

ADAPTATION IN ENERGY AND OTHER URBAN AND REGIONAL INFRASTRUCTURES: FROM ADAPTATION PRACTICE TOWARD ADAPTATION SCIENCE

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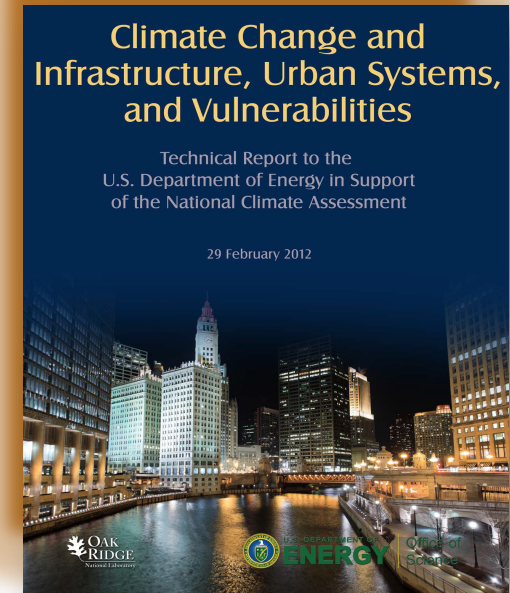


Starting with a General Framework of Thought (I):

- **Traditionally, energy and other built infrastructures have been largely overlooked as priorities for climate change impact and adaptation assessment because their sensitivities to temperature and precipitation changes are less direct**
- **But they are often at the heart of the kinds of vulnerabilities and impacts that most people care most about: comfort, convenience, mobility, labor productivity, security,**
- **And they are often threatened by increases in climate extremes and extreme events, especially in particularly vulnerable areas: storms, floods, wildfires, droughts, heat waves....**

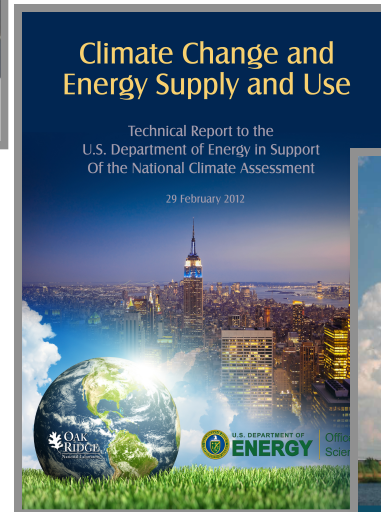
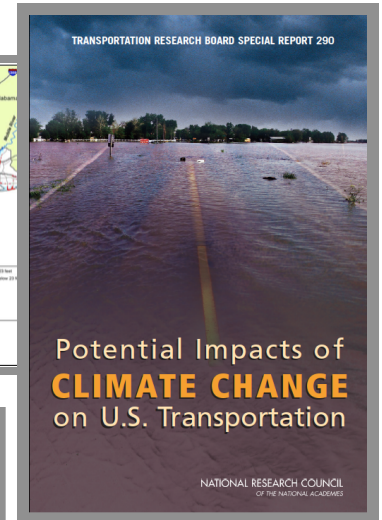
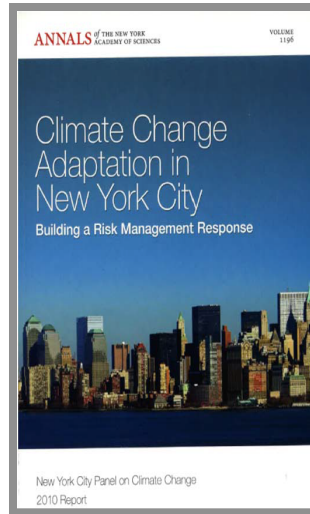
Starting with a General Framework of Thought (II):

- **How are built infrastructures different from other, more obviously climate-sensitive sectors?**
 - **Dominated by big-picture issues: large-scale events, large-scale decisions that cast long shadows, major institutions with large-scale financial and managerial resources**
 - **In many cases, already under stress: policy conditions and user demands different from the assumptions that shaped their design, aging capital stock that is difficult to replace while maintaining infrastructure services**
 - **Often thought of as structurally and institutionally rigid, not easily or readily adaptable – especially where their financial bases are public sector budgets, in a time when government expenditures are already painfully constrained**



Current Practice Includes Both Climate Change Adaptation Per Se and Multi-hazard Adaptation That Includes Climate Change as a Risk (I):

- **Climate change adaptation activities:**
 - **Mainly strategy development and planning**
 - **Urban infrastructures (e.g., King County, New York City, Boston, Chicago, smaller communities – even Aspen!) – often include attention to mitigation as well**
 - **Sectoral assessments (e.g., transportation, water, and now energy – current workshops...)**



