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Analytical Tools Shaping the Next Generation of Carbon Regulation and Trading: The New York Metropolitan Area Case Studies

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*by Edward J. Linky, Vatsal J. Bhatt & John C. Lee**

Introduction

The next generation of carbon regulation is under discussion. The United Nations Climate Change Conference in Bali, Indonesia concluded with the collective sense that the United States is now an active participant in the future of an international carbon regime. Undoubtedly, skepticism about U.S. domestic regulation of greenhouse gases ("GHGs") as well as the timetable for U.S. participation will remain. State, regional, and local initiatives to control GHGs, principally from the electric power sector, however, are well developed and on the road to implementation with draft administrative rules available for public review and comment. For instance, in the Northeastern United States, the most familiar of these initiatives is the Regional Greenhouse Gas Initiative ("RGGI"), and the recently implemented Western Regional Climate Action Initiative ("WRCAI") has gained sizeable momentum in the West. It is unlikely these initiatives will be tabled to wait for a uniform federal response.

On the programmatic side, New York City Mayor Michael Bloomberg's administration has created PlaNYC 2030, an initiative to bring clarity and definition to principles of urban sustainability. As well-intentioned as these efforts are, the first two remain confined, as RGGI is in its first generation with limited scope and geographical coverage, and the PlaNYC is still a programmatic goal statement with some initial implementation projects. The New York City-based Regional Plan Association has launched an integrated energy-land use-transportation and GHG mitigation program, Long Island 2035, in Nassau and Suffolk Counties, which adjoin the five county-boroughs of New York City.

The U.S. Environmental Protection Agency ("U.S. EPA") Regional Office in New York City ("U.S. EPA Region II") has formed a diverse partnership with Brookhaven National Laboratory, academic institutions, regional transportation, and land use planning organizations to develop a suite of analytic system models which can provide a quantitative vision of technology and management strategy options for reducing the region's carbon footprint while maintaining the energy demands of the community and the servicing of environmental infrastructure.

In this Article we provide results of a case study using models completed for New York City and one under development for Long Island, which utilizes an integrated urban energy-water systems analysis tool. The case study demonstrates integration of the MARKAL model with land use, transportation, and human health models. Combined with appropriate stakeholder participation, such case studies promise to influence the current environmental regulatory regime, including multi-media aspects of carbon control, whether at the regional or national level.

The next generation of carbon registration and exchange is going to be far more rigorous than its predecessor.

Top-down and Bottom-up Initiatives in U.S. Carbon Regulation and Markets

The next generation of carbon regulation in the United States is under consideration with three competing pieces of legislation in the United States Senate: S.280, S.485, and S.1766.[1] This next generation legislation will be much more sophisticated and hence, more complicated than previous energy and air regulatory schemes such as the 1990 Clean Air Act Amendments and the Energy Policy Act Amendments of 2006. The goal of this proposed legislation is to account for GHG generation from the usual industrial, commercial, and residential sources, in addition to land use patterns. The successor to the Kyoto Protocol of the United Nations Framework Convention on Climate Change now under discussion is very likely to address key performance elements such as "additionality and leakage." Both of these ele-

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ments have been issues surrounding carbon market exchanges in the United States and the European Union. Further, a future Asian Climate Exchange located in India or China poses additional challenges to those who claim carbon reductions and then post them for sale and exchange. Thus the next generation of carbon registration and exchange is going to be far more rigorous than its predecessor.

Despite the sense of inevitability surrounding U.S. carbon legislation and presumed conformance to the Kyoto successor, the timing of such measures remains very uncertain. For this reason, this paper focuses on bottom-up initiatives, particularly those in the Northeastern United States. In this region and specifically in the New York Metro area, there are a variety of mega-stakeholders that are uniting behind several sustainability plans and programs. These initiatives are not dependent on any of the top-down legislative proposals described above, and they may very well act independently of them for a period of time. As is suggested below, one particular analytical tool—the New York Metro MARKAL Integrated System model—can produce a quantitative vision for any of the efforts described below either individually or collectively. The output of this tool can help shape more precise regulatory schemes and financing mechanisms for greenhouse reduction technologies and strategies, and, as we show, help produce higher quality carbon credits which will be well received in the domestic and international markets.

The next wave of regulatory and planning initiatives is found at the local level of government.

Enactment of any of the top-down approaches will ultimately need to be reconciled with regulatory and planning initiatives already launched in the Northeastern and Western States. Currently, these initiatives are limited to electric power production facilities, but if federal legislation is not enacted then these initiatives will likely expand in the near future, probably around 2012.[2] RGGI is further along the regulatory track with the adoption of a memorandum of understanding ("MOU") and a Model Rule on power plants[3] working its way into several states' administrative rule procedures. The Western States Initiative was recently launched in 2007.[4]

The next wave of regulatory and planning initiatives is found at the local level of government. It is at this level that the body of this Article concentrates. Networks of researchers, municipal and regional government officials, and regional offices of federal agencies and one National Laboratory have coordinated their efforts in the New York Metropolitan area. This evolving network illustrates how local interests and needs can move ahead of top-down federal and even international regulatory schemes. The applications of the New York Metro MARKAL tool range from the next generation of electric power production and wastewater treatment facilities down to community redevelopment through zero thermal footprint zoning ordinances. The goal of ongoing studies using this tool is not to direct or influence the regulatory process *per se* but to suggest that with proper analysis virtually any of the GHG reductions requirements through international treaty or federal/state legislation can be met with existing and emerging technologies. This analytical framework provides legislators and policy makers with a quantitative vision of a sustainable future. To be sure, this sustainable future will require an extraordinary amount of self-discipline, which the United States has not needed since World War II and the international community has never faced: holding carbon caps in place for at least a century with the possibility of returning the climate in time to the patterns of the last century.[5]

New York Metropolitan Area's Bottom-Up Initiatives

There are three on-going programs in the New York Metro region, which directly focus on climate change and sustainability. These are: New York Metro Urban Modeling Consortium, PlaNYC, and the Regional Plan Association's Fourth Regional Plan, and the Northeast "Mega region." Since each of these efforts is either utilizing or considering the MARKAL tool, a brief description of each plan is warranted, as it will help crystallize some of the proposed future uses of the tool. As will be illustrated below, PlaNYC still needs a unifying tool that can, for example, evaluate the costs and benefits of using shade trees either in combination or as a substitute for other forms of building energy efficiency. Through its work with the Urban Modeling Consortium, the NYC MARKAL is uniquely positioned to provide guidance.

