCE GHG EMISSIONS

Participants discussed that in addition to becoming more resilient, cities will need to develop strategies that will lower their GHG emissions in order to achieve the goal of reducing global average temperature increase to 1.5°C and not more than 2.0°C. New York City is in a position to set an example for other cities around the world through both transformation of infrastructure as well as in taking ownership for emissions generated from the production of imported products from countries like China and Vietnam.

New York City has committed to keeping per capita GHG emissions in New York City at a level that would contribute to no more than 2.0°C increase in average global temperatures. In parallel with the city's ONE NYC visions for the future, the city aims to focus on maintaining a thriving and growing city while increasing equity, sustainability, and resiliency.[11,12]

REDUCING GHG EMISSIONS FROM BUILDINGS IN NEW YORK CITY

[11] The City of New York. 2015. One New York: The Plan of a Strong and Just City. Accessed at: http://www1.nyc.gov/html/onenyc/index.html
[12] The City of New York. 2016. OneNYC 2016 Progress Report. Accessed at: http://www1.nyc.gov/html/onenyc/index.html

Nilda Mesa spoke from the New York City Mayor's Office of Sustainability regarding how New York City is attempting to play a major role in setting the pace for how other global cities can reduce GHG emissions. She notes that the City, under Mayor De Blasio's administration, has committed to an 80% reduction in GHG emissions by 2050. In order to achieve this goal, the City is instituting sweeping sets of initiatives for architectural reform and building codes. As 75% of New York City's GHG emissions come from buildings, this is a critical infrastructure sector to target for transformation. The source of New York City's GHG emissions is different than that of many American cities—the percentage of emissions coming from building operations is much higher.. Transportation, which is a source that typically makes up a large segment of emissions in American cities is only 20% of New York City's per capita GHG emissions. In addition New York City produces about one-third of the GHG emissions compared to broader U.S. averages. However, to lower GHG emissions in transportation and solid waste infrastructure transformations are key areas of concern in addition to buildings in NYC.

In order to better understand how to reduce GHG emissions from buildings, the NYC Building Technical Working Group, a group made up of many different stakeholders from real estate developers to environmental advocates, generated 100 different energy conservation measures that could be instituted in buildings throughout the city. Building owners collected and reported to the City information and data on different measures of energy performance. Different patterns were observed among buildings, and then 21 different typologies of building types were generated based on energy use and performance patterns. Eight of the typologies were focused on emission reductions. Typologies were based on age, size of buildings, family size, and designated use as these were determined to be major drivers that help determine the most suitable pathways for emission reductions. For example, split multi-family buildings versus commercial buildings had different patterns of energy usage. Sustainability and cost effectiveness were considered for each typology. From trends in these overall typologies, low-cost strategies for emissions reductions have been developed for the different types of buildings. One of the most effective pathways for energy use transformation in New York City's building stock is to promote steam heating. About 80% of the buildings in the city already have some kind of steam heat and 90% of the city's buildings are projected to have steam heat by 2050. By regulating steam heating and instituting other modest strategies such as digital steam control, the city could reduce overall GHG emissions by 4%.

RENEWABLE ELECTRICITY GENERATION TO DECREASE GHG EMISSIONS IN NEW YORK CITY

Currently, less than two percent of New York City's energy comes from renewable sources. The city uses approximately 10,000 megawatts per year of electricity, and municipal operations make up approximately 10% of that. The vast majority of the city's electricity comesfrom natural gas generators as well as the Indian Point nuclear reactor located upstream from the city on the Hudson River. Indian Point is a point of contention for some but provides approximately 30% of New York City's electricity in a dependable and low-carbon-emissions way. One concern is that if Indian Point were to be decommissioned, coal and natural gas plants would have to make up a greater percentage of electricity sources flowing into the city, leading to increases in GHG emissions rather than reductions. Since 2005, the city has been able to eliminate 12% of the GHG emissions associated with electricity usage by relying more heavily on natural gas and renewable sources and less on coal.

Currently, no suitable renewable electricity strategy has been selected, but the City continues ongoing consultations on different options. One proposal was for an offshore wind project off the coast of Long Island, but offshore wind projects can be expensive. Hydroelectricity from upstate New York has also been explored but transmission lines are constrained. There is currently no clear path for the city to develop additional capacity. With regards to solar, usage has tripled in the last two years throughout the city, and there is a collective purchasing program in place. However, the City has a 350-megawatt target for solar and not enough is being done currently to meet that goal. Utilities have been ordered to improve data collection with regards to solar electricity generation, but how the solar market will continue to unfold is unclear at the present.

An ancillary benefit of switching to renewable electricity options are the public health benefits associated with lower-emissions electricity production. New York City has recorded some of the highest rates of asthma, especially in children, in the U.S. due to poor air quality. Poor air quality tends to affect most the communities that can least afford it and overall results in economic impacts such as absences from school and work. Public health concerns represent an additional motive for the City to reduce combustion of fossil fuels.

