Cost Effective Contributions to New York's Greenhouse Gas Reduction Targets from Energy Efficiency and Renewable Energy Resources

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ABSTRACT

This paper summarizes the results of a comprehensive analysis of the potential for energy efficiency and renewable energy resources in New York. The study includes characterization and market analysis of over 3,400 efficiency measure permutations and 30 renewable energy technologies. A key element of the study is the development of an integrated supply curve for achievable efficiency savings and renewable energy generation. This curve identifies the least-cost portfolio of investments in efficiency and renewables needed to meet reduced levels of conventional (i.e., fossil fuel) electricity generation. Projecting from market intervention strategies that have proven successful in the past, the study concludes that efficiency and renewable energy could be expected to reduce New York State's electricity generation requirements by more than 19,939 GWh annually by 2012, and by more than 27,244 GWh by 2022. This energy represents 12.7% and 16.1% of expected statewide requirements for those years. These contributions could be achieved at a net levelized energy cost of less than 3 cents per kilowatt hour, which is below those of the conventional electric generation they would avoid. The total net resource benefits attained by implementing the least-cost mix of renewable and efficiency resources are estimated to exceed \$4.5 billion in 2012 and \$9 billion in 2022[1]. The results support the conclusion that New York will be significantly better off economically if it pursues a least-cost portfolio of efficiency and renewable energy resources to meet its electric sector's greenhouse gas reduction targets.

Introduction

The New York State Energy Research and Development Authority (NYSERDA) commissioned this study of the long-range potential for energy-efficiency and renewable energy technologies to displace fossil-fueled electricity generation New York. The study, which drew impetus from the State Energy Plan[2], examined the potential available from existing and emerging efficiency technologies and practices to lower end-use electricity requirements in residential, commercial and industrial buildings. The study also estimated renewable electricity generation potential from biomass, fuel cells, hydropower, landfill gas, municipal solid waste,

[1] Results are presented in 2003 real dollars throughout this paper.
[2] New York State Energy Planning Board, *New York State Energy Plan and Environmental Impact Statement*, June 2002.

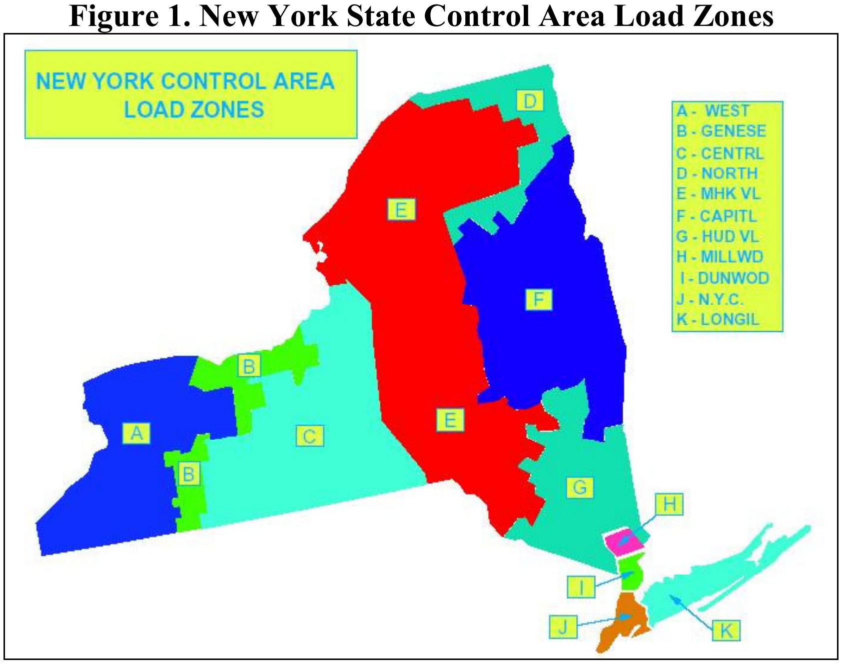
solar, and wind. The study assessed New York's efficiency and renewable potential over three time horizons: five years (through 2007), 10 years (through 2012), and 20 years (through 2022).

The study had four main objectives:

- Estimate the technical potential or theoretical maximum amount of electricity physically able to be displaced by efficiency and renewable energy technologies, both throughout New York State and in each of five control area load zones within the State.
- Of this technical potential, determine how much efficiency and renewable energy would be economical compared with conventional generation that they would avoid, both statewide and in the five specified zones.
- Working from the theoretical analysis of statewide technical and economic potential, estimate how much electricity New York could realistically expect efficiency and renewable energy resources to displace as part of a least-cost solution to the State's greenhouse-gas reduction targets established for the electricity sector over the next ten and twenty years.
- Independently assess the impacts throughout New York from currently planned energy policy and program initiatives.

The study includes separate analysis for five of the State's eleven load zones depicted in Figure 1.1: West (Zone A), Capital (Zone F), Hudson Valley (Zone G), New York City (Zone J), and Long Island (Zone K).