The New York Metro Urban Modeling Consortium

This Consortium is composed of the U.S. EPA Region II, Brookhaven National Laboratory, The Earth Institute at Columbia University, Units of the City University of New York, and the NASA Goddard Institute of Space Studies ("GISS"). Each of the members had been engaged in loosely affiliated research in various aspects of climate change in New York City, however, the principal focus of these efforts is the urban heat island ("UHI") and its impact on the electrical power network along with air quality implications for human health.

U.S. EPA Region II facilitated a MOU to be ultimately signed by Consortium members, containing a set of principles for climate models and their applications. These principles were adopted from the American Council for an Energy Efficient Economy and essentially pledge the signatories to total transparency and critical examination in modeling and applications. It is thought that this declaration of principles is the first of its kind, at least in the United States. The central model in the Consortium is the New York Metro MARKAL. Other models involve climate and health models as well as weather related models from Columbia University and NASA-GISS, respectively.

To date, the Consortium has advised several Community Planning Boards—the ultimate decision-makers on zoning ordinances—on low climate impact zoning ordinances based on the thermal impact of new development or redevelopment projects on their areas. The recent sale of two middle class housing developments Stuyvesant Town and Peter Cooper Village to private developers has raised concerns about the future sustainability of these forms of public housing in an urban, heat-island-intensified environment.[6]

PlaNYC

Mayor Bloomberg's Administration has created an ambitious and groundbreaking public forum on the future of the five boroughs of New York City through PlaNYC.[7] The effort has three basic areas for public input and technical research: population growth, infrastructure needs, and maintenance and greening of the city in order to cope with rising temperatures and sea level rise. The planning horizon is 2030. Within PlaNYC there is a comprehensive discussion of energy costs and carbon emissions from an ineffective market, inefficient buildings, and growing needs. The needs are exemplified by both the quantity and quality of electric power needed to service the demands of a dynamic academic and private sector research community along with enhanced entertainment and information services demanded in the commercial and residential sectors. Key elements of the energy section of PlaNYC include reforming the planning process for new generation, recognizing that attention must be paid to the transmission and distribution of electricity, and creating an energy efficiency authority. The working group for PlanNYC has completed a GHG inventory for the city and identified that the building sector is the biggest contributor. The Regional Plan Association[8] has stated that there are approximately 940,000 buildings in the five boroughs (counties) of New York City but that currently only 400 are "green" in some form.

The green category includes Energy Star Rated Buildings along with LEED certified, plus all other forms of green designation. Clearly, if the city is to reduce its GHG emissions from the building sector, a massive effort must be mounted to stimulate energy efficiency. Technology and accounting mechanisms exist through the Energy Star Buildings Program to reduce electric power consumption in most building types by forty percent. The principal objective of the Energy Efficiency Authority will be to dramatically increase the efficiency of the building sector and lower electric power consumption.

A second element of PlanNYC is "Million Trees NYC," a city-wide initiative to restock and reforest parks and street trees to plant one million trees within the 2030 horizon of PlanNYC. Trees can be effective in cooling certain types of buildings but are not considered as a cooling strategy per se in PlaNYC. Trees, and by implication vegetative roofs, can also have storm water control benefits. Finally, it is believed that to make use of the extended benefits of urban canopy, key regulatory issues not even yet identified must be faced. For example, only fifty percent of the urban canopy is thought to be under public control. High costs associated with maintaining the urban canopy as an effective technique for reducing climate impacts may lead to an understanding that the canopy should be designated as a regulated utility and governed by enhanced control schemes. However, one never gets to that threshold issue unless a quantitative analysis conducted by the NYC MARKAL is completed.

The Regional Plan Association and the Northeast Mega Region

In a joint venture, the Regional Plan Association ("RPA") and the Lincoln Land Institute ("LLI"), convened a meeting in Healdsburg, California to examine the concept of mega regions in the United States.[9] The Regional Plan Association has taken this report a step further and produced America 2050, in which ten emerging mega regions in the United States are identified.[10] Beyond identifying the regions the initiative is trying to identify the relationships that define mega regions and test new financing and governance methods as well as finding equitable mechanisms to distribute benefits to bypassed regions.

One of the ten mega regions in the American 2050 report is the Atlantic Coast Northeast region. The RPA usually produces in a decadal frame its vision for its traditional region—the thirty-one counties of New York City, central and northern New Jersey, western Connecticut and downstate and central New York State, which includes Nassau and Suffolk County, collectively known as Long Island. The RPA is using Long Island as a test bed for smart growth and low-carbon approaches to land use and envisions using the Long Island extension of the NYC MARKAL as its principal analytical tool.[11]

Long Island's basic infrastructure, including its commuter railroad, electric generating stations, and wastewater treatment plants, are all threatened by a rise in sea level.[12] Whether the existing network can be maintained cost effectively or will have to be modified to serve new population centers protected from the sea in a more efficient land use pattern, is the type of long-range low-carbon direction that will be explored in this planning paradigm. How the state's public utility regulatory structure may need to be reshaped to accommodate a future of low-carbon requirements and an impending sea level rise can at least be preliminarily quantified by the NYC MARKAL-Long Island extension.

