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URBAN/SUBURBAN SUSTAINABILITY PLANNING: MARKAL AS AN ANALYTICAL TOOL

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ABSTRACT: *This paper aims to expand the view of MARKAL (MARKet ALlocation model) as a tool that should be used at multiple spatial scales: global, national, regional, and local, in establishing and investigating the impacts of sustainability plans. As pointed out by many authors, sustainability is often vague and amorphous. The use of MARKAL makes it analytical and data driven. Further there is a necessity to elucidate that sustainability and environmental justice are tightly linked. By examining the Long Island MARKAL the nexus of sustainability and environmental justice is elucidated. Suggestions for examining, testing, and improving sustainability plans, such as PlaNYC are provided.*

Keywords: *Sustainability, Environmental justice, MARKAL*

INTRODUCTION

The aphorism "think globally, act locally," attributed to René Dubos, reflects the vision that the solution to global environmental problems must begin with efforts within our communities. We are called upon to consider the global impact of environmental issues such as acid rain, climate change, deforestation and ozone depletion while participating in grassroots actions in our own communities that can have a cumulative impact at a global scale. We can understand the injunction to embed environmental awareness within our daily lives in the context of the urgent goal of economic, environmental and social "sustainability." First used in this context by the United Nations Brundtland Commission (1987), 'sustainability' is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." In connecting the demands of economic growth with our environmental concerns, Daly (1990) characterizes 'environmental sustainability' as consumption levels that are within "sustainable limits." These limits require that our consumption of renewable resources, such as forests and fisheries, not exceed regeneration rates; our use of non-renewable resources, such as fossil fuels and minerals, should not outpace the rate at which we can develop renewable substitutes; our discharge of pollutants into the biosphere should not exceed the rate at which the environment can safely absorb and decompose them.

The past twenty years since the Brundtland Report have witnessed a number of sustainability initiatives, spanning institutions such as corporations, universities, and political entities at all levels, from nations and groups of nations to towns, and cities. One active area of research has explored the numerous sustainability initiatives undertaken by U.S. cities (Portney, 2003; 2005). One such example emerged in Levittown, New York, America's first suburb. In cooperation with Nassau County, the Citizens Campaign for the Environment and private corporate partners Green Levittown had been established. This initiative strived to improve the environment by improving efficiency and creating a more sustainable future. This initiative was ultimately unsuccessful, perhaps due to the failure to establish clear, measurable goals. Another example is PlaNYC 2030, a New York City initiative aimed at creating a sustainable New York City. This initiative, which incorporates a set of clear metrics, is ongoing, and has achieved the cooperation of a number of local stakeholders, among them the major universities within New York City. Common to these initiatives are the goals of economic, ecological, and social sustainability. Many of these plans set forth seemingly arbitrary goals without setting forth a clear standard for determining the "best" choices from among available options. In the words of Parris (2003), sustainability has "broad appeal and little specificity." Although few policy makers would balk at the notion of sustainability, we face ever-growing economic constraints and difficult choices (Hess and Winner, 2007). There is thus a clear need to establish quantifiable sustainability goals and to identify policies and technologies that will enable us to reach these ends. In this study we examine the potential use of an urban MARKAL model (MARKet ALlocation model) as a tool to quantify sustainability standards and foster rational, cost-based decision-making. The objective of this exercise is to develop and make more sustainable our energy system, a major component of any sustainability plan. At the same time we will consider the implications of energy choices on environmental justice.

Beyond energy planning, the MARKAL model can accommodate waste water treatment and solid waste disposal, two key components of the energy nexus. (This has been done with the Long Island MARKAL, an EPA funded project, carried out as a joint effort by Brookhaven National Laboratory, City University of New York, and Stony Brook University.) We anticipate that these analytical tools will be of use to policymakers and other stakeholders in determining how to best plan for the future.

