Planning for the Impacts of Climate Change:

an energy system perspective

Alliance/EDF workshop at Columbia University
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Agenda

Response to yesterday's speakers? A brief reflection

Climate change from multiple perspectives:

Planning for Climate Change: An Energy System Perspective

The status of climate science

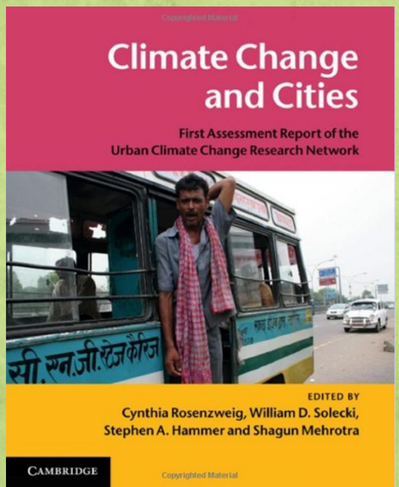
Multilateral negotiations on climate change

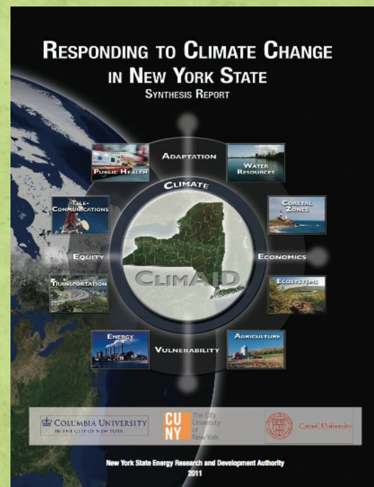
Local climate change initiatives

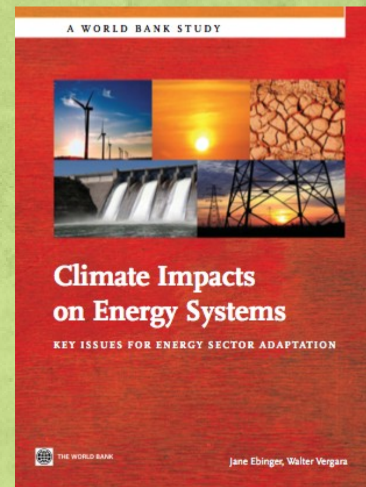
Cities at the forefront of climate action

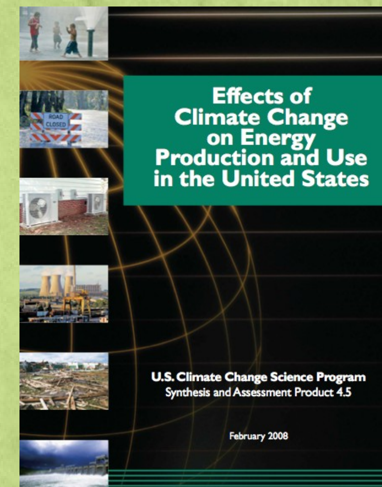
Reflecting on ye

- National Infrastructure Planning
- Environmental economics and US Politics
- Sustainable Energy & CCS
- Sustainability among the skyscrapers









Planning for the Impacts of Climate Change:

an energy system perspective

Adaptation as a new climate change imperative

Policies/regulations/programs traditionally focused on mitigation

Regardless, change is coming, so cities must assess potential climate change-related vulnerabilities and the implications for their local energy system

Urban energy systems designed to operate reliably and safely under a range of climate conditions

key is differentiating climate change from normal climate variability

Impacts will occur in both energy supply and energy demand.