REGIONAL PLANS AND CHALLENGES TO ENVIRONMENTAL PROTECTION IN NEW YORK CITY

The greater New York metropolitan region is a $1.5 trillion USD economy, which includes a broader governance area of 31 counties including the 5 boroughs/counties of New York City, covers 13,000 square miles, and is home to 23,000,000 residents. Robert Freudenberg reviewed the history of regional plans in the region beginning with the regional plan of the 1920s that recognized the city was growing beyond its boundaries in an unsustainable way and that environmental protections needed to be instituted. The 1929 plan looked towards suburbs, parks, and transportation to set out a vision for what future growth might look like. In the 1960s during the age of the baby boomers, suburban growth exhibited a share increase and the need for environmental protection began to shift away from the center to multiple sub-centers. By 1996, the region had undergone extreme urban sprawl and farmland was increasingly being claimed by urban development at an accelerated rate. This became a major concern of regional planning.

Freudenberg explained that the current era of regional planning is the fourth iteration for the New York metropolitan region and looks to address issues of climate change, equity, and governance. Other major issues include clean water and electricity sources.

Currently 60% of water sources in NYC are considered somewhat impaired because of the way development has occurred. Impervious ground cover lends to impaired water sources. Coastal pollution is also a major issue since 40% of wastewater treatment plants are in flood zones and combined sewer overflows lead to sewage influx into waterways during storms. During Hurricane Sandy, for example, 100,000,000 gallons of raw sewage were released into New York City waterways.

Electricity sources are another concern from a regional planning perspective. Much of the progress achieved in New York City's GHG emissions reductions to date has been due to augmented use of natural gas as a primary source. The closing of the Indian Point nuclear power facility represents a major challenge as the clock is ticking on the license for the plant and broader public opinion is less favorable for nuclear electricity production. The potentially bigger safety risk to the community is tough to weigh against the risk of losing a low-carbon electricity source that would be replaced by greater coal-fired electricity production, leading to

increased GHG emissions and air pollution. Meanwhile, natural gas is also under attack for a number of reasons related to negative externalities associated with fracking extraction methods and the Constitution Pipeline, at the frontline of that political battle, was recently cancelled. There is also a broader battle over whether the region should consider only internal sources of energy or should increase external sources of energy, which leads to a greater need for national energy policies and greater multilevel governance and collaboration.

Transportation and flooding related to sea level rise are additional factors important for the current era of regional planning as they relate to climate change. Transportation and land-use patterns are interconnected as different types of transport networks can result in the spread of different types of communities and land use. Since the transportation sector still relies heavily on fossil fuels, alternative sources of energy also need to be applied to the transportation sector to decrease GHG emissions and air pollution. Finally, sea level rise and flooding represent important challenges for the broader New York metropolitan region as many communities are already seeing flooding at high tide throughout the area. At a 3-foot sea level rise, many communities will be under water. Regional collaboration on this challenge is already necessary, and a regional commission for floodplain development should be considered in order to determine best usage for areas in the expanding flood plain.

WORKSHOP DISCUSSION: MULTILEVEL GOVERNANCE CONFLICTS AND NEEDS FOR INCREASED COLLABORATION BETWEEN CITY, STATE, AND FEDERAL GOVERNMENTS

- Workshop participants highlighted that there are problems with the city, state, and federal governments working together on dealing with issues that would benefit the region with respect to climate change adaptation, development in flood plains, sea level rise, wastewater treatment and water pollution, solid waste management, transportation, and GHG emissions reductions.
    - Some examples that were given for projects on which the State and City administrations have worked well include property developments such as the Atlantic Yards. New York City has also had projects that were successful in part due to the "blessing" of the state government such as water infrastructure projects.
    - The State has control over much of the critical infrastructure that supportss New York City such as freshwater supply systems and transportation.
    - The solid waste system is one infrastructure that requires attention from multiple levels of government. Participants noted that a system that generates less garbage and encourages recycling should be encouraged. Suggestions have already been made for strategies to dispose of organics and inorganics via different solid waste streams in the city; however even pilot projects were unsuccessful due to lack of land resources. Participants noted that if the City and State were working together, alternative land resources might have been suggested by the State to help the city to pilot the programs.
    - Participants also highlighted that achieving an 80% reduction in emissions by 2050 goal or getting to a level of emissions aimed at limiting global average temperature increases to 2.0°C or even 1.5°C would require strategies to be put in place that would enable state and city governments to work together with support from the federal government.

- Workshop participants also described the following conditions that have impacted infrastructure governance across multiple levels in New York City's history:
    - The foundations of infrastructure governance in New York City were developed initially in the mid-1800s during which there was almost no city government, so greater state involvement in infrastructure was necessary.
    - However, as the city grew, city government and the city council became more important, but there was no strong mayor that had responsibility over the city's infrastructure. The city government did not become fully established until the 1900s.
    - Technology, standards, and processes have all become more complicated. For example, New York City transport began with multiple, small, privately-owned rail lines that were eventually centralized into the Metropolitan Transportation Authority of the present era.
    - Different governance entities from the State and City for these infrastructure systems have presented at times political problems (e.g., barriers to a more extensive ferry system and better connection to NJ transport).
- Participants were posed with the question of how best to infuse multi-level governance in practice given the disconnect that often exists between city, state, and federal jurisdictions now.
    - The following suggestions were proposed for how to engage more meaningfully at multiple scales of governance:
        - Provide examples from the past where multi-level governance was effective;
        - Observe other countries with centralized systems of governance; and
        - Provide clear definitions of scalar connections between multiple levels of governance to identify potential points of conflict.
- In addition to multi-level governance issues within New York City, broader regional considerations were also highlighted by workshop participants as important points of consideration for both emissions reduction targets and challenges to increasing overall resiliency.
    - Participants acknowledged that the scale of GHG emissions decreases needed to reach 80% reductions by 2050 might be better achieved at the regional level.
        - One participant proposed dividing the region into deep carbon sequestration zones. However, others noted that this would be complicated to implement.
        - Participants acknowledged that the climate battle may be best fought in small concentrated areas and that collectively such areas that have gone through transformations may be able to lead improvements better than working on strategies for the nation as a whole.
    - Different scales were acknowledged as being important in how infrastructure transformations may occur in one city versus another.