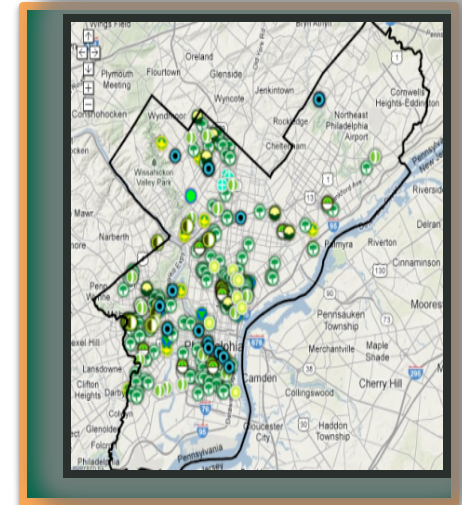
Current Practice Includes Both Climate Change Adaptation Per Se and Multi-hazard Adaptation That Includes Climate Change as a Risk (II):

- Climate change adaptation activities:
 - Mainly strategy development and planning (contd.)
 - Not constrained by a lack of down-scaled climate change projections (develop their own, use Wigley or Hayhoe, or work from IPCC-type sources)
 - Most of the adaptation actions are taking place in the private sector (e.g., insurance/reinsurance, tourism, infrastructures in vulnerable areas), but information sources are extremely limited
 - adaptation is often the one climate change response issue that is not contentious...



Current Practice Includes Both Climate Change Adaptation per se and Multi-hazard Adaptation That Includes Climate Change as a Risk (III):

- **Multi-hazard adaptation activities:**
 - **Particular focus on water infrastructure vulnerabilities**
 - **In urban areas, in response to growing concerns about stormwater and wastewater handling; e.g., Philadelphia's “Green City, Clean Waters” program:**
 - **A 25-year commitment to convert more than 1/3 of the city's impervious land cover to green facilities, along with stream corridor restoration and preservation**
 - **Being implemented through leveraged funding from the development community as a part of every new development project**
 - **Has catalyzed a Model Neighborhood program to encourage community participation in greening the city**
 - **More generally, a focus of the American Society of Civil Engineers (ASCE) “water infrastructure” report card, 2011: by 2020 US will have fallen \$84 billion short of needed investments in critical water systems, meaning \$416 billion in lost GDP and 700,000 lost jobs and increased vulnerability to both flooding and droughts.**