Key issues

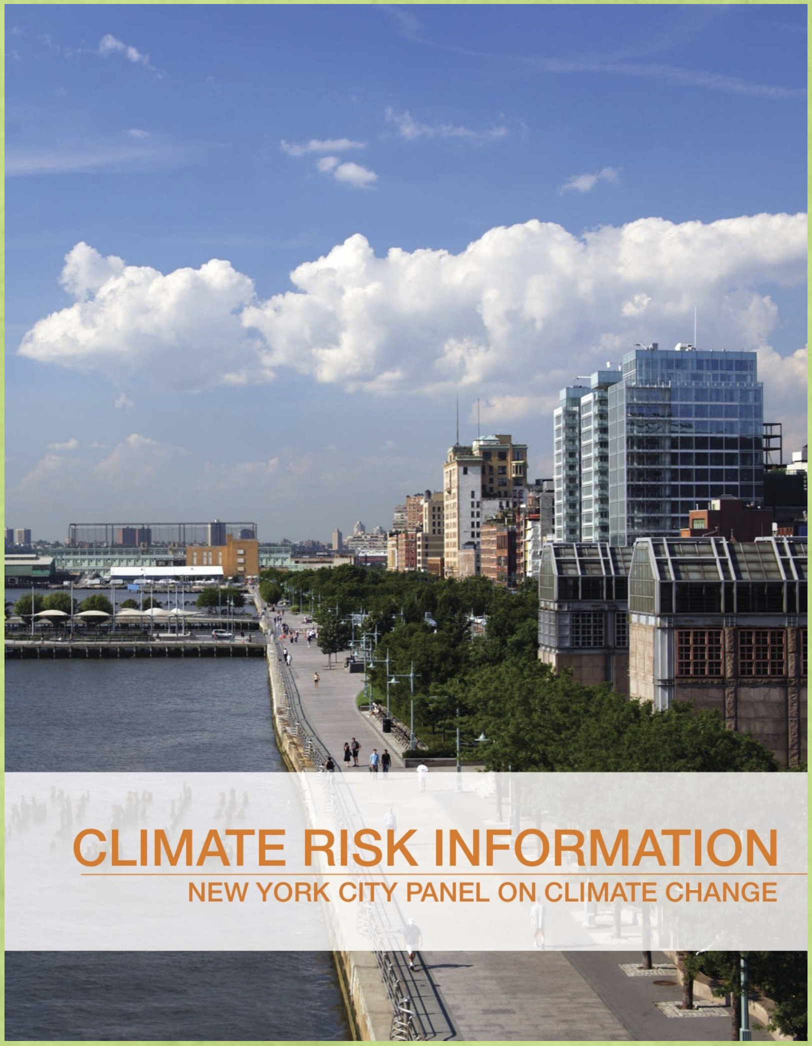
The role of science in identifying climate vulnerabilities