Future Directions for the Regulatory Process

As we noted, in the on-going RGGI rule adoption process, the regulation of power generation facilities in the signatory states will change by 2012. Regulatory elements of PlaNYC in the energy sector will stimulate markets for energy efficiency in buildings and these efficiency improvements may generate tradable carbon credits in the New York State electric grid. Planning processes under development on Long Island and at the Community Planning Board in New York City can potentially reshape zoning ordinances relating to low-carbon and low-thermal impact on land use patterns.

The New York City MARKAL and its Long Island extension are tools fully capable of responding to all of the challenges noted above. This bottom-up approach can serve as an example of how low-carbon planning approaches can be implemented when guided by a tool such as an urban-based MARKAL.

Urban Energy, Water, and Solid Waste Systems Analysis

An integrated urban energy-water systems analysis tool, Urban MARKAL, recently developed by the Brookhaven National Laboratory, has the capability to influence existing air, water, solid waste, and zoning regulations. The urban energy model, MARKAL, along with the building energy simulation model and a meso-scale climate model, was developed under a grant from the U.S. EPA Region II. Water and wastewater analysis capabilities were integrated with urban energy in MARKAL with the grant from the U.S. Department of Energy's ("DOE") grant to support the Energy-Water Nexus program. The Urban MARKAL model incorporates a technology database rich with existing and future technologies that is tied to the performance of urban infrastructure systems. The Urban MARKAL model incorporates active and passive approaches to central and distributed energy resources, electric grids and energy consumption, water supply and wastewater treatment grids, and passive approaches to reducing thermal load on the sites of public housing and commercial building projects.

MARKAL Modeling Framework for Integrated Strategic Planning

Energy, water, wastewater, and solid waste disposal systems are highly interdependent. For optimal sustainable operation of cities, long-term strategic planning and management is required for the detailed sub-system and the integrated macro-system. MARKAL provides a comprehensive and integrated systems planning and management methodology.

The MARKAL model is a technology-driven linear optimization model of the urban energy system that runs in five year intervals over a fifty year projection period.[13] MARKAL provides a framework to evaluate all resource and technology options within the context of the entire energy/materials system, and it captures the market interaction among fuels to meet demands (e.g., competition between gas and coal for electricity generation). The model explicitly tracks the vintage structure of all capital stock in the economy that produces, transports, transforms, or uses, energy and the associated materials.

In MARKAL, the entire energy system is represented as a network based on the reference energy system ("RES") concept. The RES depicts all possible flows of energy from resource extraction, through energy transformation, distribution, and transportation, to end-use devices that satisfy the demands of useful energy services (e.g., ton in cooling, lumen-second in lighting). Figure 1 illustrates a simplified RES in graphical form. The U.S. MARKAL model has detailed technical representations of four end-use sectors: residential, commercial, industrial, and transportation, as well as fossil fuel and renewable resources, petroleum refining, power generation, hydrogen production, and other intermediate conversion sectors.

Technology choice in the MARKAL framework is based on the present value of the marginal costs of competing technologies in the same market sector. On the demand side, the marginal cost of demand devices is a function of levelized capital cost: Operation and Maintenance ("O&M") cost, efficiency, and the imputed price of the fuel used by these devices. For a specific energy-service demand and period, the sum of the energy-service

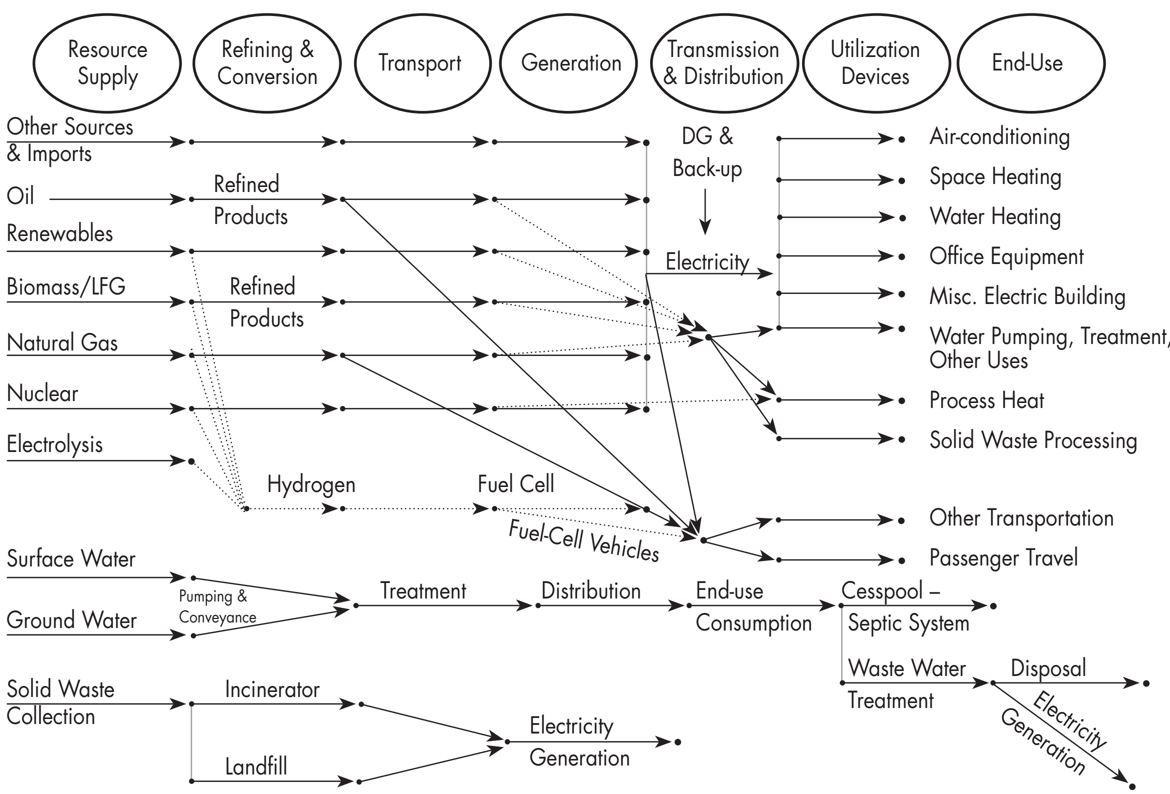

Figure 1. MARKAL Reference Energy System with Water, Waste Water, and Solid Waste Systems

output of competing technologies has to meet the projected demand in that period. The relative size of the energy-service output, or market share, of these technologies depends not only on their individual characteristics—technical, economic, and environmental—but also on the availability and cost of the fuels they use. The actual market size of a demand sector in the future depends on the growth rate of the demand services and the stock turnover rate of vintage capacities. MARKAL dynamically tracks these changes and defines future market potential. Another factor considered in MARKAL that affects the market penetration of a specific demand device is the sustainability of the expansion in the implied manufacturing capacity to produce these devices.

