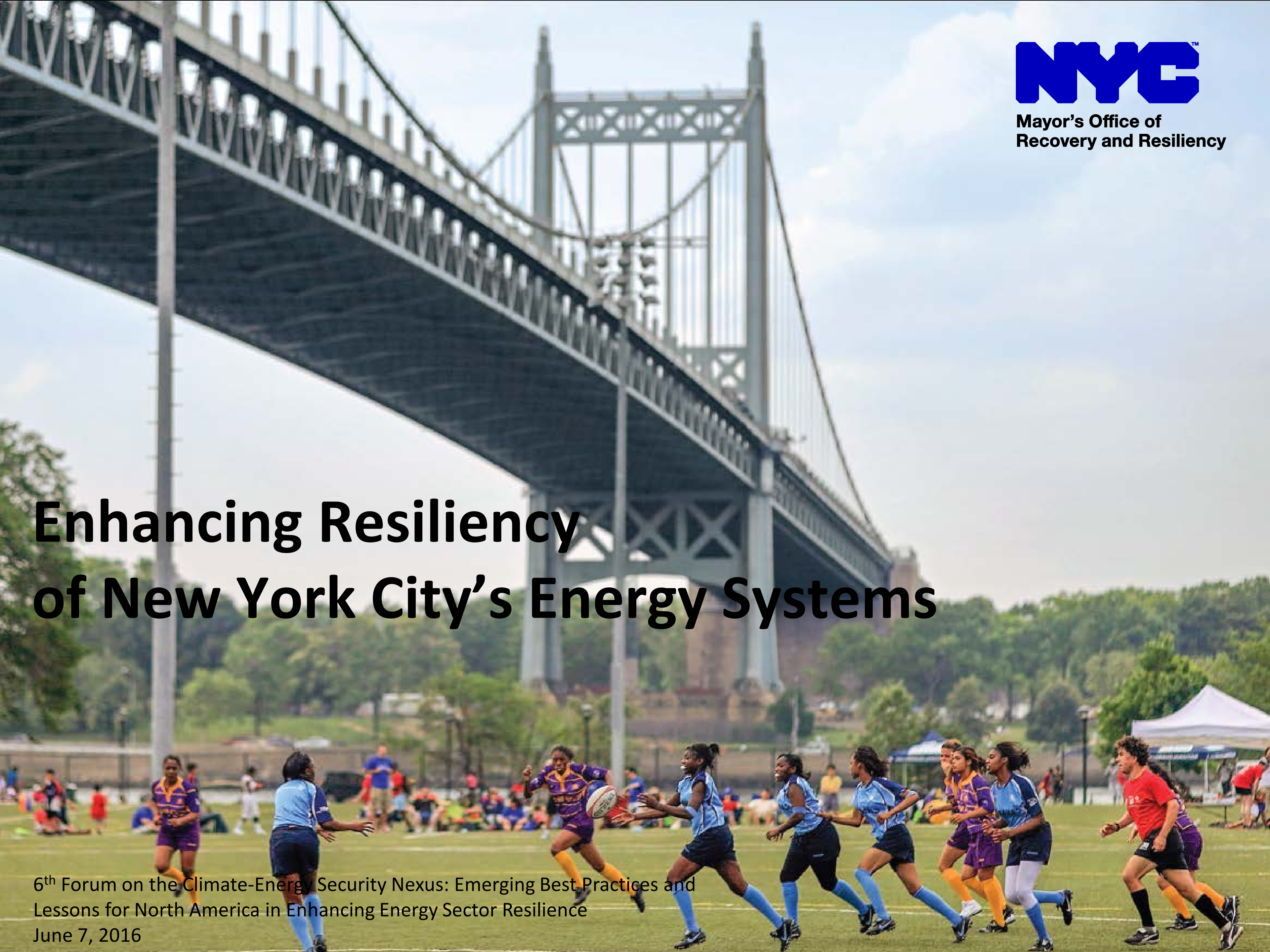


Mayor's Office of Recovery and Resiliency

Enhancing Resiliency of New York City's Energy Systems

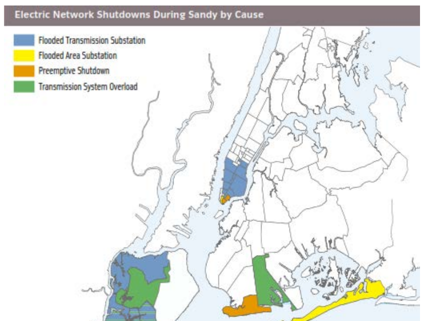
6th Forum on the Climate-Energy Security Nexus: Emerging Best Practices and Lessons for North America in Enhancing Energy Sector Resilience
June 7, 2016

Energy System Disruptions

Recent events such as Hurricane Sandy and Hurricane Irene caused significant disruptions to the region's energy systems