MARKAL AS AN ANALYTICAL TOOL TO IMPROVE SUSTAINABILITY

MARKAL is an integrated energy systems analysis methodology used to design optimal strategies for long-term energy security, climate change mitigation and environmental sustainability at local, regional and national scales by nearly 100 institutions in more than 55 countries. The methodology comprehensively evaluates costs and benefits of alternative technology and resource use options to aid effective decision making. It identifies interdependencies of various energy sub-systems (including energy supply, production, distribution and consumption technologies and alternatives (Figure 1) and comprehensively analyzes the behavior of the entire energy system for long-term planning. MARKAL is a bottom up linear programming model that captures interactions and potential substitutions between energy forms and technologies, from conventional energy resources such as oil and natural gas to renewable energy sources such as wind and solar. MARKAL has found a range of technology and policy applications, including the determination of least-cost energy systems subject to energy and environmental policies such as: 1, restrictions on emissions; 2, required use of renewable energy resources; and 3, the introduction of energy regulations, taxes, and subsidies.

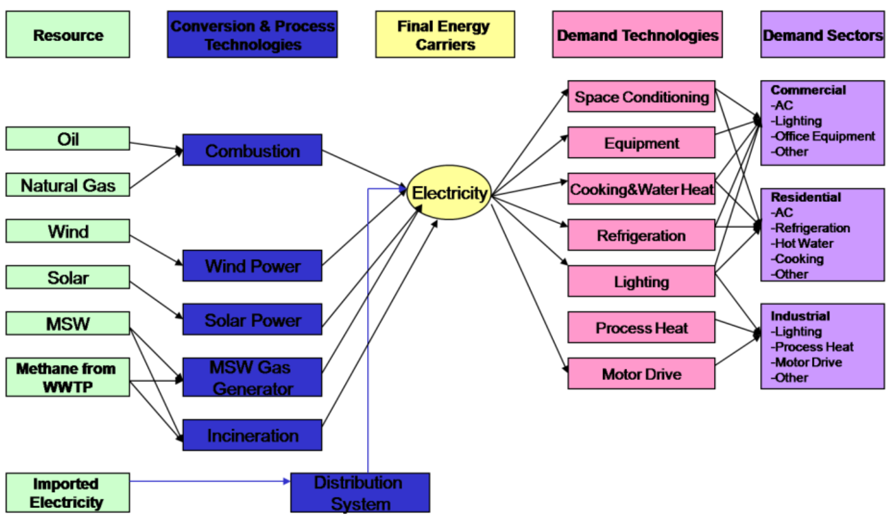

Figure 1. Simplified RES from Long Island MARKAL.

MARKAL is a dynamic and highly flexible, bottom up model which would be beneficial to policy makers investigating the possible impacts of various sustainability plans. Often noted in sustainability plans, such as PlaNYC 2030, are minimum renewable portfolios, emissions caps and taxes, and demand side management ranging from peak shaving to efficiency standards (e.g., Energy Star). MARKAL provides a framework for analyzing the impacts to these types of policy changes over various planning horizons.

The economic and environmental impact of proposed energy technologies and policy instruments will be estimated with respect to a baseline, "business-as-usual" scenario. This baseline represents our best projection of energy use and emissions over the planning horizon. The backbone of this model is captured by the MARKAL Reference Energy System (Figure 1). The Reference Energy System requires input data (actual and projected) from primary energy supply (e.g., diesel fuel imports), intermediate conversion and process (e.g., electricity generation), to end-use technologies (e.g., computer) that satisfy energy service demands (e.g., office equipment). Every component in the RES (Reference Energy System) is characterized by three groups of data: technical (e.g., efficiency), economic (e.g., capital cost), and environmental (e.g., carbon emission coefficient).

Long Island specific and regional historical energy demand-supply data were used to establish the base year (2005) RES in the Long Island MARKAL model. This model represents a "proof of concept" that MARKAL can be used to jointly model waste water, municipal solid waste and energy systems. These linkages provide policy makers with an invaluable tool for addressing a broad range of energy and environmental policies. The base year RES provides a balanced stance (partial equilibrium) based on which future energy-environmental-economic scenarios can be formulated. If no Long Island specific data were available (characteristics of a specific technology, existing or future), they were taken from many existing MARKAL databases in the world community as a starting point.