- One participant noted that smaller cities may have more success as they can afford to be more experimental.
- While the same methods may not work in all cities, New York City can still collaborate with other cities to learn best practices and figure out solutions.

- A regionally-focused versus a city-only focused approach was also recognized as a major challenge to increasing resilience for the New York metropolitan region. Participants agreed it was important to take a regional approach beyond the five boroughs.
  - Participants discussed how the first phase of the New York City Panel on Climate Change (NPCC) encouraged a regional perspective on infrastructure. However, after Hurricane Sandy, each individual area had their own specific process. With the current reinstatement of the NPCC, the regional approach is becoming more prominent. The City is playing a leadership role by addressing governance challenges with other cities in the region, and New Jersey and New York state governments.

PANEL II: ECONOMICS OF INFRASTRUCTURE TRANSFORMATION

Moderator

- ***Douglas Price, CUNY Institute for Sustainable Cities – City University of New York***

Panel Members

- ***Projjal Dutta, New York City Transportation Authority***
- ***Rae Zimmerman, New York University***
- ***Michael Bobker, City College of New York – City University of New York***

The discussion in Panel II aimed to answer the overarching questions: How much will the transformation of critical sustainable infrastructure cost to deploy and what are best options to finance these costs? Three specific queries were also posed: 1) How can the costs and benefits on critical infrastructure transformation be more effectively estimated? 2) What key lessons can be learned from past programs of financing transformative changes in urban critical infrastructure? 3) What are innovative approaches to financing transformative change in critical infrastructure in other locales (i.e., cities, regions, countries) that might be applicable to New York City?

Projjal Dutta described relationships among transportation infrastructure, land-use patterns, and urban density in New York City. Rae Zimmerman discussed the importance of accounting and how to value infrastructure transformations. Finally, Michael Bobker presented benefits and costs of electricity infrastructure options for New York City.

VALUING PUBLIC TRANSPORTATION INFRASTRUCTURE AND URBAN DENSITY

Projjal Dutta proposed that greater value be placed on increasing urban density and expanding public transportation infrastructure to encourage sustainable transformation. Suburban utopia, with its resulting sprawl and reliance on the energy-guzzling, individualized automobile, is one of the largest energy-consumption factors in the American model of urbanization and suburbanization. The model is not sustainable; however, it is being exported to developing countries that are basing their own suburban development on the personal automobile and the infrastructure that enables that mode of transit. The result is that in India, China, and elsewhere, due to their greater population densities, traffic jams, urban sprawl, intense transportation energy consumption, and increased GHG emissions are duplicated on an even more massive scale than in American cities.

Land use planningcould contribute to energy reduction when a greater value is put on energy consumption. For example, more expensive costs associated with the individual automobile infrastructure of the 20th century could lead to greater concentrated urban density and improved public transportation infrastructure. If a value is placed on the environmental benefit of greater urban density and improved public transportation infrastructure, energy use and cost savings could become much more sustainable. The question for how to create more sustainable urban developments globally raises the associated question of how best to market and propagate lessons from New York City to other cities in the U.S. and globally—since per capita emissions in New York City are approximately one-third of the average per capita emissions in the United States. In New

York City, these energy and emissions savings come from a greater value placed on increased urban density, smaller family size, and increased opportunities for public transportation.

Workshop participants discussed how negative externalities such as increased resource consumption and higher emissions can be included in the cost-benefit considerations of different models of urban density development and public transportation infrastructure. Participants suggested the need to sell the 'greenness' of the electron for increased transit options relying on clean electricity as a fuel source. Others noted that ride sharing attempted to put value on car-pooling to decrease the number of automobiles on the road; however, it was noted that ride-sharing benefit programs are not having a transformational impact on single-car usage where it has been deployed.

Additionally, participants discussed how cities that have large amounts of suburbanization with a lack of public transit options and rail options outside of the city's core can transform their transportation systems for greater sustainability. In some cases participants noted, employers are increasingly attempting to provide privatized versions of public transport (e.g., Google's transport system in the San Francisco Bay Area). However, in general there was a feeling that society still has to come up with better mechanisms to support density and better public transportation infrastructure.