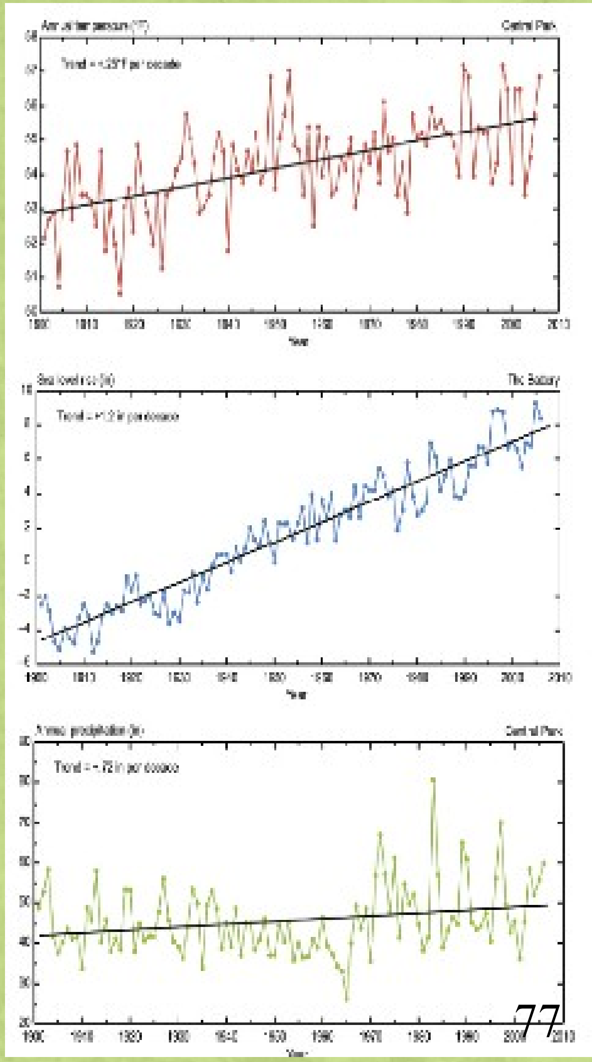
Supply vs. demand impacts

Adaptation strategies

Leadership on adaptation planning

The role of scientific assessment





Example: NYC – Baseline Climate and Mean Annual Changes

	Baseline 1971-2000	2020s	2050s	2080s
Air temperature Central range[2]	55 °F	+ 1.5 to 3 °F	+ 3 to 5 °F	+ 4 to 7.5 °F
Precipitation Central range[2]	46.5 in	+ 0 to 5 %	+ 0 to 10 %	+ 5 to 10 %
Sea level rise[3] Central range[2]	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid Ice-Melt Sea Level Rise[4]	NA	~ 5 to 10 in	~ 19 to 29 in	~ 41 to 55 in

Source: New York City Panel on Climate Change 2009

NYC – Extreme Weather Events

	Extreme Event	Baseline (1971-2000)	2020s	2050s	2080s
Heatwaves & Cold Events	# of days/year with maximum temperature exceeding:				
	90° F	14	23 to 29	29 to 45	37 to 64
	100° F	0.4[1]	0.6 to 1	1 to 4	2 to 9
	# of heat waves/year[2]	2	3 to 4	4 to 6	5 to 8
	Average duration (in days)	4	4 to 5	5 to 5	5 to 7
	# of days/year with minimum temperature below 32° F:	72	53 to 61	45 to 54	36 to 49
Intense Precipitation & Droughts	# of days per year with rainfall exceeding:				
	1 inch	13	13 to 14	13 to 15	14 to 16
	2 inches	3	3 to 4	3 to 4	4 to 4
	4 inches	0.3	0.2 to 0.4	0.3 to 0.4	0.3 to 0.5
	Drought occurs, on average[3]	~once every 100 yrs	~once every 100 to 100 yrs	~once every 50 to 100 yrs	~once every 8 to 100 yrs
Coastal Floods & Storms[4]	1-in-10 yr flood to reoccur, on average	~once every 10 yrs	~once every 8 to 10 yrs	~once every 3 to 6 yrs	~once every 1 to 3 yrs
	Flood heights associated with 1-in-10 yr flood (in feet)	6.3	6.5 to 6.8	7.0 to 7.3	7.4 to 8.2
	1-in-100 yr flood to reoccur, on average	~once every 100 yrs	~once every 65 to 80 yrs	~once every 35 to 55 yrs	~once every 15 to 35 yrs
	Flood heights associated with 1-in-100 yr flood (in feet)	8.6	8.8 to 9.0	9.2 to 9.6	9.6 to 10.5
	1 in 500-yr flood to reoccur, on average	~once every 500 yrs	~once every 380 to 450 yrs	~once every 250 to 330 yrs	~once every 120 to 250 yrs
	Flood heights associated with 1-in-500 yr flood (in feet)	10.7	10.9 to 11.2	11.4 to 11.7	11.8 to 12.6

1 Decimal places shown for values less than 1 (and for all flood heights), although this does not indicate higher precision/certainty. More generally, the high precision and narrow range shown here are due to the fact that these results are model-based. Due to multiple uncertainties, actual values and range are not known to the level of precision shown in this table.

2 Defined as three or more consecutive days with maximum temperature exceeding 90°F.

3 Based on minima of the Palmer Drought Severity Index (PDSI) over any 12 consecutive months. More information on the PDSI and the drought methods in general can be found in Appendix B.

4 Does not include the rapid ice-melt scenario.

Source:
New York City Panel on Climate Change 2009

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Climate Change impacts/risks most relevant to urban energy systems will vary from region to region (1)