Energy, water, wastewater, and solid waste disposal systems are highly interdependent.

On the supply side, the technology choices made in MARKAL are based on the imputed price of the energy products (e.g., coal, natural gas, biomass) and the marginal cost of producing energy from conversion technologies (e.g., power plants, burners, distributed generation plants) to meet electricity demand (endogenously determined in MARKAL). The cost of resource input for production, exogenously projected in MARKAL, such as imported oil prices and cost of uranium ore, together with the characteristics of supply technologies (including electricity generation) determine the market share of a particular fuel type and the technology that uses it. The supply-demand balance achieved for all fuels under the least energy-system cost represents a partial equilibrium in the energy market. In particular, the intertemporal new investments in nuclear technologies under this equilibrium determine the market deployment of these technologies. Additionally, policies can be modeled that explicitly or implicitly provide economic incentives for less competitive technologies to accelerate their learning curves or market penetration.

New York City Integrated MARKAL for Urban Electric Peak Load Studies

Brownouts and blackouts in America's Northeast and West, as well as in Europe in the recent years, have been attributed to overloaded grids and substations coupled with the UHI effect.[14] Ensuing adverse economic impacts led to lawsuits against the utilities.[15] Concerned with the economic impacts along with the effects on human health, energy, and the environment, planners have felt the need for better energy planning and mitigation strategies in major metropolitan areas.[16]

The New York City integrated MARKAL project, supported by U.S. EPA Region II, is a collaboration of Brookhaven National Laboratory ("BNL") and State University of New York at Stony Brook. The project uses a portfolio of models interactively to evaluate mitigation strategies covering demand-side management (e.g. energy star technologies) and UHI mitigation measures, such as city greening techniques. A detailed New York City multi-regional MARKAL model was developed to simulate current and projected energy and electricity demands, electricity transmission and distribution requirements, and peak load patterns in the city and selected hot spots. EnergyPlus, a building energy simulation model developed by the U.S. DOE, is used to quantify specific building end-use energy flows and electricity load patterns.[17]

During the same time, the New York State Energy Research and Development Authority ("NYSERDA") and Department of Environmental Conservation initiated a project to examine "green" UHI mitigation strategies like urban forestry and green/reflective roofs. The project, comprising Hunter College, City University of New York, and the NASA-Goddard Institute of Space Studies, uses a meso-scale climate model, MM5, supported by geographical information system-based land use and land cover models. Researchers on both projects had long-standing cooperation on related projects such as the Metroeast Regional Climate Study for New York City. This study was part of the U.S. Global Change Research Program and had basic scoping elements of energy saving and UHI.

Cooperation between these two projects was sought to quantify UHI effects in EnergyPlus resulting from "green" mitigation strategies. The reduction of end-use energy demands in buildings due to these changes is measurable in EnergyPlus, which is then fed to MARKAL to measure peak load and emission reductions. Figure 2 schematically represents the "portfolio of models" approach and interactions of EnergyPlus and UHI study with MARKAL framework

The energy utility for New York City, the Consolidated Edison Company, identified overloaded sub-stations and high heat emitting locations considered as hot spots to study the impacts of mitigation strategies and reduced electric demand during the summer peak period. The New York City MARKAL project considered the Lower Manhattan hot spot as a case study to measure the benefits of the mitigation strategies. This task of integrating all modeling approaches, however challenging, provides an insightful methodology to enable New York City and other urban areas to develop and test policies for energy efficiency and UHI mitigation and to determine the expected economic and pollution prevention ("P2") metrics for mitigation policies.[18] This experimental exercise provides a "validation of concept," and it is anticipated that as the exercise moves toward a "proof of concept" methodology that will be prudent enough to be used at a utility scale.

The model calculates the least-cost system configuration that satisfies externally defined demands for final energy services (e.g., air conditioning), while taking into account environmental objectives such as reductions in CO_2, NO_X, and SO_X emissions.

The MARKAL outputs include quantified P2 metrics for each time period over the time horizon of interest such as

