The Energy-Water Nexus (EWN): a New York City Pilot Study

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Presentation Outline

- Description of the BNL New York City Pilot Study
  - Area
  - Steering Committee
- MARKAL-Water Model
- Scenarios
- Results and Recommendations
New York City Pilot Study

Goals:

- Determine the key energy-water planning issues for an urban area - New York City
- Develop and apply an integrated energy-water decision-support tool to facilitate urban energy-water planning
- Identify the activities and framework needed to achieve successful integrated energy-water planning
  - Challenges (regulatory/policy issues, data, necessary tools, programmatic issues, etc.)
  - Suggestions for steering committee establishment and the interactions and activities of the steering committee
  - Development and application of tools and methods
New York City Study Area

- 1.3 BGD supplied
- 19 reservoirs, 3 controlled lakes
- 3 aqueducts
- 2 distribution reservoirs
- 3 rock tunnels in the city (1, 2, 3)
- Network of risers and 6000 miles of distribution mains

- 1.4 BGD treated
- 14 wastewater pollution control plants
- 93 pumping stations
- 494 permitted outfalls

Area: 321 mi² (~ 830 km²); Population: 8,213,839

Energy Supply: Keyspan, Reliant Resources, NRG Energy, and NYPA

Distribution: Consolidated-Edison

*Forecasted peak electricity demand 11,020 MW (80% in-City generation) 2003*

By 2008, 3,780 MW of new electricity resources needed
Challenges Facing NYC Energy System

**Energy Demands**
Water & Wastewater Systems, Transportation, Commercial, Industrial, Residential

- Inefficient, old buildings
- Increased energy demands for water & wastewater treatment and transportation upgrades
- Demand side Emissions & Climate Change impacts

**Energy Generation**
NYPA, NRG, Entergy, Keyspan, Reliant, Con Edison

- Aging power plants
- Energy shortfalls by 2011-12
- Barriers to building new power plants
- Emissions and Climate Change impacts

**Energy Delivery**
Con Edison, Keyspan

- Upgrading electricity, steam and gas delivery infrastructure
- Meeting peak demand
- Transmission line siting/installations
New York City Pilot Study
Steering Committee Roles

- **Tasks and Activities**
  - Identify the energy-water issues for NYC
  - Guide the development of the integrated energy-water tool
  - *Assist* and guide BNL researchers in obtaining needed energy-water data and information
  - Select key energy-water strategies to be evaluated using the developed decision-support tool
  - Review final report

- **Comprised of a Diverse Group of Stakeholders**
  - Columbia University Professor/NASA GISS Researcher
  - USEPA Region 2 – Senior Energy Policy Advisor
  - Consulting Firm (HDR)
  - Water Environment Research Foundation
  - NYC Department of Environmental Protection
  - Energy Company in NYC (Consolidated Edison)
Decision Support Tool: MARKAL

- Developed at BNL in 1970s in collaboration with IEA (International Energy Agency) – continuously updated/validated
- Flexible and transparent framework with a well documented methodology

- Over 100 institutions in 55 countries currently use it for energy systems analysis
- Use of MARKAL at U.S. DOE R&D policy decisions
  - Applied R&D Programs (NE, EERE, FE & OE) – GPRA 1993
  - Office of Nuclear Energy – GNEP
  - Office of Policy and International Affairs
  - Hydrogen Economy
  - Energy-Water Nexus
MARKAL Model Basics

- Utilizes a state-of-the-art *dynamic linear programming* framework
- Provides a *technology-rich* basis for estimating energy dynamics *over a multi-period horizon* (2005-2050)
- Models *environmental, technological* and *policy* restrictions
- Generates *least-cost* energy path based on *perfect foresight* and *life-cycle costs* of technologies and competing alternatives (cradle-to-grave)
- Identifies the *most cost-effective* pattern of *resource use* and *technology deployment* over time
Modeling Water Systems

- Detailed fresh and wastewater flows and technologies

![Water System Diagram]

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Leading NYC Energy and Water Planning Challenges

- Identified by the Steering Committee
- Reliable operation of drinking water and wastewater systems increases energy demands (UV treatment and Croton filtration plant)
- Enforcement of water conservation and assessment of the total benefits (e.g., water and energy savings)
- Evaluation of the impacts of climate change on energy and water systems
- Ensuring future energy and water supply security
- Planning for water withdrawals for steam production
- City-wide integrated planning of energy and water systems
Policy Options Analysis

Several energy-water integrated planning scenarios were developed, based on issues identified by the steering committee.

- **Scenario 1**: Water-Efficient Appliances: Energy and Water Use Impacts
- **Scenario 2**: WasteWater Treatment: Deploying More Fuel Cells
- **Scenario 3**: New York City Water Supply: Impacts of Increased Energy Demands for New Treatment
- **Scenario 4**: New York City Steam Generation: Water Supply and Energy Impacts
- **Scenario 5**: Climate Change Models and Research: A Link with Energy and Water
Scenario 1
Water-Efficient Appliances

![Bar chart showing water savings from different scenarios of top load with front load technology change-out.]

- 5% change-out of Top Load with Front Load Technology: 0.5 MGD
- 15% change-out of Top Load with Front Load Technology: 2.0 MGD
- 20% change-out of Top Load with Front Load Technology: 4.0 MGD
- 50% change-out of Top Load with Front Load Technology: 10.0 MGD
Scenario 1
Water-Efficient Appliances
Scenario 1
Water-Efficient Appliances

*SOX emissions are negligible because most of the power plants in NYC use natural gas and fuel oil*
Scenario 2
Wastewater Treatment: Deploying More Fuel Cells

Fuel Cell Capacity at NYC WWTFs

- Anaerobic Digester
  - ADG
  - ADG Processing
    - Water Removal
    - Sulfur Removal
  - Fuel Cell
    - Electricity (35%)
    - Recovered Thermal Energy (45%)
    - Rejected Thermal Energy (20%)

- Sewage Sludge

Years
- 2005
- 2010
- 2015
- 2020
- 2025

MW
- 0
- 5
- 10
- 15
- 20
- 25
- 30
- 35
Scenario 2
Fuel Cells

Net CO2 Savings for New York City

Net Savings in Criteria Pollutants for New York City
New York City Pilot Study
Lessons Learned

- Steering Committee Composition and Roles Crucial to Success
- Existing Energy Studies and Decision Tools can be Modified to Include Water
- Linkages to Climate Models will be a Challenge