Table ES.3. Energy Sector Vulnerability to Climate Change

Item	Relevant climate impacts: General	Specific	Additional	Impacts on the energy sector
Climate change impacts on resource endowment				
Hydropower	Runoff	Quantity (+/-) Seasonal flows high & low flows Extreme events	Erosion Siltation	Reduced firm energy Increased variability Increased uncertainty
Wind power	Wind field characteristics, changes in wind resource	Changes in density, wind speed Increased wind variability	Changes in vegetation (might change roughness and available wind)	Increased uncertainty
Biofuels	Crop response to climate change	Crop yield Agro-ecological zones shift	Pests Water demand Drought, frost, fires, storms	Increased uncertainty Increased frequency of extreme events
Solar power	Atmospheric transmissivity	Water content Cloudiness Cloud characteristics	Pollution/dust and humidity absorb part of the solar spectrum	Positive or negative impacts
Wave and tidal energy	Ocean climate	Wind field characteristics No effect on tides	Strong nonlinearity between wind speed and wave power	Increased uncertainty Increased frequency of extreme events
Climate change impacts on energy supply				
Hydropower	Water availability and seasonality	Water resource variability Increased uncertainty of expected energy output	Impact on the grid Wasting excessive generation Extreme events	Increased uncertainty Revision of system reliability Revision of transmission needs
Wind power	Alteration in wind speed frequency distribution	Increased uncertainty of Energy output.	Short life span reduces risk associated with Climate change Extreme events	Increased uncertainty on energy output
Biofuels	Reduced transformation efficiency	High temperatures reduce thermal generation efficiency	Extreme events	Reduced energy generated Increased uncertainty
Solar power	Reduced solar cell efficiency	Solar cell efficiency reduced by higher temperatures	Extreme events	Reduced energy generated Increased uncertainty
Thermal power plants	Generation cycle efficiency Cooling water availability	Reduced efficiency Increased water needs, for example, during heat waves	Extreme events	Reduced energy generated Increased uncertainty
Oil and gas	Vulnerable to extreme events	Cyclones, floods, erosion and siltation (coastal areas, on land)	Extreme events	Reduced energy generated Increased uncertainty

Source: World Bank 2011

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Climate Change impacts/risks most relevant to urban energy systems will vary from region to region (2)

Table ES.3 (continued)

Item	Relevant climate impacts			Impacts on the energy sector
	General	Specific	Additional	
Impacts on transmission, distribution, and transfers				
Transmission , distribution, and transfers	Increased frequency of extreme events Sea level rise	Wind and ice Landslides and flooding Coastal erosion, sea level rise	Erosion and siltation Weather conditions that prevent transport	Increased vulnerability of existing assets
Impacts on design and operations				
Siting infrastructure	Sea level rise Increased extreme events	Flooding from sea level rising, coastal erosion Increased frequency of extreme events	Water availability Permafrost melting Geomorphodynamic equilibrium	Increased vulnerability of existing assets Increased demand for new good siting locations
Downtime and system bottlenecks	Extreme weather events	Impacts on isolated infrastructure Compound impacts on multiple assets in the energy system	Energy system not fully operational when community requires it the most	Increased vulnerability Reduced reliability Increased social pressure for better performance
Energy trade	Increased vulnerability to extreme events	Cold spells and heat waves	Increased stress on transmission, distribution, and transfer infrastructure	Increased uncertainty Increased peak demand on energy system
Impacts on energy demand				
Energy use	Increased demand for indoor cooling	Reduced growth in demand for heating Increased energy use for indoor cooling	Associated efficiency reduction with increased temperature	Increased demand and peak demand, taxing transmission and distribution systems
Other impacts				
Cross-sector impacts	Competition for water resources Competition for adequate siting locations	Conflicts in water allocation during stressed weather conditions Competition for good siting locations	Potential competition between energy and nonenergy crops for land and water resources	Increased vulnerability and uncertainty Increased costs

Source: World Bank 2011

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Potential supply-side impacts: Thermo-Electric Power plants

Higher temperatures and drought

cooling water impacts

- Nuclear plants more vulnerable than other facilities?

Extreme rainfall/storm events

greater water turbidity and storm debris affecting intake filtration?

District energy facilities particularly vulnerable?