THE IMPORTANCE OF VALUING AND ACCOUNTING IN INFRASTRUCTURE TRANSFORMATION

Rae Zimmerman led a discussion on valuing infrastructure—that is for every dollar that is put into infrastructure transformation there are environmental savings that vary from infrastructure type to infrastructure type and need to be fully accounted for in the cost-benefit analysis of infrastructure projects. Zimmerman described how her research has aimed to 'follow the money' in infrastructure projects in New York City. For instance, she looks at observed government spending on infrastructure, transportation, and water to see where the efficiencies and waste were and how spending changed when there was an emergency. Post-Hurricane Sandy, for example, reports indicate that funds were lost in part because disaster relief could not be fully accounted for in an inadequate accounting system.

Several key factors were highlighted to improve valuing and accounting systems in New York City for infrastructure transformation:

- Addressing the continued stove-piping of infrastructure funds. Projects have different priorities and should be treated via separate funding streams when possible and appropriate.
- Recognizing a need to accomplish more than one goal at a time. For example, improving New York City Housing Authority housing conditions should be addressed but so should affordable housing and green building infrastructure.
- Combined Sewer Overflow systems throughout New York City need to be supplemented and improved with green infrastructure technologies for better storm drainage management.
- Wildlife corridors and green spaces should be developed both for the protection of wildlife and public enjoyment and for reduced carbon emissions (which should be included in a better accounting system for GHG emissions and savings in New York City).

- Existing green spaces should be valued for their ecosystem services, including carbon emission reductions, cleaner air, habitats for wildlife, and public spaces for recreation and enjoyment.

Even without new accounting systems for sustainable infrastructure transformation, there are intentions by New York City's administration to reduce carbon emissions. The high costs of the *status quo* have not traditionally been included in the valuation and accounting systems for infrastructure in the City. Pollution, carbon emissions, degraded habitats and public health are all expensive externalities of the current infrastructure in New York City and need to be appropriately valued when discussing transformations of these infrastructures for sustainability. Challenges are present as much of the infrastructures need to be addressed on a regional level. The city alone cannot change its accounting system to fix the problem—state and other regional actors must follow suit. Additionally, finance sources are increasingly harder to secure such that infrastructure is not being replaced on the cycle of 'repair and replace' that it should be.

The workshop participants discussed how the role of human behavior is also an important consideration when creating valuation models of infrastructure development, because people do not always make rational decisions. For example, people may not always choose the shortest mode of travel even when it benefits them.

COSTS AND BENEFITS OF NEW YORK CITY'S ELECTRICITY INFRASTRUCTURE

Michael Bobker noted the importance of focusing on electricity infrastructure reform in New York City because it is a traditionally carbon-intensive sector and an infection point for cascading disasters due to extreme events like storms or heat waves. More resilient systems need to be put into place to ensure that electricity is reliably available even when parts of the infrastructure go down.

As the New York City electricity infrastructure system ages, replacement opportunities existfor new low-carbon and resilient technology installation that include more distributed power, renewable resources, and electricity-powered vehicles. Distributed resources would include more on-site power generation, which is associated with higher efficiency and lower carbon footprint since not as much of the energy is lost through transmission over long distances. Moreover, wind resources connected by new transmission lines and battery storage would help to improve both emissions reductions and enhance reliability of the system during shocks and disturbances.

Currently, the value of New York City's electricity infrastructure is estimated at:

- $37 billion USD – Distribution network within the city
- $20 billion USD – Generation assets (valued at approximately $1.5 Million USD per Megawatt)
- $25 billion USD – Transmission lines into the city

Electricity infrastructure system planners in the city are currently aiming to implement a 1000-3000 Megawatt of electricity generation capacity (i.e. $3 million-$5 million USD per Megawatt with a total cost of $3 billion-$15 billion USD ($5 billion to $10 billion USD probable). Because of the high cost, there needs to be a cost-competitive alternative and there is great potential for green, renewable electricity infrastructure investments, new players, and distributional pathways to transform the current electricity infrastructure to become more sustainable.. One of the barriers is that when no one drives the investments (i.e., if left to local and regional

utilities) decision-makers tend to wait on each other to see who will make the first move. This lack of leadership tends to reduce the volume of change and transformation possible in the investments. Another barrier to transformative electricity distribution infrastructure can be technical. For example, in South Brooklyn there have been technical barriers to creating a community-level power sourcing project and micro-grid at the abandoned Pfizer Pharmaceuticals plant.

However, the opportunity for greater distributed generation of electricity is large. Co-ops have played a crucial role in transformations in various cases (e.g., ownership of municipal utilities in Sacramento, California and Cleveland, Ohio. In some cases, small cities are successfully developing projects such as total energy plants. For larger cities, the same types of distributed energy systems successful in test cases in small cities are not always applicable. Workshop participants noted that one of the reasons why Europe has been able to produce successful pilots of distributed energy infrastructure is that smaller cities there have greater capacity to develop and implement these types of projects. At the building scale or sub-station level, there are opportunities to begin to transform the system even in larger cities such as New York, as is the case with Con Edison projects in Brooklyn and Queens.