The baseline case (2005-2050) is driven by the projected energy service demand (DM) in the Model. The projections of these energy service demands utilize the econometric equations estimated in New York City MARKAL. This involves the insertion of the latest or updated projection values (2010-2050) of the explanatory variables (drivers) into the energy end use projection equations. Although the Baseline Case projects a "business as usual" energy system path by incorporating existing and planned measures and development programs into the model, it should not be taken as the prevailing energy market for the future in the absence of additional mitigation policies and measures. Rather, it only provides a reference basis to evaluate impacts of additional alternative scenarios representing recommended policies and measures. Figures 2, 3, and 4 show the output of the base case scenario run on the Long Island MARKAL, in regards to energy use in electricity generation, electricity supply by source, and electricity demand by sector, respectively.

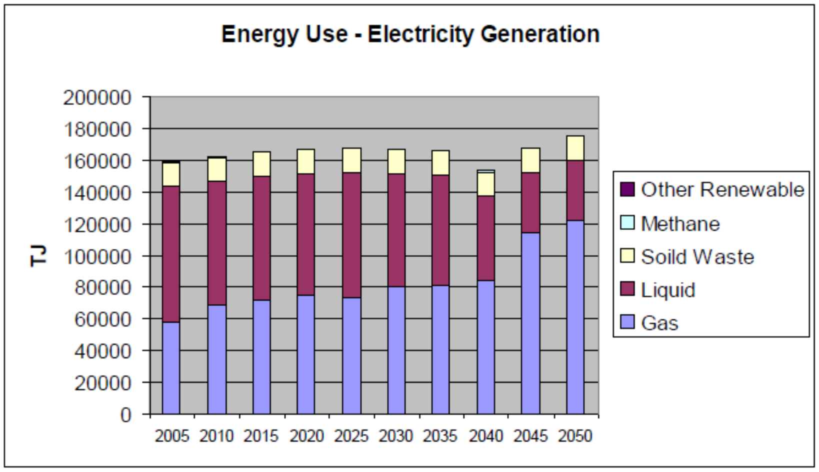

Figure 2. Energy use by electricity generation from LI MARKAL.

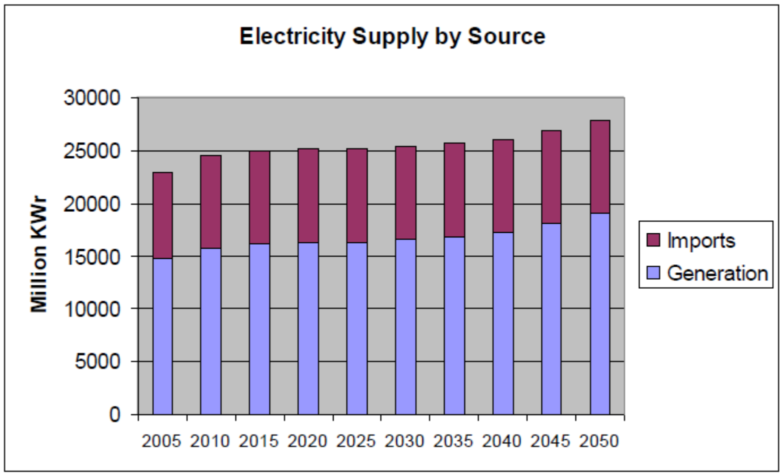

Figure 3. Electricity supply by source from LI MARKAL.

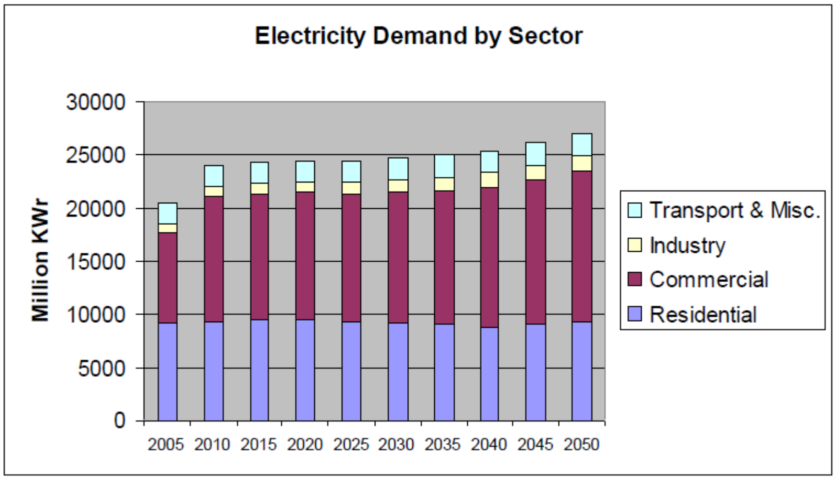

Figure 4. Electricity demand by sector from LI MARKAL.