August 13, 2012, 4:58 PM | 12 Comments

Heat Shuts Down a Coastal Reactor

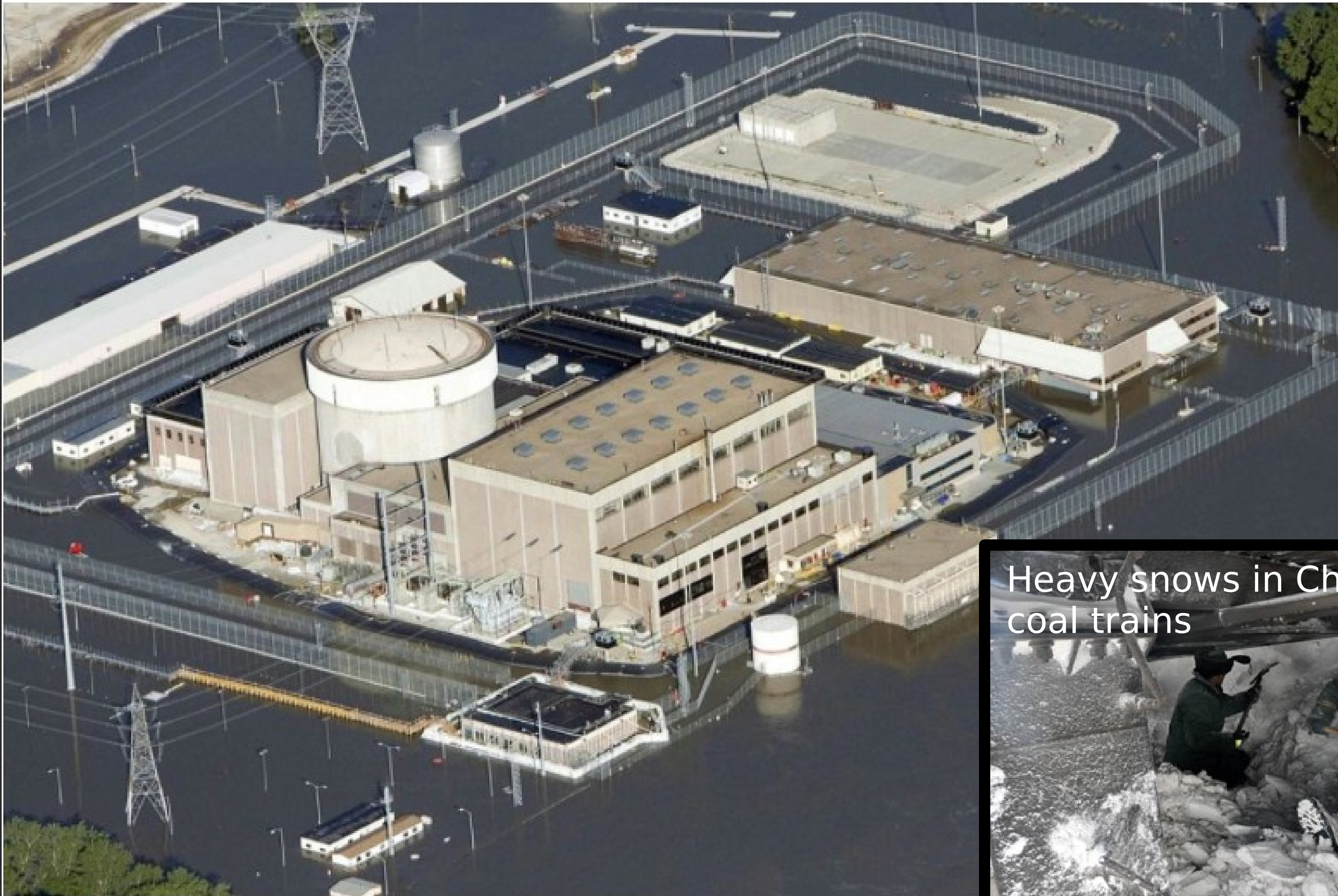
By MATTHEW L. WALD

C.M. Glover for The New York Times

A reactor ceased operations on Sunday at the Millstone Nuclear Power Station in Waterford, Conn.