PANEL III: SOCIAL EQUITY OF INFRASTRUCTURE TRANSFORMATION

Moderator:

- ***Marta Vicarelli, University of Massachusetts – Amherst***

Panel Members:

- ***Juan Camilo Osorio, New York City Environmental Justice Alliance***
- ***Robin Leichenko, Rutgers University***
- ***Joel Towers, New School University***
- ***Chris Boone, Arizona State University***

The discussion during Panel III aimed to address the overarching question: How can it be ensured that potential changes to critical infrastructure be engaged by all parties and have comparable impact across economic, racial, and ethnic lines? Three specific questions were posed: 1) What are the best practices for ensuring social equity during transformative change? 2) What are the key data and information needs to promote social equity in the context of critical infrastructure transformation? 3) How can concerns of community vulnerability and resilience be best positioned within the transformative change of critical infrastructure?

Marta Vicarelli opened the panel by discussing social equity and infrastructure transformation in the Sustainable Development Solutions Network. She overviewed three important points for determining costs and benefits of infrastructure transformation that better explain issues of social equity and fairness—how time is defined, how populations change with time, and how spatial patterns of consumption change over time. Juan Camilo Osorio then presented an overview on different organizations and projects in the New York City area committed to increasing environmental justice. Robin Leichenko discussed how social equity and justice factor into climate change scenarios and gentrification. Then, Joel Towers and Chris Boone discussed how environmental justice relates to and can be factored into infrastructure transformations for sustainability.

INTRODUCTION

Marta Vicarelli described how the United Nations Sustainable Development Solutions Network (SDSN) has been building on ongoing municipal planning efforts with the USA Sustainable Cities Initiative (USA-SCI), a program led by Jeffrey Sachs that looks at three pilot cities in the United States—New York City, New York; San Jose, California; and Baltimore, Maryland.[13] These pilot cities in the USA-SCI are implementing city-university collaborations to help achieve the Sustainable Development Goals (SDGs) in each of the cities to be used as a model worldwide. Vicarelli explained that in many ways New York City is already far ahead as the OneNYC plans were being developed while the SDGs were being negotiated and many of the principles were built into OneNYC. At the policy level, the goal is to assess the city's strategies and identify quantifiable targets to measure progress toward the SDGs.

Vicarelli noted that one of the implicit merits built into the Sustainable Development Goals is that social issues are included from the outset. This forces thinking about social equity in ways that have traditionally been

[13] Sustainable Development Solutions Network. 2016. USA Sustainable Cities Initiative. Accessed at: http://unsdsn.org/what-we-do/solution-initiatives/usa-sustainable-cities-initiative-usa-sci/

lacking. Dealing with the "soft' issues such as the intended and unintended consequences of infrastructure investments are an important consideration for the SDGs. The history of large infrastructure development in urban areas globally highlights that these transformations have been accompanied by social winners and losers—illustrating the importance of considering equity and justice in infrastructure transformations.

Vicarelli noted that in order to better understand how issues of social equity and fairness factor into infrastructure transformations, the following three dimensions should be considered:

1. Time: Consideration of the initial (short-term) as well as the long-term costs of action must be included in cost-benefit analysis for infrastructure transformation. When considering cost-benefit analysis with regard to climate change, this means including consideration of intergenerational and intergenerational equity and fairness. Included in the analysis must be what are the most efficient ways to bring lower costs without sacrificing equity and who will be responsible for paying. Both cross-sectional and long-term equity analyses must be done.
2. Population Change: Changing populations over time also need to be considered.
3. Spatial Patterns: Spatial patterns have an impact on and are impacted by climate change. Emissions from infrastructure within the city and consumption patterns outside of the city will both contribute to how a city responds to climate change.

Infrastructural transformation can occur on different spatial and temporal scales with support from multiple levels of governance—city, regional, state, and federal administrations. In order for such transformation to be widely effective, best practices and knowledge sharing should be highlighted from cases with successful transformations to better inform the process elsewhere. More specifically, data are required to help assess the effectiveness of the proposed infrastructure transformations.

NEW YORK CITY ENVIRONMENTAL JUSTICE ORGANIZATIONS AND INFRASTRUCTURE PROJECTS

Juan Camilo Osorio discussed the New York City Environmental Justice Alliance (NYC-EJA)—a non-profit network directly connected to the mission of grassroots organizations for issues of environmental justice. Camilo Osorio said a key component of the path to resilience is a local pathway that understands the value of community-based planners. The local pathway involves communities that are directly affected by environmental burdens such as pollution, exposure to toxic substances, and sea level rise and flooding. Environmental justice work that improves resilience for all communities starts from the bottom up rather than from the top down.

One such project in New York City is the Waterfront Justice Project, which was started prior to Hurricane Sandy and has produced maps that show where waste management facilities are located in storm surge and flooding zones. Many heavily industrialized areas in the city are extremely vulnerable to storm surge and flooding and can spread exposure of pollution and toxic substances to communities who live in proximity to these sites. These communities are often-times disproportionately vulnerable due to lower incomes, historic segregation, and already-existing public health conditions. For example, the community of Red Hook in Brooklyn is located in a heavily industrialized area with the potential to spread toxic exposures during flooding events. Likewise, in the South Bronx, potential flooding exposure compounds already-disproportionate

exposure to pollutants. For example thousands of dump trucks go through this area and the community has a higher rate of chronic health conditions such as asthma. In the South Bronx, another community vulnerability is the Hunts Point food distribution center, which is located in the flood plain but was not impacted greatly during Hurricane Sandy because it was low tide in the area during the surge. However, this location points to a need to consider resilient food supply and distribution measures by the city as well. Prior to the Waterfront Justice Project, the city was not fully taking into account the exposure of these communities to climate change impacts in New York City. In these types of alreadyvulnerable communities, the importance of incorporating social equity assessments into discussions on climate change issues is crucial.