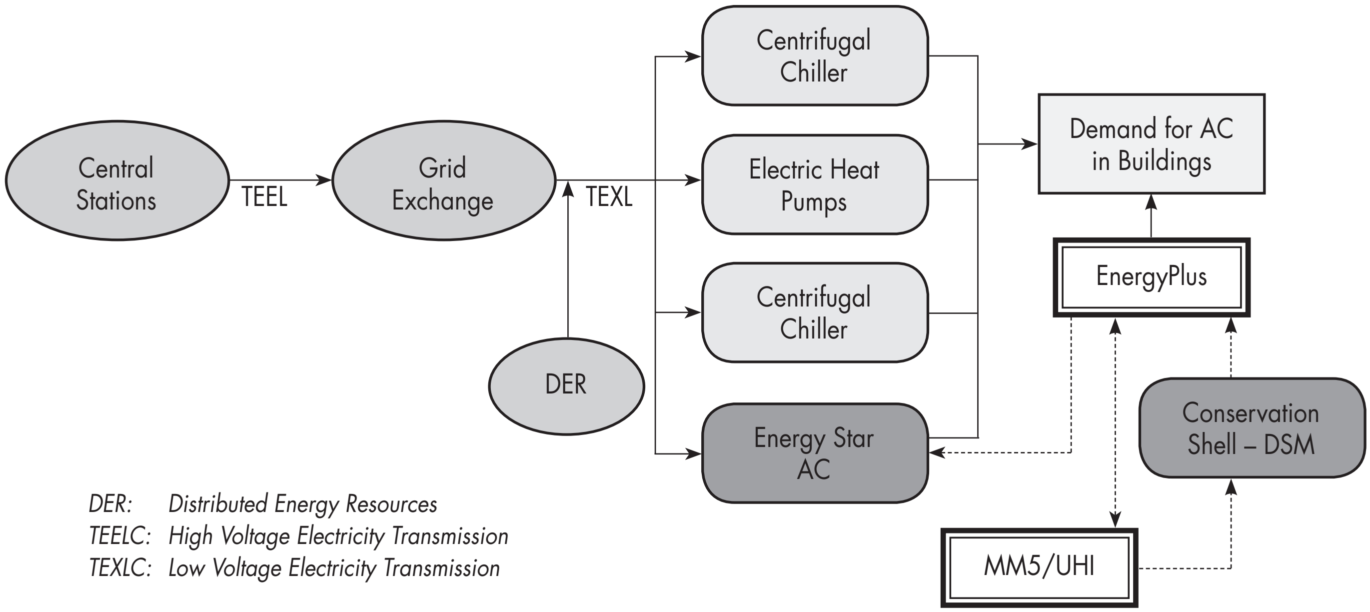

Figure 2: EnergyPlus and UHI Study Interactions with MARKAL Framework

projected reductions in waste emissions from stack gases from implementation of energy efficient technologies, the U.S. EPA Energy Star Building Program or renewable energy technology portfolios. Potential future extensions of the model to incorporate material flows into the standard model to produce an energy-materials version of MARKAL would support a broader systems approach to addressing waste minimization and pollution prevention than discussed in this report and could contribute in the future to broader adoption of ISO-14000 environmental management systems.[19]

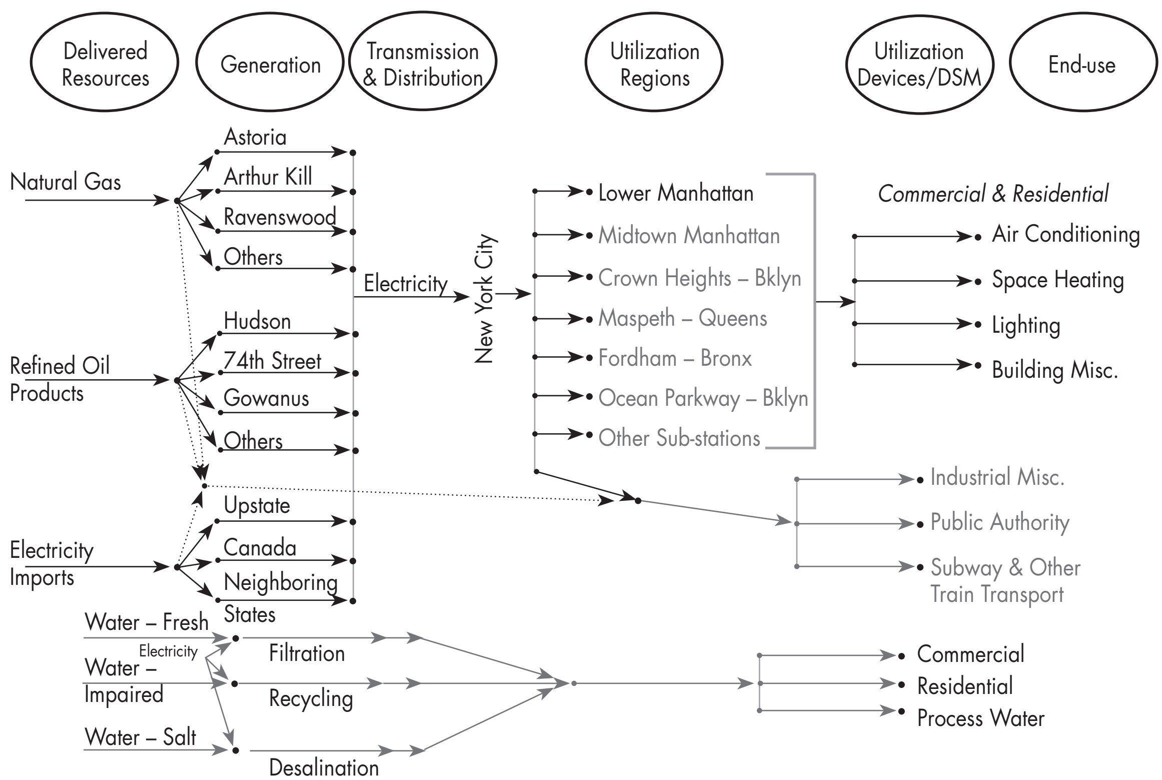

Figure 3: Reference Energy System for New York City Regional MARKAL Model[20]

MARKAL has been applied with the joint efforts of U.S. EPA and BNL, for instance, towards examining the effects of implementing Energy Star Building Program technologies in Hong Kong and Taiwan to measure reductions in energy use and subsequent CO_2 emissions.[21] U.S. EPA is currently funding a project to develop a Northeastern regional version MARKAL model ("NEMARKAL") for the six New England states. The states of New York and New Jersey may participate in the exercise once the concept is validated. The U.S. EPA Office of Research and Development ("ORD") is the principal funding agency along with in-kind contributions from state participants. Unlike the MADRI and RGGI, the NEMARKAL is a comprehensive stationary and mobile source technology evaluation tool that addresses issues from GHG reductions in the electric generation and transportation sectors, reductions of Clean Air Act criteria pollutants, and reducing energy intensity in commercial and industrial buildings. This model is intended as the pilot and flagship of a group of nine regional models for the continental United States. NEMARKAL primarily focuses on State Air Quality Programs as they are developed by the Northeastern States Coordinated Air Use Management ("NESCAUM")—an organization composed of State Government Air Quality Directors. Taking this framework into consideration, future regional MARKAL models should be developed on the structure of nation's electric grid, considering Regional Transmission Organizations ("RTOs") as boundaries for other regional models.