Once the base case has been established, scenarios called for in sustainability plans can be run and analyzed. Possible scenarios include:

- Carbon Tax or Cap and Trade policies: Both taxes and caps on carbon dioxide emissions have been proposed as a method for combating possible human induced global warming. A wide range of proposals to impose mandatory caps on U.S. greenhouse gas emissions have been introduced in the U.S. Congress (Paltsev et al., 2008). A carbon tax on carbon dioxide emissions could be somewhat simply implemented into MARKAL, as carbon content of fossil fuels used are easy to calculate and trace (Fullerton, 2001). The burden of such a tax would be distributed over all areas (residential, commercial, industrial, etc.) and will help environmental protection (Pehlivan and Demirbas, 2008). By raising the variable costs of producing electricity from fossil fuels an incentive will be established to shift towards cleaner technologies (Green, 2008). MARKAL allows for both caps and taxes to be incorporated into the model. This specific scenario has been run on the Long Island MARKAL model. Results of this scenario can be used beyond carbon emissions and cost. The environmental justice section of this paper explains how these results have been used to examine equity issues on Long Island.
- Minimum Renewables Portfolio Standards: Another possible policy scenario could be the implementation of minimum renewable energy sources, as per the NYS Renewable Energy Portfolio Standard (RPS). According to NYS Public Service commission mandate, enacted by Governor Paterson by 2015, 30% of all retail electricity must be from renewable sources (http://www.nyserda.org/rps/index.asp). This number was increased from a previous level of 25% by 2013. Currently there are 24 states, in addition to the District of Columbia, that have enacted RPS policies. These states account for more than half of US electricity sales (http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm). MARKAL allows for minimum renewables by incorporating a constraint equal to the desired minimum renewable and defining each electricity generating technology as renewable or non renewable. The model is flexible in allowing the standard to change over time, for example, 25% renewable by 2013 and 30% renewable by 2015. This is frequently done in MARKAL models, but has yet to be carried out in regards to a specific sustainability plan.
- Goals for market penetration of new efficient goods, legal changes such as banning incandescent light bulbs, or mandating standard minimum efficiencies for various demand devices: MARKAL is a bottom up model and as such great detail can be included in the demand side of the problem. Demand devices or end use devices, such as specific types of lighting or air conditioning, can be specified by the model. Newer, more efficient devices may be included into the analysis with set market penetrations going forward in time. Further, the elimination of various types of technologies may be analyzed, such as phasing out incandescent light bulbs, as is being done in the European Union (European Commission on Energy) and in California (AB 1109, signed into law October 12, 2007).

An example of an Urban Sustainability Plan that could be modeled using MARKAL is PlaNYC 2030. PlaNYC has six major areas of focus in regards to sustainability: land, water, transportation, energy, air, and climate change. Although each of these areas is interconnected, the key is energy. Energy is the driving force of transportation, has a major impact on our land, water, and air, and plays a role in climate change. Many of the 14 initiatives in PlaNYC's energy initiatives can be modeled in MARKAL to help policy makers establish and meet their goals, for example:

- Initiative 2: "Reduce energy consumption by City government - We will commit 10% of the City's annual energy bill to fund energy-saving investments in City operations." The PlaNYC 2030 report gives the example of using LED stoplights as one investment that will lead to energy-savings. There are countless end uses that can incorporated into MARKAL's bottom up structure. By running scenarios with varying market penetrations a greater savings could possibly be achieved, at a lower cost.
- Initiative 3**: "**Strengthen energy and building codes for New York City." This initiative calls for the establishment of regular building code reviews on a three year cycle. Scenarios could be run on the incorporation of something as small as mandating CFLs, or establishing rules for new construction related to LEED or Energy Star standards.
- Initiative 8: "Facilitate repowering and construct power plants and dedicated transmission lines." This calls for one of three scenarios: repowering existing power plants, building new power plants, and/or building new facilities outside of NYC. All three of these options, with varying technologies and facility sizes can be placed into the MARKAL model.
- Initiative 9: **"**Expand Clean Distributed Generation ('Clean DG')." Much like in initiative 8, MARKAL allows for varying technologies to be pitted against one another, with the optimal solution being chosen.
- Initiative 11: "Foster the Market for renewable energy." Within MARKAL, a minimum renewable scenario can be run. As NYS is mandating 25% of its electricity be derived from renewables, by 2013, a local NYC minimum renewable scenario can be run. Further, should the City establish projects for various sized renewable, such as solar, once incorporated into the model, the impacts on the rest of the sector can be determined. Another area of concern is waste-to-energy and wastewater treatment. MARKAL has recently been shown to be able to model wastewater treatment, municipal solid waste, and energy in the Long Island MARKAL (Lee et al., 2009). This could be carried out in NYC as well.