Potential energy supply chain impacts

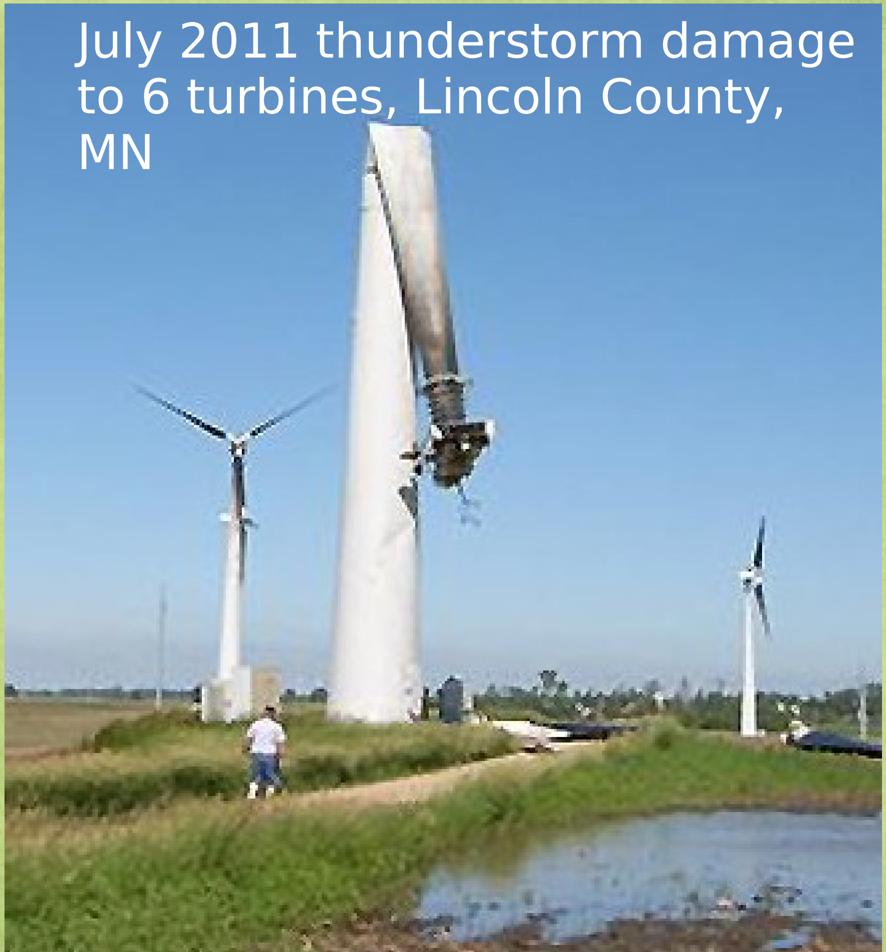
An aerial view of the Fort Calhoun Nuclear Power Plant in eastern Nebraska, surrounded by Missouri River flood waters June 24, 2011. The Missouri River, swollen by heavy rains and melting snow, has been flooding areas from Montana through Missouri. Residents have been shoring up levees around towns as federal officials widen flood gates to allow record or near-record water releases to ease pressure on reservoirs. Reuters [Missouri River at lower right.]