New York Case Study Outcomes

The integrated MARKAL/EnergyPlus/UHI framework for modeling the energy supply/demand electric loads of buildings, along with the effects of UHIs in major urban areas, provides a systematic approach toward identifying and implementing opportunities and policies for the reduction of energy system loads and related P2 metrics. This framework pulls together the recognized and widely-applied MARKAL reference energy system model, the U.S Department of Energy's EnergyPlus model for buildings, and recent UHI mitigation modeling. Taken together, these facilitate the study of electric peak loads as well as energy system supply side capacity requirements and P2 metrics.

Benefits of Urban MARKAL Model

The benefits of using integrated urban MARKAL methodology include the following:

Energy, Water, and Solid Waste Systems

- Provide reliable energy, water, and wastewater systems
- Reduction in energy use per capita (Btu/capita)
- Increased use of renewable resources
- Decreased reliance on imported fossil fuels
- Increased use of efficient appliances and green technology
- Increased use of bio-fuels and solid waste recycling
- Increased production of electricity from water treatment plants
- Decrease in energy for buildings, water supply, and treatments and transportation

Sustainability

- Reduction in water use per capita
- Increase in recycling of solid waste
- Efficient and reliable building technologies and transportation
- Reduction of GHG emissions, criteria pollutants, and other multi-media pollution

Urban Community

- Assure reliability of systems
- Provide a clean environment
- Keep energy costs as low as possible

Preliminary results obtained from this portfolio approach indicate that Energy Star and UHI mitigation strategies, employed in tandem, can potentially lead to savings in energy, P2 metrics, and system cost:

- Lower aggregate demands and consequentially, reduced supply-side requirements indicated by MARKAL.
- Reduced peak load requirement of the Lower Manhattan Sub-station, which moderately impacts the New York City's energy system peak as shown in Figures 4 and 5.
- Curtailed emissions of carbon dioxide and other criteria pollutants within the city are expressed in Figure 6.