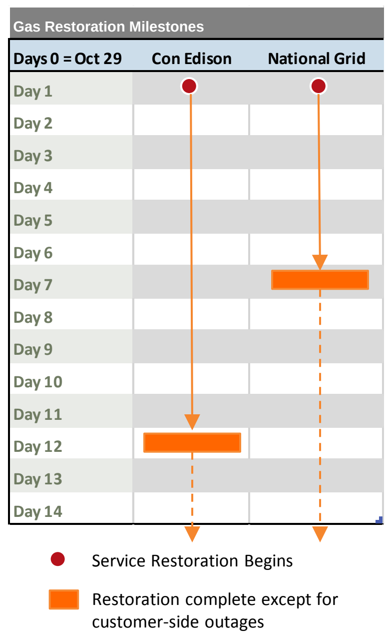
Sandy had significant and diverse impacts across New York City's…

Electric Network

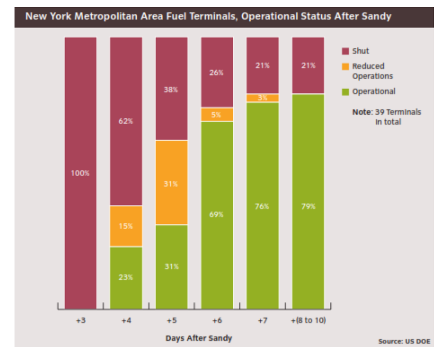


Utility workers pumping water out of underground electric vaults post-Sandy

Natural Gas Distribution



Liquid Fuels Supply



Lines form outside of a gas station in Sunnyside, Queens after Sandy.

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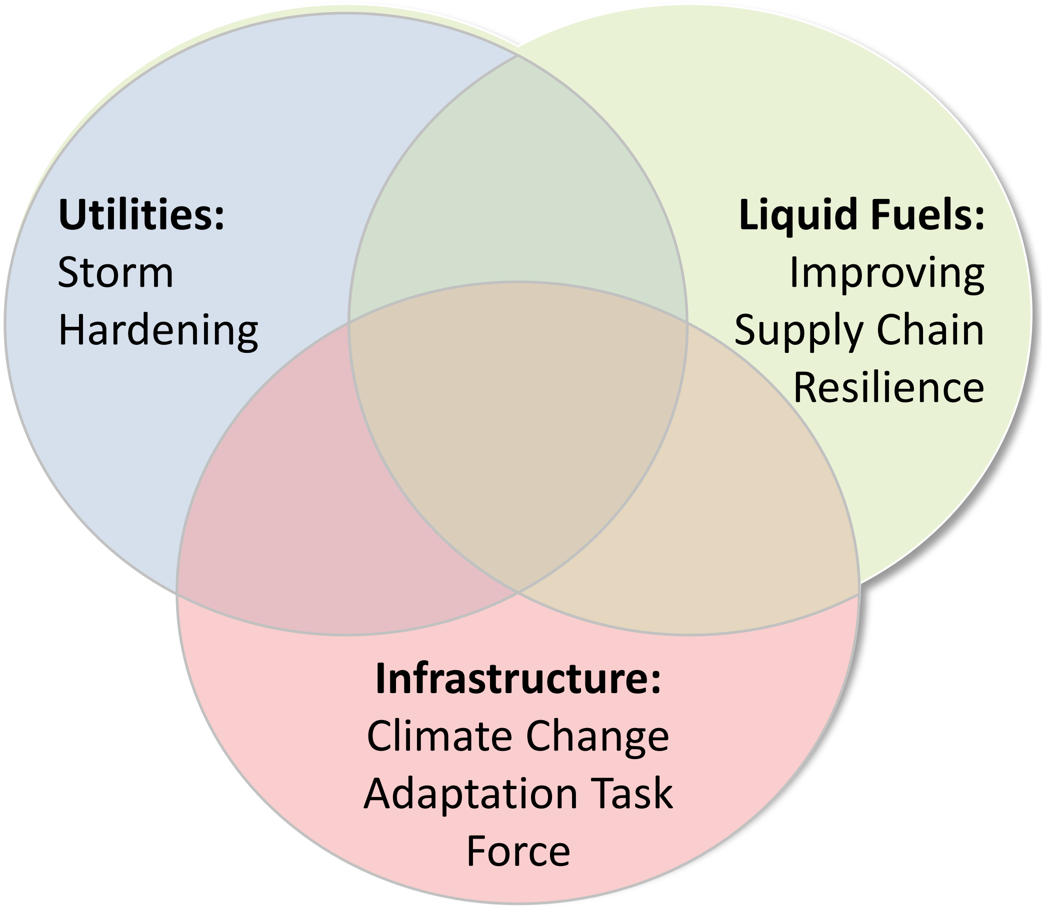
Energy System Resiliency Efforts Overview

Prior to and since Sandy, NYC has coordinated and led various energy system resiliency efforts