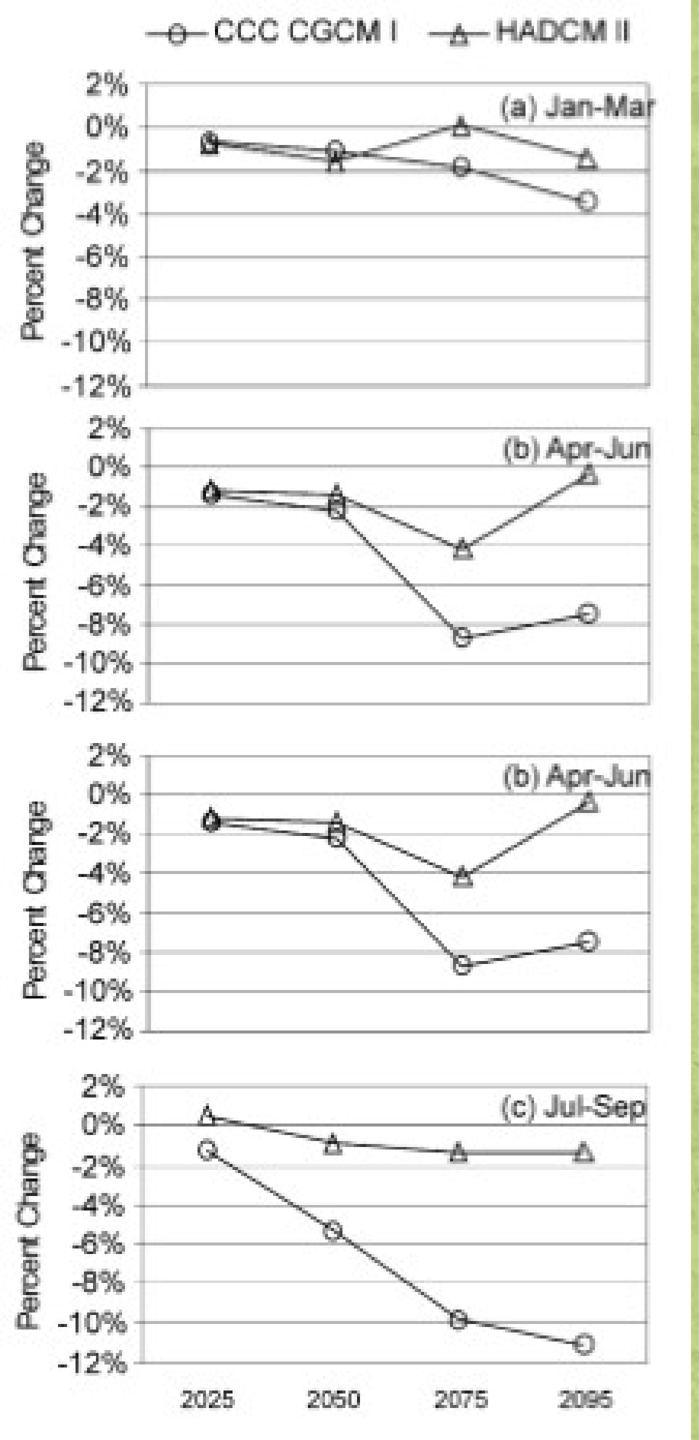
Fort Calhoun Nuclear Power Plant, about June 18, 2011

Potential supply-side impacts – Renewable Energy

- Wind
  - Changes in wind speed affect total outp
  - Extreme storm event risks to turbines



July 2011 thunderstorm damage to 6 turbines, Lincoln County, MN



Potential supply-side impacts – Renewable Energy

Hydro

Temperature change (less snowpack means more spring runoff, less summertime runoff)

- Change in overall supply
  - Competition for supply (e.g. Niagara Falls tourism vs power generation?)
- Change in timing of supply availability?
  - Snowpack = water “bank”

Niagara River output and water level

Source; Hammer, NYS ClimAID 2011

Potential supply-side impacts – Renewable Energy

Biomass/biofuels

Temperature change modifies regional agriculture profile

Vulnerability to pests

Drought = fire

BUT, longer growing season

Potential supply-side impacts: Energy Transmission and Distribution

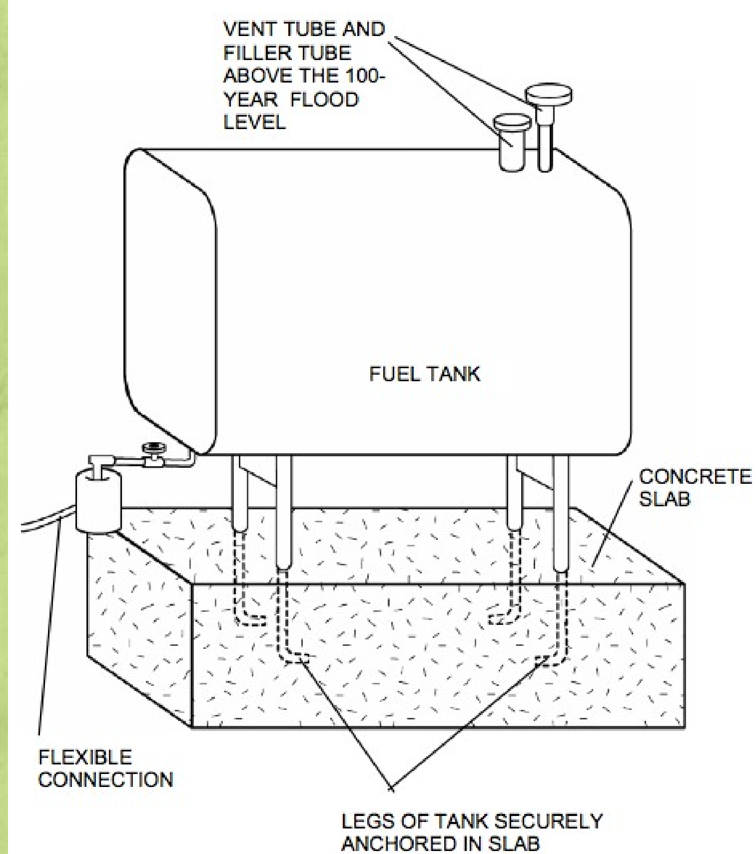
Longer growing season increases tree trimming program requirements