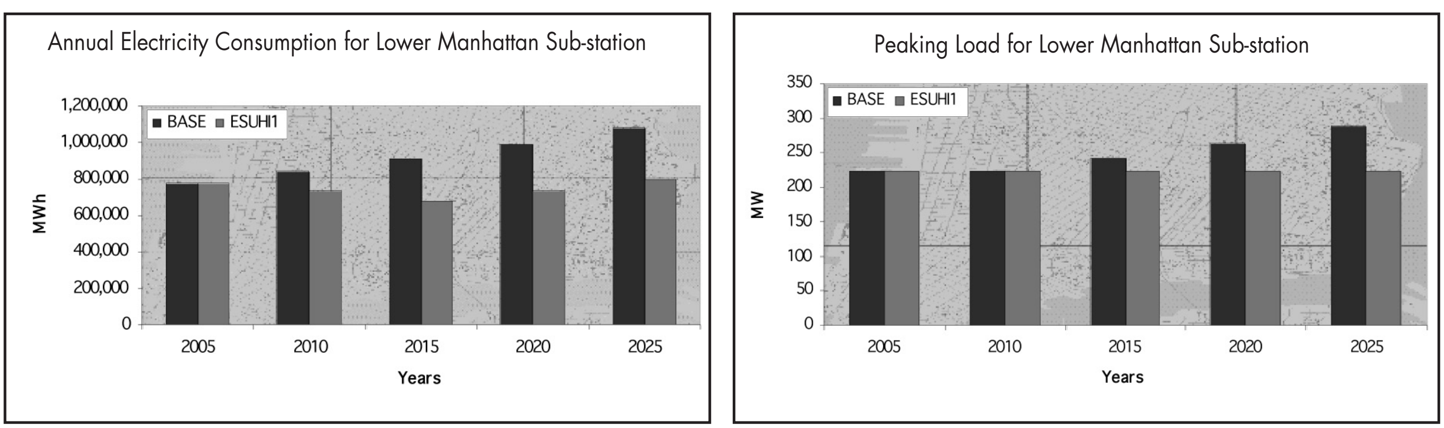

Figure 4: MARKAL Simulations for Lower Manhattan Case-study

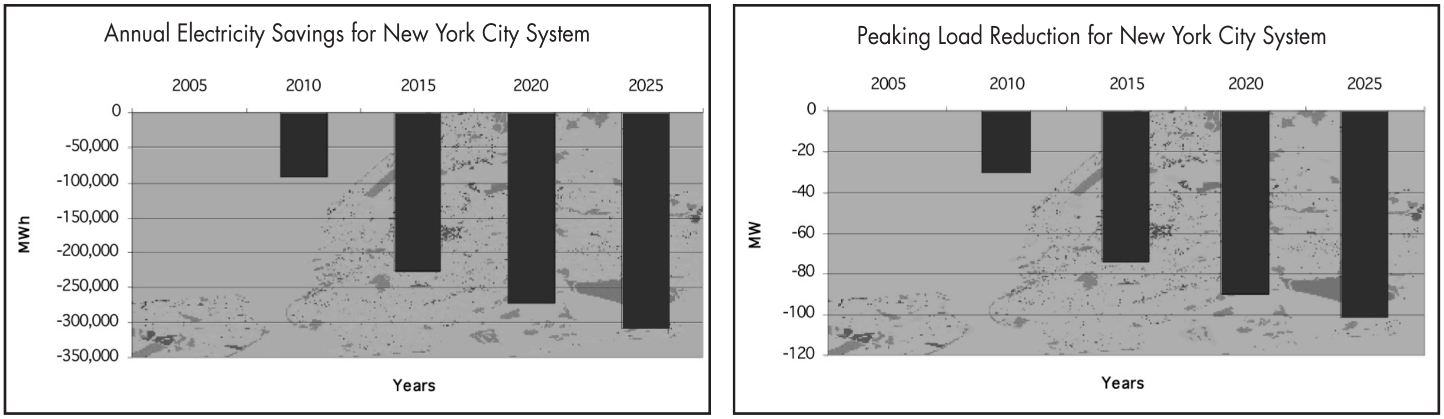

Figure 5: Impacts of Lower Manhattan Reductions on New York City Energy System

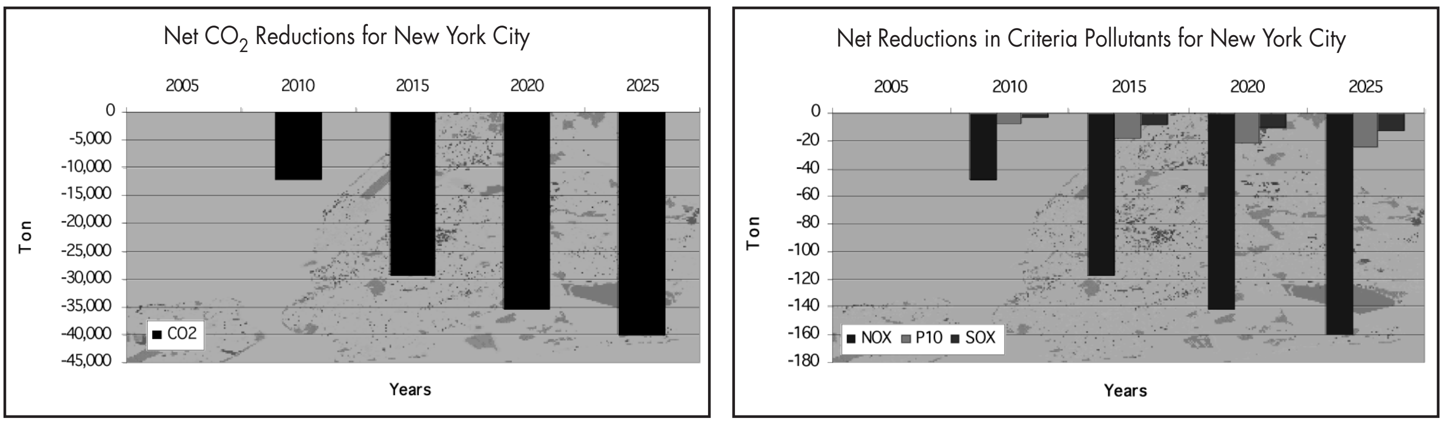

Figure 6: System Wide P2 Benefits

These activities and current programs in the U.S. EPA regions create infrastructure to study energy saving and emissions reduction strategies. The framework of the New York City MARKAL project features cooperation between different state and federal agencies, academic institutions, and the industry, highlights "validation of concept." Further "proof of concept" for necessary development mechanisms is required to create implementation projects as a next step. A new generation of programs and public and private sector partnerships, state energy agencies (e.g., NYSERDA), regional transmission grid operators and green building community can be augmented to provide effective implementation projects. Such a concept and portfolio approach can be replicated on a national level to achieve desired reductions in energy consumption to relieve grid congestions, UHI effects, and emissions.

MARKAL Integration with Other Urban Sub-systems

MARKAL models dynamic interactions among energy and water availability, supply, distribution, and consumption technologies. This novel approach uses highly interconnected formulations to represent and integrate the inherent multidimensional feedbacks with other systems important to the multi-disciplinary urban systems analysis. Examples of factors include the energy-water nexus, solid waste, transportation, land-use change, climate change, and public health, as shown conceptually in overview in Figure 7. The MARKAL methodology quantifies these relationships while accounting for evolutionary and revolutionary technologies and parametric characteristics pertaining to energy and water supply, distribution, and consumption.

This approach explicitly models fundamentally crosscutting issues and their interactions, which then determine technology performance and ultimately Research, Development, Demonstration, and Deployment ("RDD&D") expenditure decisions. Additionally, it can model endogenous technological learning and learning-by-doing formulations at the forefront of research and technology improvements over the years. Based on programmatic or research objectives, the project develops benefits metrics (measurable targets) for proposed technologies and scientific solutions, and the project then tests the technologies for water-efficient energy supply and energy-efficient water supply through scenario-based examination. These metrics help prioritize technologies for deployment on the basis of short and long-term technical, economic, environmental, and social benefits. The approach uses various sensitivity analyses to explore key technical and economic risks and barriers to the future deploy-