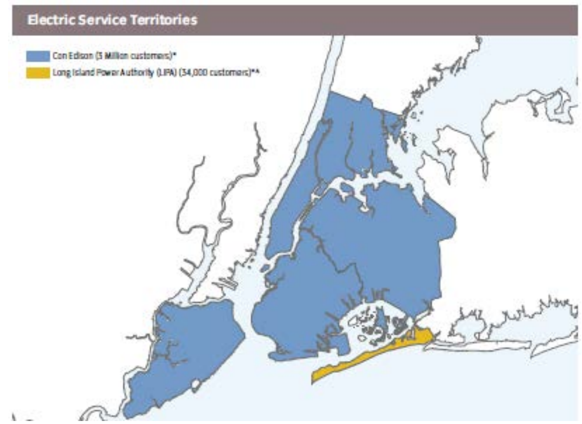
Utilities: Con Edison Overview

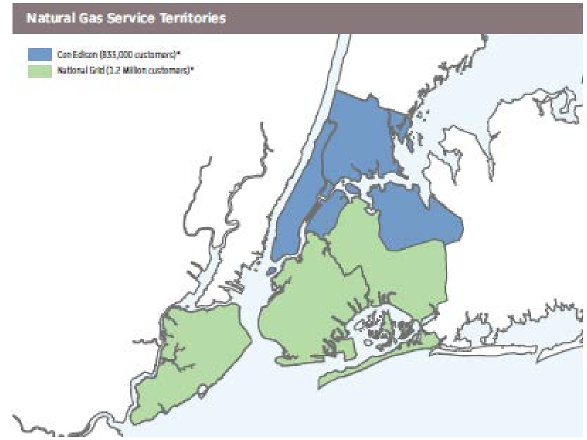
Con Edison is a private, investor-owned utility that provides electric, gas and steam services to all or a large portion of NYC residents

Electric Distribution:
- Serves over 3 million customers[1]
- 85% underground mesh system; 15% overhead loop / radial

Gas Distribution
- Serves over 1.1 million customers[1]
- High pressure and low pressure systems

Steam Generation & Distribution:
- Serves over 1,700 buildings in Manhattan





1 Customer numbers are based off of meters. Many multi=family residential buildings are Con Edison master-metered then sub-metered

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Utilities: Storm Hardening Collaborative

The Collaborative is a stakeholder-based process to guide and inform Con Edison's thinking and prioritization of resiliency investments and climate risks

Con Edison Collaborative Timeframe: 2013-2016

Total expenditure: ~$1 billion USD

Key outputs:

- Agreed-upon investments in electric, gas, steam and telecom projects
- Risk and asset prioritization model informed by a societal CBA
- Flood protection standard of FEMA 100-year floodplain + 3' feet
- Commitment to in-depth climate change vulnerability study

Utilities: Con Ed Storm Hardening Projects

Investments focused on minimizing and mitigating the effects of flooding, surge and wind to critical equipment and supporting a fast, flexible system recovery

	Project Areas
Electric	• Coastal network (e.g., submersible equipment, sectionalizing) • Overhead distribution (e.g., reduce feeder segment size) • Substations (e.g., floodproof and/or elevate critical equipment) • Transmission system reinforcement (e.g., upgrade towers)
Gas	• Distribution system (e.g., LPP replacement) • Tunnel Reinforcement • LNG Plant Hardening
Steam	• Generating stations • Steam distribution
Telecom	• Harden Radio Sites • Extension of CCTN (enables secure SCADA, voice and video) • Elevation of telecom equipment

Utilities: Adapting the Collaborative Model

Work is under way to commence similar Collaborative efforts with the remaining NYC-area utilities

Liquid Fuels: Sandy's Impacts

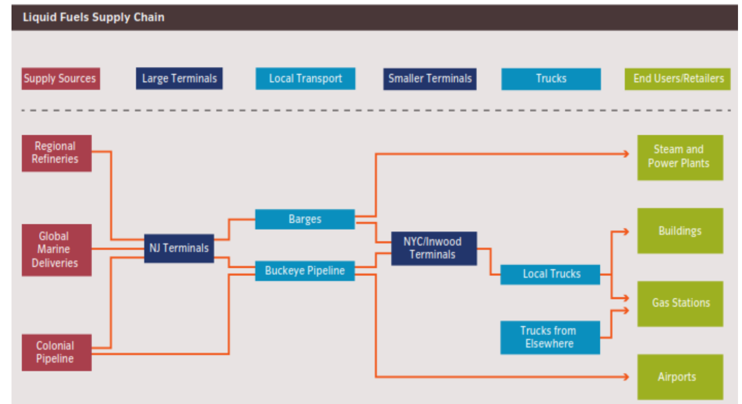
Hurricane Sandy disrupted all major components of the regional fuel supply chain