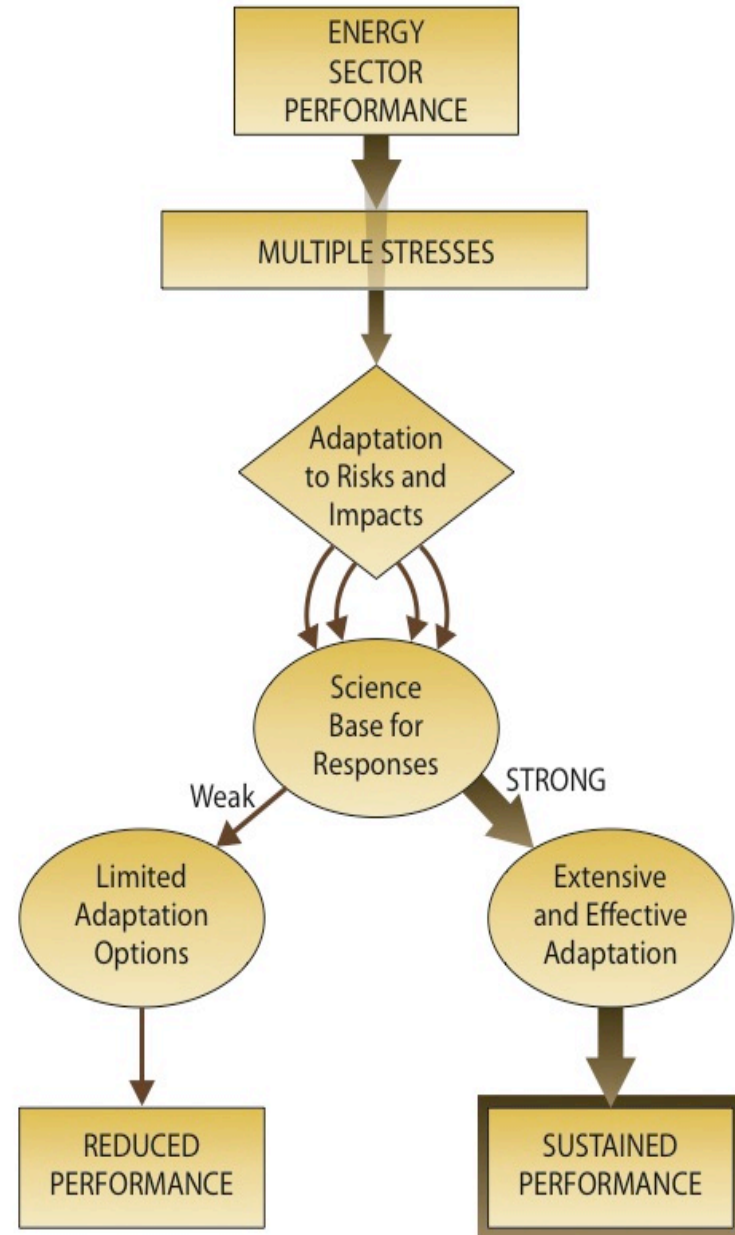
Big Green Map

		Watersheds in the Combined Sewer Area			
		Tookany/Tacony-Frankford Creek	Cobbs Creek	Delaware River	Schuylkill River
Dry Weather Water Quality, Aesthetics and Recreation	Water quality concerns (including bacteria and dissolved oxygen)	●	●	●	●
	Potential sewage flows in separate sewered areas	●	●	●	●
	Litter and unsightly streams that discourage recreational use	●	●	○	○
	Safety concerns along streams and stream corridors	●	●	○	○
Watershed Stewardship	Limited public awareness and sense of stewardship	●	●	●	●
	Recreational opportunities and public access below potential	●	●	●	●
Healthy Living Resources	Degraded aquatic and riparian habitats	●	●	○	○
	Limited diversity of fish and other aquatic life	●	●	○	○
	Channelized stream sections	●	○	○	○
	Loss of wetlands	●	●	●	●
	Utility infrastructure threatened by bank and streambed erosion	●	●	○	○
Wet Weather Water Quality and Quantity	Water quality concerns (including bacteria and dissolved oxygen)	●	●	●	●
	CSO and stormwater impacts on stream channels	●	●	○	○
	Total Maximum Daily Load and fish advisories established for PCBs	○	○	●	●
	Little volume control and treatment of stormwater flows in separate sewered areas	●	●	○	○

One Recent Development Is a Move toward Adaptation Science, as a Stronger Foundation for Adaptation Practice:

- **Adaptation research and practice are not necessarily adding up to advances in adaptation science:**
- **...as a cross-cutting body of theory, agreements on standards for analysis and treatment of such issues as uncertainty, and time series of fundamental data as a basis for evaluating options, along with a body of fundamental science and technology to enlarge the range of options at all scales and for all parties**
- **NRC 2010 identifies three categories of adaptation science:**
 - **Improving capacities for adaptation analysis and assessment**
 - **Improving the menu of adaptation options and our knowledge of their costs, benefits, potentials, and limits**
 - **Improving knowledge about how to implement and manage adaptation**

Adaptation Science, Building a Stronger Foundation For Adaptation Practice:



Some Adaptation Science Initiatives from a Multi-hazard Perspective Include:

- **A focus on improving the resilience of national built infrastructures to all hazards through research opportunities and priorities: Infrastructure Subcommittee, Homeland and National Security Committee, OSTP, e.g.:**
 - **Improved indicators of resilience**
 - **Innovative materials**
 - **Improved sensors**
 - **Rethinking “optimization” in a risk management context**
- **An interest on the part of ASCE in rethinking codes and standards for built infrastructure design, construction, and operation**
 - **To remove assumptions of “stationarity” of climatic and other parameters**
 - **To encourage flexibility as an objective for infrastructure capital stock**

Adaptation Science Initiatives from a Sectoral Perspective Include a Recent DOE Assessment of Climate Adaptation Science and the Energy Sector:

- **Including science for analysis and assessment: e.g., understanding feedbacks and tipping points, projecting severe weather events, improving the ability to analyze alternative adaptation strategies, and incorporating adaptive behavior in long-term projections of climate change impacts (and CC)**
- **Science to support electricity supply and use: e.g., more efficient and affordable space cooling technologies, advanced approaches for cooling thermal electric power plants that are less water-consumptive, T&D technologies less vulnerable to heat waves, technologies for peak-shaving, potentials for regional intertie capacities and distributed generation, improved options for storage and backup**

Adaptation Science Initiatives from a Sectoral Perspective Include a DOE Assessment of Climate Adaptation Science and the Energy Sector:

- **Science to support liquid and gas fuel supply and use: e.g., increasing the resilience of coastal and off-shore production and distribution systems to severe weather events, materials to cope with new operating conditions such as heat and ocean acidification, new and adapted technologies for infrastructure for exploration and production in relatively vulnerable regions such as the Arctic, new technology and policy options for responding to surprises**
- **Science to support water for energy development: e.g., power plant cooling for regions vulnerable to water scarcity, water use efficiency improvement, improving the understanding of groundwater dynamics and recharge, improved information about water use**

A Particular Interest of the DOE Office of Science Is in Fundamental Science to Support Innovative Technology Adaptation:

- **Materials to cope with new operating conditions**
- **Sensors to monitor physical attributes of the environment and performance of energy technologies and systems**
- **Novel mathematical and computational approaches for complex system design and operation**
- **Improved IT systems, including monitoring and control systems to increase information and support flexible responses to disruptive events**
- **Accelerated development of affordable desalination as a response to regional water scarcity, especially near coasts (public/private sector adaptation research collaboration?)**

In Summary, for Energy and Other Infrastructures, the Issue Is Not Just Noting and Encouraging Current Adaptation Strategies and Actions but Also Improving the Science Base for Adaptation Options:

- **Enlarging the menu of options and supporting stronger analytical and technological capabilities, related to addressing uncertainties and potentials for surprises**
- **Improving knowledge of costs, benefits, potentials, and limits of available and new adaptation options**
- **Increasing recognition that climate change adaptation is a significant field of research and development, along with climate science and climate change mitigation**