Another climate change impact that brings additional concerns for already-vulnerable communities in New York City are increased heat waves. Planning for more resilient infrastructure development must include vulnerability to heat, which is expected to increase due to climate change. Extreme heat exposure kills many more people per year than flooding or storm surge. While these climate change impacts are important, the city has been falling behind on planning infrastructure for a future with increased instances of extreme heat exposure. The New York City Department of Health has already been doing cutting- edge research on vulnerability to heat exposure, but has not focused as much on its geographic distribution. The vulnerability to heat includes a combination of different demographic, socio-economic, and age indicators. A couple of areas already thought to be vulnerable include the Black boundary in central Brooklyn and other places where utilities have trouble meeting energy demands during extreme heat days. Moreover, the Brownsville substation has been identified as an important megawatt capacity gap.

Camilo Osorio also discussed how greater collaboration is needed between environmental justice groups and labor unions. He noted that historically these groups have been on separate sides of environmental issues. However, quality-of-life factors are becoming a more critical part of discussions on how to transform infrastructures that labor has tended to defend in the past.

Workshop participants discussed how decision-making processes for infrastructure transformation need to be more inclusive and ensure that those in impacted communities have input throughout the entire process. Many energy projects, for example, may bring increased resiliency but may also bring increased pollution to the areas in which they are located. To deal with this, equity considerations need to be built into projects from the beginning. Additionally, the community can be trained to occupy jobs in community energy projects to foster local ownership or co-ownership of such entities. Financial mechanisms for energy infrastructure projects also need to address equity questions. Reforms encourage co-owning of infrastructure by multiple investors. Community participation may also take the form of owning of shares in energy projects. People in New York City Public Housing Association housing, for example, could own a share of the potential energy-producing infrastructure on their building in exchange for the services.

CLIMATE CHANGE, SOCIAL AND ENVIRONMENTAL JUSTICE, AND GENTRIFICATION

Robin Leichenko discussed social equity and infrastructure transformation, noting how climate change involves equity considerations. Leichenko noted that we often think of climate change as a global issue (as it

is) but that impacts of climate change on the adaptive capacity of communities and local populations need to be assessed. Thus, the impacts of climate change need to be assessed at different scales. Vulnerability is about exposure, but it also involves the adaptive capacity of individuals and communities and how they are able to respond to crisis and shocks. After Hurricane Sandy, for instance, in coastal New Jersey, some homeowners were able to recover after the event. However, many low and medium- income households could not afford to rebound after the flooding as available resources and insurance payments were not enough to cover the costs incurred from the storm's damages. Strategies need to be developed that help to make the resources available for disaster recovery more equitable.

Leichenko emphasized that every regulation and new technology has an equity implication. She asked workshop participants to consider whether it is even possible to solve climate change or increase sustainability without addressing the inequalities that underlie society. Green gentrification, for example, has been a problematic concern for some areas of New York City where improvements in infrastructure and environment led to higher property values and displacement of the pre-existing communities. Just because an improvement is "green" or environmentally friendly does not necessarily mean it is socially equitable. Equity, therefore, is an important factor in considering the impacts on communities of improvements in green space and infrastructure—these transformations need to occur forthe benefit of local communities rather than displacing them. Environmental justice groups have an important part to play in advocating for communities to reduce social vulnerability and improve resiliency. Moreover, infrastructure transformation projects should include plans for members in vulnerable communities to be able to afford renewable resources when new infrastructure isdeveloped. An equitable plan for vulnerable communities must include community sustainability and coastal protection so that people do not have to choose between the two.

Climate justice is framed by social justice and environmental justice. While more just buildings and institutions can be constructed, individuals and communities must also be able to use them in a resourceful manner. Therefore, environmental justice is best viewed from an instrumentalist perspective. Ecosystem services can be used to improve environmental justice through green infrastructure implementation. By starting from the perspective of social justice and consideration of vulnerable communities and then combining with environmental justice concerns, infrastructure transformation can be most effectively achieved. For example, when data are needed, communities can be involved from the beginning in the data gathering process—this participatory approach can be used in the implementation of projectsthrough each stage of the transformative process.

ENVIRONMENTAL JUSTICE AND GREEN INFRASTRUCTURE TRANSFORMATIONS

Joel Towers discussed how infrastructure has historically both in design and in implementation happened *to* people and communities rather than *with* them. He noted that infrastructure development projects are often difficult to do in an inclusive manner. Inclusiveness is especially challenging from a social justice perspective for low-income communities. Environmental justice and urban climate change problems being faced in New York City are often intertwinted. Infrastructure is an ongoing challenge for the city as the infrastructure is aging compared to developing nations who are currently building new transportation and other urban systems

(such as China). There is simply not enough financing available to replace all the aging infrastructure in New York City.