Gradual warming vs more extreme weather events – will snow/ice/storm risk to transmission lines increase or decrease?

Flooding risk

Fuel storage in homes/businesses

Damage natural gas distribution lines or rail network?



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Potential demand-side impacts

- Impact on TOTAL energy demand will vary
  - northern cities (winter peaking due to heavy heating load) = reduced demand?
  - southern cities (summer peaking due to air conditioning) = increased demand?
  - impact on power sharing between north and south?
- Extreme heat events = potentially large impact on PEAK energy demand as cooling demand

NYISO Zone	Weather Station	Heating Season: Decrease in MWp electricity demand in 2020s	Cooling Season: Increase in MWp electricity demand in 2020s
Zone A	Buffalo	14–27	55–111
Zone B	Rochester	9–18	53–105
Zone C	Syracuse	19–37	61–122
Zone D	Massena	5–10	7–15
Zone E	Watertown	11–21	29–57
Zone F	Albany	15–29	63–126
Zone G	Poughkeepsie	12–25	72–145
Zone J	NYC (LGA)	40–80	249–497
Zone K	Islip	27–58	194–387

Source: NYSERDA ClimAID study 2011

	2035 - 2064		2070 - 2099	
	Lower Emissions	Higher Emissions	Lower Emissions	Higher Emissions
Onset of Summer	-6	-11	-9	-21
End of Summer	+10	+16	+12	+23
First Frost (Fall)	+1	+16	+6	+20
Last Frost (Spring)	-8	-14	-16	-23
Length of Growing Season	+12	+27	+29	+43
First Leaf (Spring)	-3	-5	-7	-15
First Bloom (Spring)	-4	-6	-6	-15

(1) Special Report on Emissions Scenarios (SRES) B1 (B1 also used for DEP projections - see Chapter 1)
(2) SRES A1F1 (higher than A2, which was the high scenario for DEP projections - see Chapter 1)

Source: The Northeast Climate Impacts Assessment, 2006.

Air conditioning load the key to demand-side impacts?

Increasing summer temperatures may increase AC saturation

Varies widely by locale; NYC currently ~82%

Increasing AC saturation and/or peak usage can have exponential impacts on total system generation capacity requirements

Load impacts vary widely by sector depending on space conditioning needs

NYC residential power demand (50% for space conditioning) vs. industrial (7%)

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Air Conditioning Saturation Rates by Type and Locale

http://www.census.gov/housing/ahs/data/metro.html (Table

Adaptation Strategies (Energy Supply & Distribution)

Power plant location

Proposed Brooklyn power plant raised 4 ft due to new climate maps

Air vs. water cooling for thermal power plants?

Indian Point proposal to build closed circuit water cooling = $1+ billion

Greater supply diversification to limit potential for supply loss from hydro or thermal power plants?

Or simply more generation capacity?

Change assumptions for reliability of

Adaptation Strategies (Energy Demand)

"Urban heat island" mitigation strategies

Tree planting programs

Reflective or green roofs

Pricing programs that discourage energy use during peak demand periods

Building codes/guidelines to minimize solar gain, avoid in-house energy system flooding risk, etc.

Windows, insulation, air conditioning efficiency, HVAC upgrades to cut demand in existing buildings

District cooling systems development or

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Where is EDF on these issues?

- Can climate change be handled by the company's existing disaster planning strategy? Or is something new required?
- How does the challenge present itself at different locales or along different time scales throughout the EDF system?
- What are <u>your</u> needs? What are <u>EDF</u>'s needs?