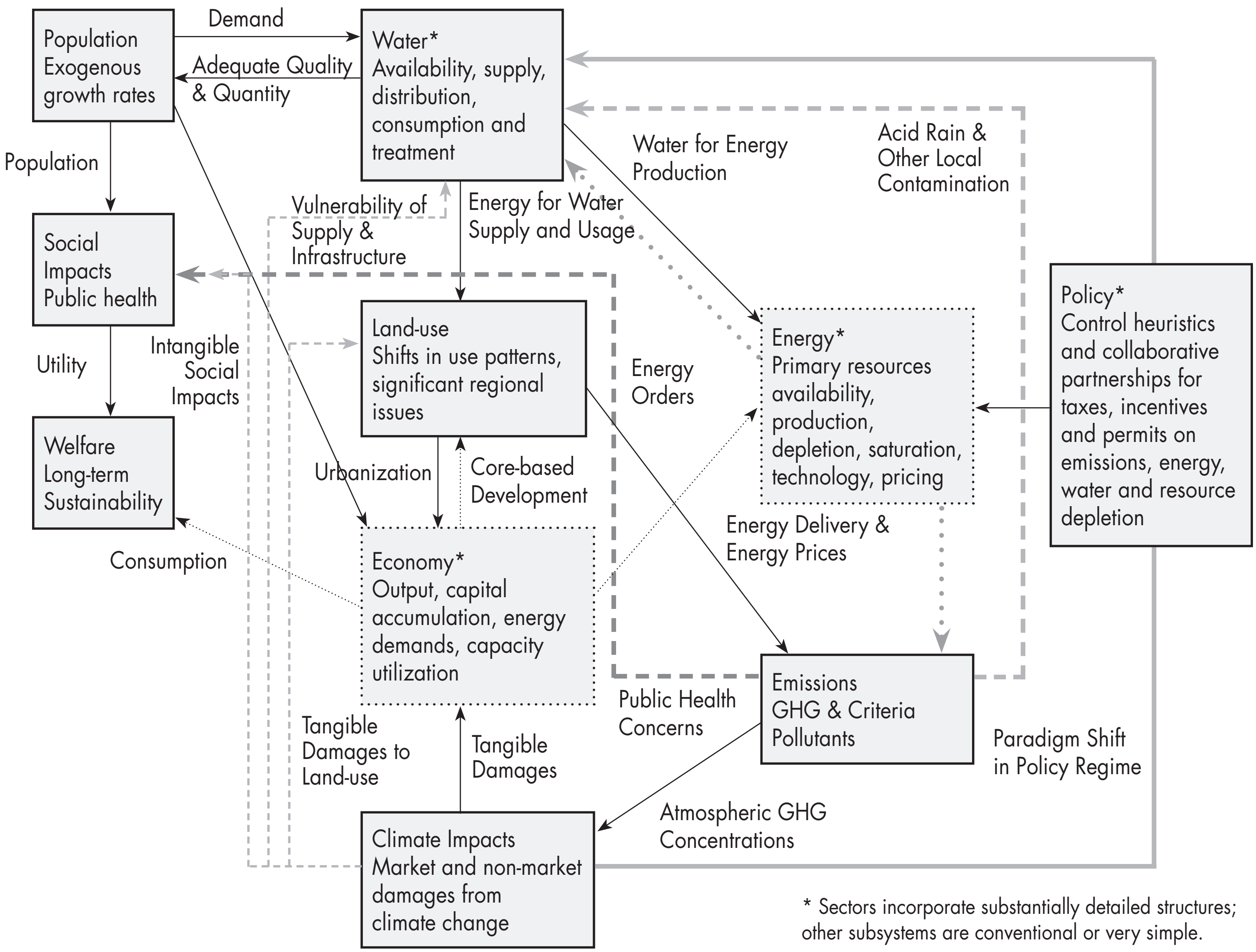

Figure 7: Major Feedback Processes Among Energy, Water, and Associated Systems to be Incorporated with the MARKAL Analysis

ment of the competing technologies. For example, the urban MARKAL methodology is able to analyze the expected benefits of solar energy and biologically-derived fuels. In addition, the MARKAL model can work with existing modeling platforms such as water body models for Chesapeake Bay, New York Harbor Estuary, and Long Island Sound to produce estimate-targets of GHG reductions from both individual media and from an ecosystem as a whole.

Successfully modeling cross-media ecosystems entails solving a number of scientific and computational challenges such as ensuring that consistent assumptions are used at the boundary of the media, and managing the large number of models and data sets that are typically required. The National Oceanic and Atmospheric Administration and the U.S. EPA Atmospheric Sciences Modeling Division jointly developed a Multimedia Integrated Modeling System ("MIMS") that provides solutions for some of those challenges.[22] MIMS is a non-substantive model architecture which allows media specific models to share and cross relate data and results, which will be used to integrate MARKAL with other proven integrating models such as the U.S. EPA Community Multiscale Air Quality Model ("CMAQ") because the alignment of stakeholders on Long Island and New York City has already been accomplished through PlaNYC and Long Island 2035.

In spite of its detailed nature, the model formulation is transparent; its behavior is clearly connected to the assumptions and causal structure of the model, and it has a simple-to-work-with model interface. It is very helpful, therefore, in creating a common understanding with stakeholder participation to address complex challenges of energy, water, solid waste, climate change, and land-use, as well as improving fundamental understanding of these interconnected sub-systems in a comprehensive approach. The model is able, but not limited to: (1) quantify water needs for the future and the amount of "new" water produced or water efficiency achieved by enabling technologies; (2) predict gaps in the regional water availability and energy sector demand and the energy saved or produced as a result of the applied technologies; (3) identify energy and water efficiency and conservation opportunities; (4) promote new science and technology for advanced water treatment and reclamation; (5) quantify environmental sustainability and energy security benefits of proposed technologies; and, (6) describe potential markets and benefits of energy-related science and technology programs, along with their energy and water-related impacts.

Conclusion

Promoting the need to accelerate adaptation and mitigation to the impacts of climate change in the New York Metro Region is where the suite of models centered on MARKAL analysis provides a unique framework with ongoing environmental planning programs. The results of these ongoing case studies can provide the analytical basis and background for future carbon control in a compressed timeframe. Combined with appropriate stakeholder participation, such case studies hold the promise of influencing the current environmental regulatory regime, including multi-media aspects of carbon control, whether at the regional or national level.

Endnotes: Analytical Tools Shaping the Next Generation of Carbon Regulation and Trading

[1] Resources for the Future, *Key Congressional Climate Change Legislation Compared in Latest RFF Document* (Oct. 31, 2007), *available at* http://www.rff.org/rff/News/Releases/2007Releases/Nov2007ClimateChangeBillsinCongress.cfm (last visited Jan. 29, 2008).

[2] Regional Greenhouse Gas Initiative Memorandum of Understanding, *available at* http://www.rggi.org/docs/mou_12_20_05.pdf (last visited Jan. 29, 2008).

[3] *See* Model Rule & Amended Memorandum of Understanding, Regional Greenhouse Gas Initiative website, http://www.rggi.org/modelrule.htm (last visited Mar. 1, 2008).

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