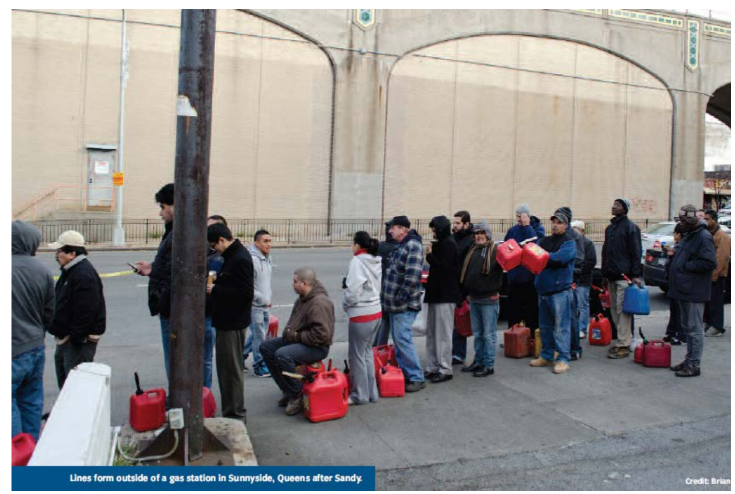
Sandy's Impacts on the Liquid Fuel Supply Chain

- Refineries
- Pipelines
- Port and waterways
- Terminals
- Gas Stations

Lessons Learned

- Regional nature of the fuel supply chain: critical components may be outside local jurisdiction
- While the supply chain is flexible and resilient, there exist critical nodes.
- Liquid fuel distribution is highly dependent on electric power supply




Lines form outside of a gas station in Sunnyside, Queens after Sandy.

Credit: Brian

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Liquid Fuels: Resiliency Initiatives

Initiatives address priority areas that were identified by stakeholders post-Hurricane Sandy

Key NYC Initiatives

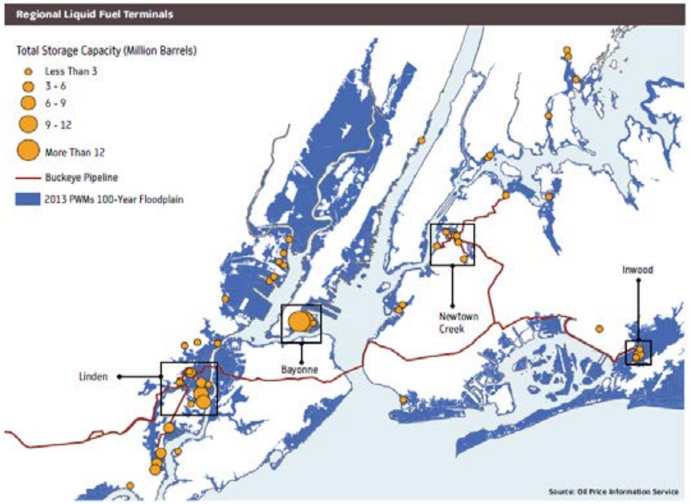
- Assess key fuel terminals for climate vulnerability (with NYS)
- Develop a communications protocol to enhance situational awareness
- Develop City emergency fuel plan