Towers also highlighted that the word infrastructure can be a challenge because it encompasses so many different systems in the city. Hard infrastructure includes water tunnels, roads, and bridges. However, soft infrastructure systems are also important such as zoning and building codes. Likewise, financial regulation is one of the most important types of soft infrastructure. There needs to be work on both hard and soft infrastructure systems. Zoning and building codes, for example, impact the affordability of homes for low-income communities and vulnerable people. Under such circumstances, social justice needs to be a consideration and transformation of soft infrastructure essential to addressing the process of gentrification.

Accounting plays a critical role in ensuring that social and environmental justice is achieved. Both consumption-based accounting and production-based accounting are crucial to these justice issues. Some view consumption-based accounting as more important than production-based accounting.

As discussed earlier in the workshop, green infrastructure development and environmental cleanup can sometimes result in a paradox where market forces are leveraged to clean up vulnerable areas and then serves as a driver of gentrification and dislocation of the vulnerable communities that live in the area of redevelopment. Historically, infrastructure development in the city has resulted in the poor being displaced. Strategies must be put in place to ensure that as infrastructure is improved in the city, it does not lead to the mass dislocation of low-income populations. At the transformation level that takes into account 1.5°C warming, gentrification is likely to occur as vulnerable areas of the city undergo green infrastructure development. Therefore, the challenge is to develop pathways for community collaboration so that low-income populations can take ownership and be involved in the process.

Chris Boone noted that the *process* of infrastructure transformation needs to be observed and recorded, not just the outcomes. He reiterated the importance of incorporating thoughts and wishes of local communities throughout the entire process and also highlighted how local knowledge of the people should not be a wasted resource. Boone also noted how infrastructure planning tends to create path dependencies so having ecosystem services considered and communities along the way can create pathways to achieve environmental justice. The top priority in infrastructure transformation should be the livelihoods of the most vulnerable; this will lead to a more robust process that will benefit the entire community. Regarding data collection during the process of infrastructure transformation, Boone also recognized the value of having community members involved in collecting data, but also noted that people often have time constraints. During the discussion, it was also brought up that experts should be involved with coordination of data collection and that costs associated with participatory research can be high.

Participants also discussed how one of the biggest challenges for equitable and just infrastructure transformation relates to the financing and political will needed to successfully develop new projects. The political will that exists in the city needs to be channeled into figuring out how to finance these transformations. Many of the cost-benefit analyses of long-term (e.g., 100 years) of infrastructure transformation take into

account climate change and justice, but there is not even clarity on where the next 10 years of funding will come from. Towers noted that climate change poses enormous risks for the global financial system and that losing value on stranded assets will have an impact on local communities. Alternatives include repurposing the buyout of utilities to something society wants and socialization of the costs for renewable energy development.

WORKSHOP DISCUSSION

- Participants discussed what the best time is for engagement with communities during infrastructure transformation processes, such as new energy development projects, and agreed engagement needs to occur 'early and often', and not after all the different parts of the plan have already fallen into place.
- Issues were highlighted by participants concerning when the broader public in the city begins to switch to more heavy reliance on solar. If many people began to disconnect from Con Edison to switch to individual solar-generating capacity, prices will go up on electricity provided from Con Edison, potentially costing the most for the most-vulnerable communities with lower incomes and lack of access to the resources to invest in solar.
    - Participants noted that it is critical to determine how systems can be put into place to help subsidize energy costs for individuals still connected to Con Edison.
    - It was also noted that while utilities are private, they are highly regulated, and thus, they must respond to social goals—including a transition to low-carbon alternatives in the future.
- In cases where current infrastructure systems are failing, emergence of middle levels of infrastructure have filled the gap.. For example, in cities where there is lack of funding for and political action on public transportation development, private companies like Uber and Lyft in California have rapidly developed to bridge the gap.
- Discussion also explored public-private zones in the city. For example, sidewalks in the city are publicly used but individually maintained. Workshop participants suggested that green roofscapes should be seen as a similar type of public-private space, recognizing that roofs are private property but that they can also be used as a public good.
- Participants also discussed how the shift toward a focus on consumption versus production is a challenge because there needs to be inclusion of both aspects when considering issues of equity and infrastructure transformation. Focusing only on consumption highlights the individual scale rather than the broader problems of GHG emissions associated with the production methods used. The things individuals and communities want to consume should be produced in a more sustainable way that does not externalize costs.
- Infrastructure is deeply embedded in the generation of livelihoods throughout the city, and participants noted that infrastructure development is a highly political process. Yet, many fail to recognize the political nature of the process of infrastructure development. Studying the discourse through which infrastructure is produced highlights the political interests involved in the process.

- Participants also highlighted that population density, while desirable from a sustainability perspective, needs to be planned in a socially equitable way. For example, high density based on slum-like conditions might have a better carbon footprint but is not socially equitable or acceptable.
- Focusing on resilient households as well as on resilient communities may be another beneficial scale to study and target in order to better achieve sustainability and resilience more broadly.

WORKSHOP RECOMMENDATIONS AND CONCLUSIONS

Cynthia Rosenzweig, NASA/GISS and Columbia University
Peter Marcotullio, Hunter College – City University of New York
William Solecki, Hunter College – City University of New York

The workshop co-organizers asked the workshop participants to review the objectives of the workshop and suggest actions and strategies to achieve them.