ENVIRONMENTAL JUSTICE

Oran Young stated that environmental equity is "a matter of taking steps to ensure that the rich and powerful do not insulate themselves from environmental harm largely by displacing problems on to the poor and weak." The Environmental Justice Movement is generally agreed to have been developed in the US during the 1970s primarily as a result of racially divided siting of environmental risks, waste management being the major issue (Harvey, 1996; Dobson, 1998; Agyeman, 2002). The United Church of Christ's Commission for Racial Justice report in 1987 is seen as a seminal paper that pushed environmental justice to the mainstream, with many other papers following it. Bowen (2002) reviewed 42 such environmental justice papers and noted many flaws in statistical analysis and overall methodology. Been (1994) posed an interesting question; what came first, the hazard or the population? But regardless of when these locally unwanted land uses were established, it is important that no one group feels the brunt of there effects.

Environmental justice is "more than just distribution" of "environmental ills," it is also about participation in the environmental policy making process. This participation can promote policies and actions that link sustainability with environmental justice. Faber and McCarthy (2001) call for "sustainability and environmental protection," as a means to ensure a more "socially and ecologically just society." Further, environmental justice is ultimately about sustainability, as environmental justice leaders have fought hard against the label of NIMBYs (Not In My Backyard) and in turn proclaiming themselves NIABYs (Not In Anyone's Backyard) (Dowie, 1995).

By establishing sustainability plans and analyzing the results with MARKAL, one could determine the impacts on environmental justice in a given area. For example, if peak demand is lowered, more heavily polluting peaking plants may not have to operate. By comparing various transportation technologies (e.g., hybrid, diesel, clean diesel, natural gas, etc) one could improve ambient air quality in urban asthma hot spots. By improving sustainability, the economy, environment, and equity of a region improve (Campbell, 1996). Unfortunately, few cities combine environmental justice with sustainability (Warner, 2002). MARKAL provides an opportunity to analytically do this. An example of this is seen in a carbon tax scenario run on the Long Island MARKAL. The results of a $10 flat tax on carbon emissions is a 3.1% lower cumulative cost and 6.4% cumulative drop in CO_2 emissions. The first plants to be dropped by the model are older, more heavily polluting technologies.

The impacts on environmental justice of a policy change can be seen in the case of the Northport Power Plant (1,564 MW Capacity), one of the largest oil burning plants on the East Coast and which has been grandfathered to not meet Clean Air Act standards, as it was built in the 1960s and ‘70s. When the baseline model is run, the facility continues to run, producing 24064.54 TJ of electricity each year, until 2040. By running a carbon tax scenario of $10 per ton, the facility begins to phase out by 2010; shedding 10,000+ TJ of primarily oil based capacity, in favor of cleaner natural gas. By 2030, newer, smaller capacity technology natural gas combined cycle facilities that are over 60% more efficient are substituted into the mix. The impacts of these facilities can be spread over a larger area, thereby not solely influencing one group.

CONCLUSION

Sustainability and sustainability plans are generally nonspecific and lack clear analytical data and often ignore or fail to provide clear data in regards to environmental justice. MARKAL provides a possible solution to these problems. The Long Island MARKAL has been used to test the impacts of a carbon tax on the electricity generating system of the local area. Further, it has been used to determine the impacts on environmental justice in regards to electricity generating facility locations. This paper provides ideas for using MARKAL to test, develop, and improve sustainability plans at varying special scales.

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