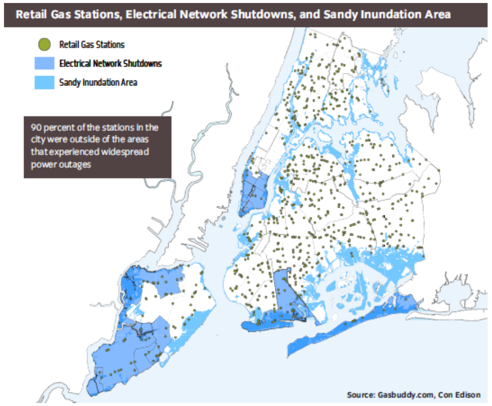
Key State Initiatives

- Provide backup generators to critical gas stations
- Establish State reserve

Key Federal Initiatives

- Establish Federal reserve





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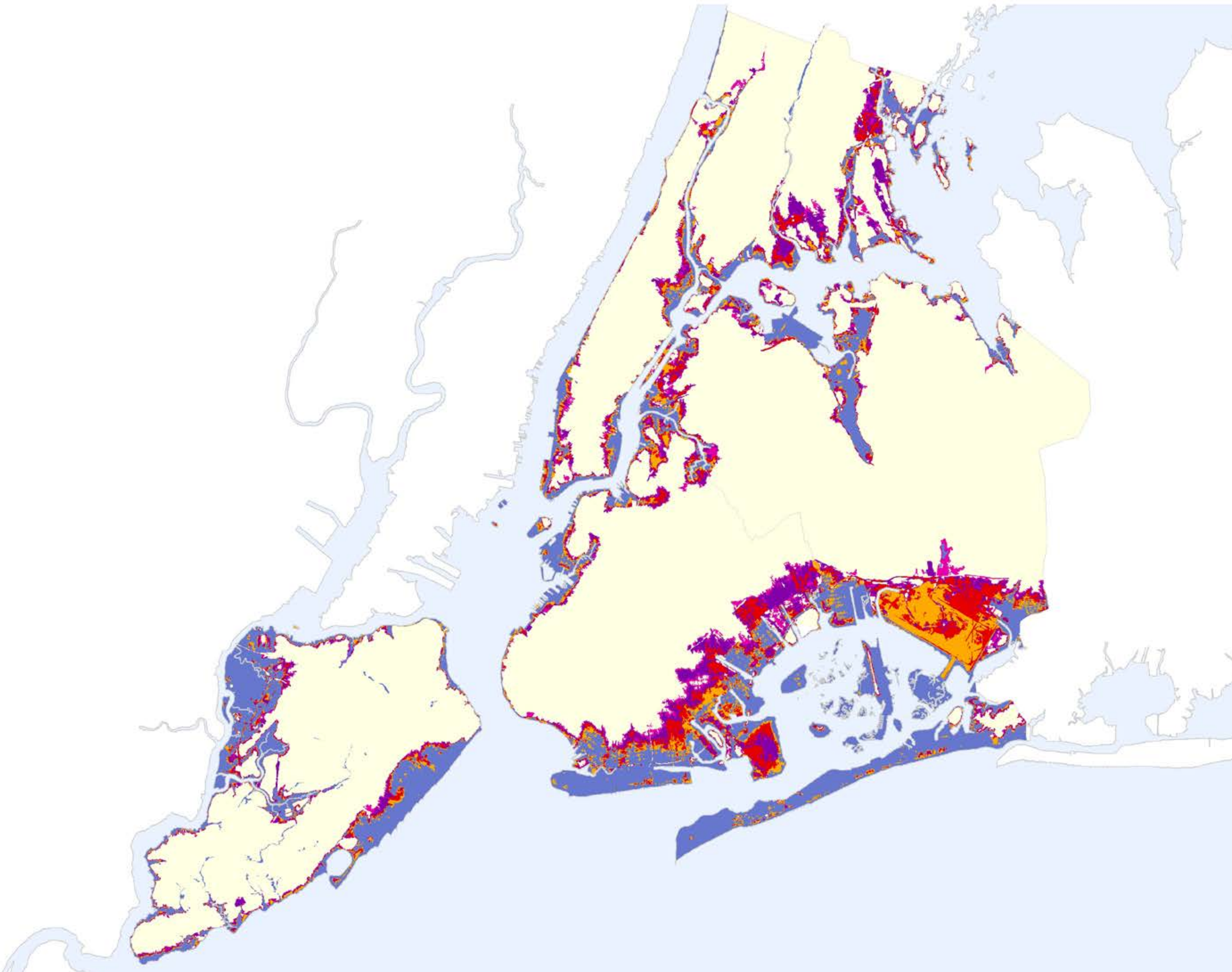
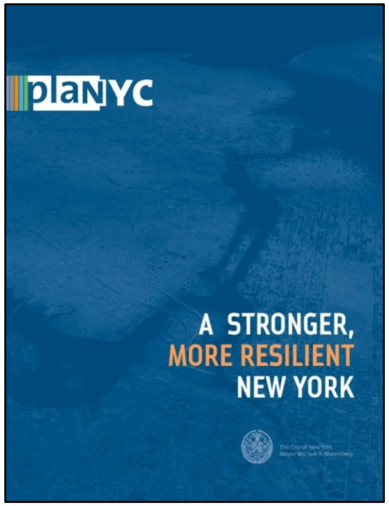