OVERALL OBJECTIVE

The overall objective of this workshop was to review and assess possible pathways for the *transformation* of New York City's critical infrastructure for sustainability.

Workshop participants developed a guiding vision for future infrastructure transformation pathways in New York City to include the following:

- Do no harm
- Include full accounting of all costs and benefits to avoid conflict
- Guide social investments to reinvest in assets and market new technologies
- Foster political will
- Improve communication of new technologies and opportunities
- Adhere to environmental and ethical principles
- Recognize the multiple benefits/co-benefits of new infrastructure
- Collaborate across boundaries
- Implement climate mitigation and adaptation simultaneously from the beginning of and throughout the transformation process

OBJECTIVE 1: IDENTIFY CRITICAL INFRASTRUCTURE SYSTEMS AND NEEDS FOR NEW YORK CITY

Workshop participants proposed the following summary messages in response to Objective 1:

- Various levels of government (e.g., city, state, and federal) need to be fully coordinated and share information and responsibility. The appropriate level of governance should be identified for each type of infrastructure so that initiatives can be spearheaded by the level of government that can most effectively institute the appropriate transformation of that infrastructure.
- Regional governance of each infrastructure system (i.e., fresh water, electricity production and transmission, and transportation) could benefit from sector-specific governance teams.
- From the beginning of infrastructure development projects, the end use needs to be a focus.
- Solid waste management should incorporate adaptive reuse to achieve a 90% reduction in the waste generated in the city.

- Urban density needs to be addressed with a broad top-down and bottom-up framework that promotes socially equitable density and greater public transportation options.

OBJECTIVE 2: SCOPE SOLUTIONS TO THE NEEDS AND ESTIMATE THE COSTS OF TRANSFORMATION TO SUSTAINABILITY

Workshop participants proposed the following summary messages in response to Objective 2:

- Mechanisms are needed to price both positive and negative externalities to more fully include all considerations in the cost-benefit analysis of infrastructure development projects.
- A green banking system in a similar set up to that in Copenhagen, Denmark can be used as a model forinstitutional financing of sustainable projects.
- In dealing with the short-term period for infrastructure development, the following should be done:

  Develop clear time scales for infrastructural development and investments: make shorter-term goals, medium-term goals, and longer-term goals (e.g., goals for 2025, 2030, 2050, etc.)

  - Reduce demand by having people assess their own behaviors and better understand the impacts of their behaviors. Individual behavior change could greatly curtail consumption patterns.
- Develop stronger market signals for long-term investments in infrastructure transformation.
- Implement a carbon tax to finance infrastructure transformations as has been done by British Columbia.
- Issue climate bonds to finance infrastructure transformations similar to how the Metropolitan Transportation Authority issues bonds. Education will be needed to inform the bond market on net negative carbon bonds.
- Programs should be put in place for vulnerable communities when transitions are occurring. Community leaders should be involved in the decision-making and accounting processes.
- Labor should be included in the infrastructure transformation (e.g. retrain former coal industry workers in new energy infrastructure job opportunities and systems).
- External auditing is needed since this is often self-reported and may result in inflated costs.
- Measurement and data collection need to be done on climate hazards avoided due to the implementation of new infrastructures.

OBJECTIVE 3: DEFINE THE SOCIAL EQUITY AND HEALTH ISSUES OFTRANSFORMATION

Workshop participants proposed the following summary messages in response to Objective 3:

- Both benefits and costs, including social costs, need to be addressed. The situation where widespread benefits are present but with significant externalities affecting certain populations must be avoided.
- Cost-benefit analysis needs to be conducted that includes intergenerational equity. A net-present value does not provide much information about distribution of benefits and costs in the future.
- Social equity needs to be a factor in all infrastructure transformation projects.

- Underlying vulnerabilities need to be addressed in communities when infrastructure projects are being discussed, designed, and implemented.
- Positive and negative externalities and the communities the benefit/harm need to be day-lighted.
- Compensation should be an option for vulnerable communities.
- Fair-share distribution of externalities should be promoted.

CONCLUDING THOUGHTS

The workshop concluded with participants bringing forward the following final thoughts:

- Sea level rise may increase more than what has already been discussed. In this case, transitions in coastal zones should consider moving communities out of the flood zone.
- Transformation in transportation infrastructure or in electricity infrastructure such as renewables will not necessarily result in encouraging the widespread use of adoption of these new technologies. Therefore, governance and government will play a crucial role in these transformations.
- As New York City often serves as an example for other cities, strategies for infrastructural transformation need to be well planned prior to implementation so as to enable New York to continue to play a leadership role.
- Sustainable infrastructure transformation should be multi-purpose, that is they should have multiple goals they achieve at the same time (e.g., increasing resiliency, decreasing emissions, improving social equity, etc.)
- Solutions need to be scalable for adoption in the private sector as well as the public sector.
- Individual behavior changes and reduction in consumption should occur at a level such that everyone is consuming less and not just select groups.
- Finally, the message for a sustainable future needs to be positive to achieve the best results.