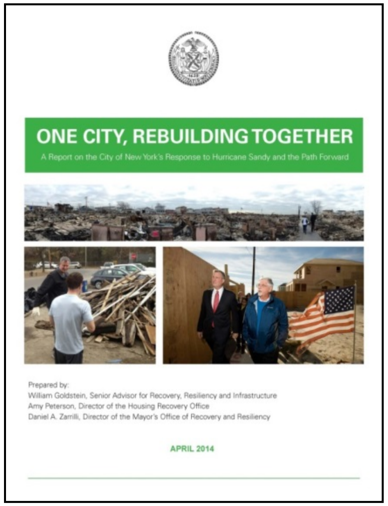
Climate Change Adaptation Task Force

The CCATF was first established in 2008 and helped our Sandy recovery

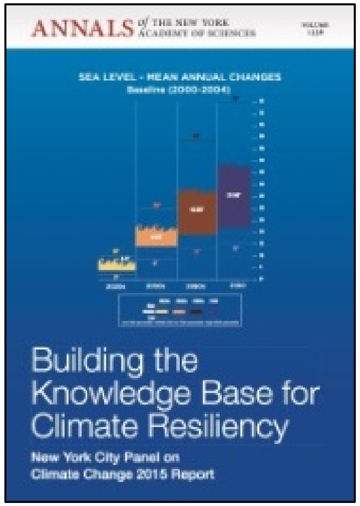
2007 & 2011



2013



2014



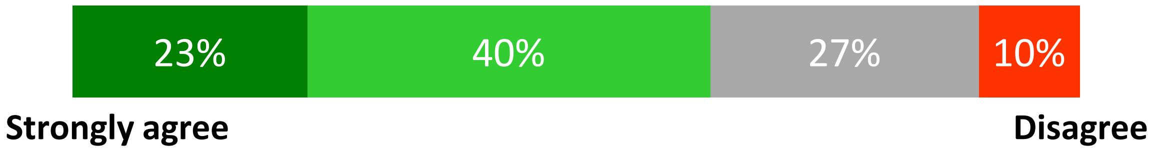
2015

CCATF **CCATF** **CCATF**

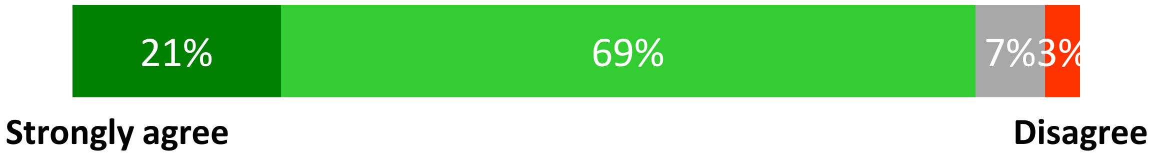
CCATF: Reconvened in June 2015

Informal survey results point to planning and progress since Sandy…

Have a clear resiliency plan in place.



Made significant progress in resiliency/ climate adaptation since Sandy.

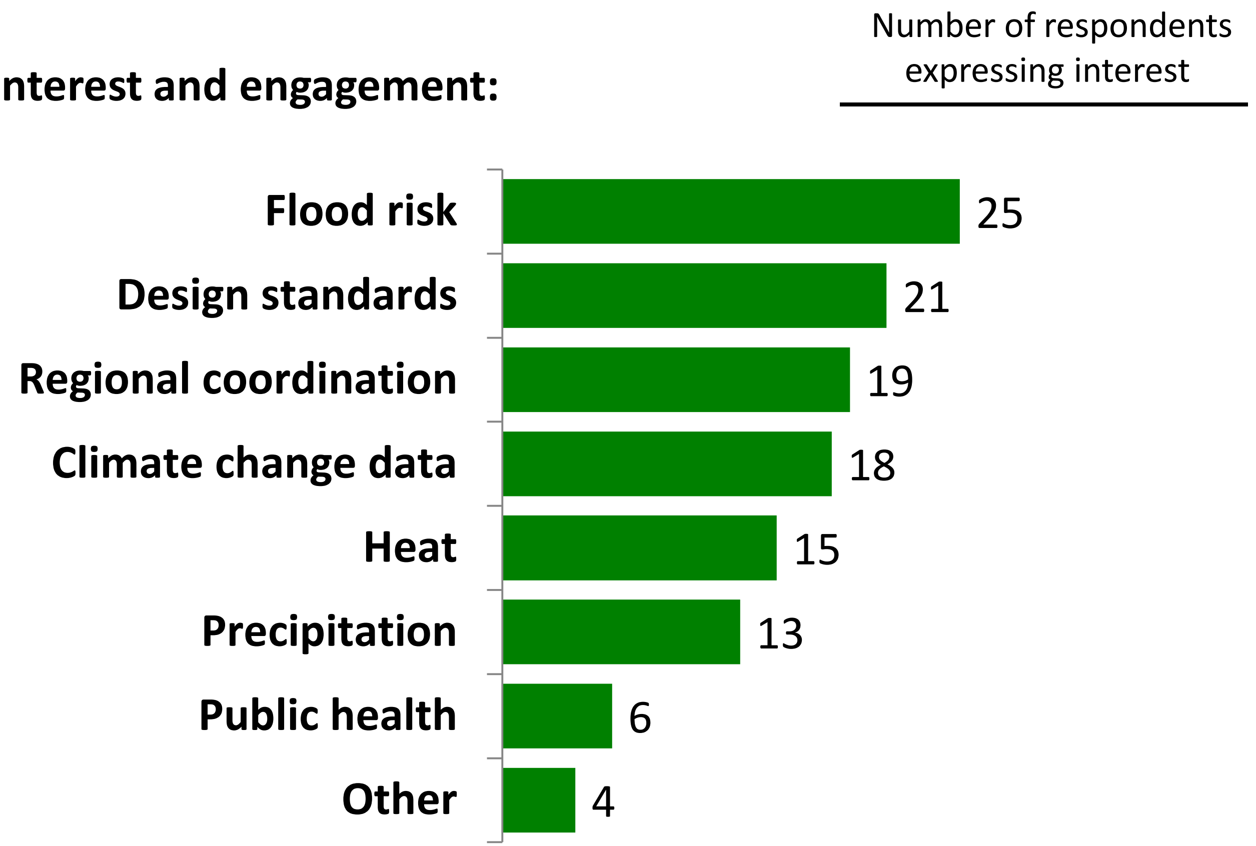


Based on 30 and 29 respondents, respectively.

CCATF: Reconvened in June 2015

… and a desire to engage on a number of topics.

Topics of interest and engagement:



Note: Results based on 27 respondents.

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CCATF: Overview

Stakeholders are divided into working groups to assess and adapt to climate risks across sectors

Scientific Advisory Panels

New York City Panel on Climate Change

60 Stakeholders

- City Agencies
- State Agencies
- Federal Agencies
- Private Sector

Working Groups

- Energy
- Telecom
- Transportation
- Water and Waste
- Parks
- Buildings

Key Activities

- Review climate projections
- Create inventory of at-risk infrastructure
- Develop and coordinate adaptation strategies
- Evaluate design guidelines for critical infrastructure

Outputs

- Updated and expanded asset inventories and assessments
- Design Standards Framework
- Repository of Resilience Guidelines
- Public report

CCATF: Objectives

CCATF objectives are codified in Local Law 42, which passed in 2012.

2012 Local Law 42:

- Identify critical infrastructure in New York City that could be at-risk from the effects of climate change
- Facilitate knowledge sharing and develop coordinated adaptation strategies to secure these assets
- Develop a report with findings and recommendations

July 2015 update:

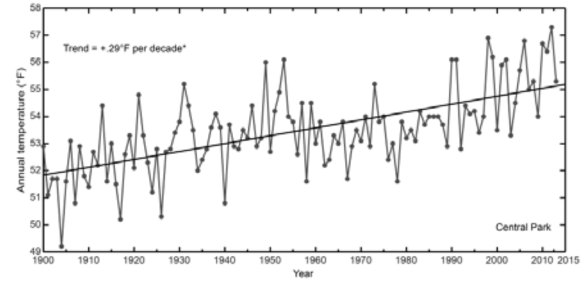
- Adds telecommunications as sector of interest

CCATF: Observed Climate Trends (1900-2013)

NYC has already observed sustained changes to climate over the past 100 years

Temperature*

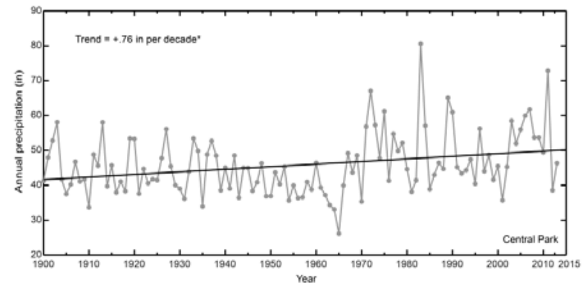
Mean **annual temperature** has **increased** at a rate of **0.3°F per decade** (total of 3.4°F).



Precipitation*

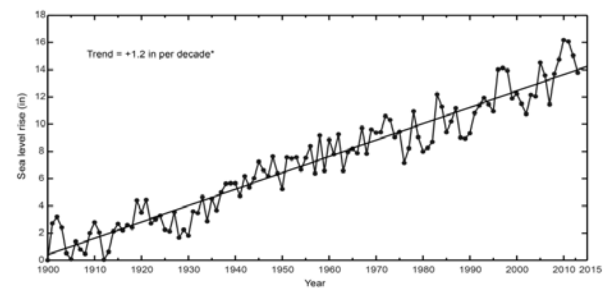
Mean **annual precipitation** has **increased ~0.8 inches per decade** (total of 8 inches).

Year-to-year (and multi-year) **variability** of precipitation has become **more pronounced**, especially since the 1970s.



Sea Level

Sea level rise in New York City has averaged **1.2 inches per decade** (total of 1.1 feet), nearly twice the observed global rate over a similar time period.



Source: NPCC, 2015

* Observations made in Central Park.

Confidential

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CCATF: Phase 1

Stakeholders review climate projections for the NYC-region

Climate Variable		Projection									
		Baseline (1971-2000)	2020s (2010-2039)[2]		2050s (2040-2069)[2]		2080s (2070-2099)[2]		2100[4]	
			Middle Range[1]	High End[1]	Middle Range[1]	High End[1]	Middle Range[1]	High End[1]	Middle Range[1]	High End[1]
Average Temperature[5]		54°F	+2.0 to 2.9 °F	+3.2 °F	+4.1 to 5.7 °F	+6.6 °F	+5.3 to 8.8 °F	+10.3 °F	+5.8 to 10.4 °F	+12.1 °F
Heat Waves and Hot Days[5]	Number of days per year with maximum temperature at or above 90° F	18	26 to 31	33	39 to 52	57	44 to 76	87	-	-
	Number of heat waves/year	2	3 to 4	4	5 to 7	7	6 to 9	9	-	-
	Average duration (days)	4	5	5	5 to 6	6	5 to 7	8	-	-
Precipitation and Inland Flooding[5]	Annual Precipitation	50.1 in.	+1 to 8%	+10%	+4 to 11%	+13%	+5 to 13%	+19%	-1 to +19%	+25%
	Days per year with rainfall exceeding 2 inches	34	3 to 4	5	4	5	4 to 5	5	-	-
		Baseline (2000-2004)	2020s (2020-2029)[3]		2050s (2050-2059)[3]		2080s (2080-2089)[3]		2100[4]	
			Middle Range[1]	High End[1]	Middle Range[1]	High End[1]	Middle Range[1]	High End[1]	Middle Range[1]	High End[1]
Sea Level Rise[5]		0	+4 to 8 in.	+10 in.	+11 to 21 in.	+30 in.	+18 to 39 in.	+58 in.	+22 to 50 in.	+75 in.
		Baseline	2020s (2020-2029)[3]		2050s (2050-2059)[3]		2080s (2080-2089)[3]		2100	
			Middle Range[1]	High End[1]	Middle Range[1]	High End[1]	Middle Range[1]	High End[1]	Middle Range[1]	High End[1]
Coastal Flooding[5] (Storm Surge with Sea Level Rise)	Future annual frequency of today's 100-year flood	1%	1.1 to 1.4%	1.5%	1.6 to 2.4%	3.6%	2 to 5.4%	12.7%	-	-
	Flood heights (feet) associated with 100-year flood (NAVD88)	11.3	11.6 to 12.0	12.1	12.2 to 13.1	13.8	12.8 to 14.6	16.1	-	-
			Spatial Scale of Projection		Direction of Change by the 2080s			Likelihood		
Extreme Hurricane Winds			North Atlantic Basin		Increase			More Likely Than Not (>66% Probability)		
Drought[6]			New York Metro Region		Increase			More Likely Than Not (>66% Probability)		

1) Middle Range refers to 25th to 75th percentile of model-based outcomes; High End refers to 90th percentile of model-based outcomes
2) Temperature and precipitation projections uses time slices of 10-year intervals. Time slices are centered around a given decade (for example, "the 2050s" time slice refers to the period from 2040 to 2069)
3) Sea level rise projections use time slices of 10-year intervals. Time slices are centered around a given decade (for example, "the 2050s" time slice refers to the period from 2040 to 2069). **If your asset's useful end of life falls between two timeslices, use the later projection (for example, a 2070 end of life should use the 2080s projection).** Because the rate of sea level rise is increasing with every passing decade, selecting the preceding time slice may not accurately reflect true sea level rise risks.
4) The 2100 temperature and precipitation projections do not encompass a range, but rather signify the estimated range of temperature and precipitation change in the year 2100
5) Temperature and precipitation observations are taken at Central Park; coastal flooding observations are taken at The Battery
6) Projections are for short duration droughts

Climate Projections were developed by the New York City Panel on Climate Change
For more information, see: *Building the Knowledge Base for Climate Resiliency (http://onlinelibrary.wiley.com/doi/10.1111/nyas.2015.1336.issue-1/issuetoc)*

CCATF: Phase I

Stakeholders then evaluate the risk that climate trends pose to their assets and the potential consequences of such a disruption

Category

- Infrastructure
- Social Infrastructure
- Buildings

Asset Class

- Energy
- Transportation
- Water, sewer and waste
- Telecommunications
- Parks
- Critical buildings
- Non-critical buildings

Climate Risk

- Average temperature increase
- Heat waves
- Inland flooding and precipitation
- Sea level rise
- Coastal flooding
- Extreme hurricane winds
- Cold snaps

Self Assessment

- Asset / Component Description and Location
- Potential Impact of Climate Variable over Useful Life of Asset
- Likelihood of Disruption
- Magnitude of Consequence
- Primary and Secondary Dependencies

CCATF: Initial Lessons Learned

On Process

- Trust and collaboration is essential from the beginning, and obtaining buy-in on the structure and approach of the risk assessment is important
- Clarify definitions and what you are capturing, e.g. is it the vulnerability to the asset, system, stakeholder, City?
- Strike the right balance between asset-based and a systems-based assessment

CCATF: Initial Lessons Learned

On Risk Assessment and Analysis

- Like-assets are not always assessed with the same level of risk, making an apples to apples comparison difficult.
- Limits to types and quality of information that will be shared on a voluntary basis, especially from private sector stakeholders (e.g., telecom, energy)
- Understanding what levers the City has to motivate stakeholders, in particular those over which the City does not have direct control (transport, telecom, fuels)