Figure 1. New York State Control Area Load Zones



Scope of Efficiency and Renewable Energy Potential Analysis

The study examined literally thousands of efficiency and renewable applications to different buildings, industries and markets. Table 1 indicates the number of efficiency technologies and practices analyzed in each of the residential, commercial, and industrial sectors.

This table also shows the different markets in each sector to which these technologies and practices were applied, along with the end-uses and the market segments covered in the potential analysis. In the commercial sector, for example, Table 1 shows that the study examined 87 technologies and practices applicable to nine end-use categories in four markets involving nine building types. Thus, the commercial efficiency potential analysis dealt with 2,163 technology and practice applications.

Table 1. Technologies and Practices Examined in the Efficiency Potential Analysis

	SECTOR:		
	RESIDENTIAL	**COMMERCIAL**	**INDUSTRIAL**
Number of Technologies	**50**	**87**	**39**
Markets	New construction	New construction	New construction
	Retail product sales	Renovation	Process overhaul/Replacement
	Retrofit	Remodel/Replacement	Retrofit
		Retrofit	
End Uses	Cooling	Cooling	Motor systems
	Lighting	Exterior lighting	Lighting
	Space heating	Interior lighting	HVAC
	Water heating	Office equipment	Industry-specific processes
		Refrigeration	
		Space heating	
		Water heating	
		Whole building	
		Miscellaneous	
Market segments	**2 building types:**	**9 building types:**	**4 industry sectors:**
	Single family	Education	Manufacturing
	Multifamily	Grocery	Agriculture
		Health	Mining
		Lodging	Construction
		Office	
		Restaurant	22 specific industries
		Retail	
		Warehouse	
		Other	

Table 2 provides the breakdown of technology applications studied in the renewable energy potential analysis. In all, the analysis examined 32 configurations of the eight renewable energy technologies studied.

Table 1.2 Technologies Examined in the Renewable Potential Analysis

Table 2.Technologies Examined in the Renewable Potential Analysis

Biopower	**Municipal Solid Waste**
Biomass Cofiring with Coal	Waste-to-Energy Large
Biomass Gasification	Waste-to-Energy Small
Biomass Combined Heat and Power	Solid Waste Digestion
Fuel Cells	**Photovoltaics**
Fuel Cell Polymer Electrolyte Membrane	Photovoltaic Residential
Fuel Cell Phosphoric Acid	Photovoltaic Commerical/Industrial
Fuel Cell Solid Oxide	Photovoltaic Building Integrated
Fuel Cell Molten Carbonate	
	Solar Thermal
Hydro Power	Residential Domestic Hot Water
Hydro Relicense	Commerical Domestic Hot Water
Hydro Repower	Commerical/Industrial Ventilation Pre
Hydro Expanded Capacity Existing Dam	Solar Absorption Cooling
Hydro New Dam sites	
	Wind
Landfill Gas	Wind Farm Installations
Landfill Gas Large Systems	Cluster Installations
Landfill Gas Engines	Small Wind Installations
Landfill Gas Microturbines	Offshore Wind Installations

Technical and Economic Potential Analysis

The technical potential for efficiency and renewable energy represents the theoretical outer bounds of the electricity resources physically available for exploitation, without any regard for cost or market acceptability. By itself, technical potential has no direct applicability to policy or resource planning, which requires information about these characteristics of efficiency and renewable resources. Consequently, the technical potential estimates in this study were only used as the foundation for further analysis.

The economic potential for efficiency and renewable energy is the sub-set of the technical potential that is available at costs below the projected costs of the conventional electric generation. For this study, NYSERDA provided values for avoided electricity generation and fossil fuel costs through 2022 for each of the five load zones analyzed. The study assessed statewide economic potential twice, using the lowest and highest zonal avoided costs.

The same caveats on the use of technical potential results apply to economic potential. Since it is derived directly from technical potential, economic potential likewise does not represent achievable potential and therefore cannot be directly applied in policy making or resource planning. As is the case with technical potential, the economic potential estimates have meaning only as inputs to further analysis (such as in planning for programs targeted toward specific amounts of electricity savings from efficiency or renewable energy technologies in particular markets).

Achievable Potential Scenario Analyses

The study's analysis of achievable potential from efficiency and renewable energy adds two key ingredients missing from the technical and economic potential analysis:

- Market barriers to acceptance of efficiency and renewable energy technologies and practices that could potentially be overcome through targeted policies and market intervention strategies; and,
- Additional administrative costs of such programs and policies to promote higher market acceptance of efficiency and renewable energy technologies.

This study analyzed two distinct achievable potential scenarios:

- Potential contributions toward meeting the State's GHG targets; and,
- Expected achievements under currently planned initiatives

For each of these two achievable potential scenarios, the study estimates electric energy and peak capacity impacts. It also projects and compares efficiency and renewable energy resource benefits and costs to New York's economy.

For this study the electric energy offsets required to meet statewide GHG reduction targets for 2010 and 2020 are based on the 2002 State Energy Plan. For the year 2010, the target is a 5% reduction from 1990 levels; for 2020, it is a 10% reduction from 1990 levels. The study interpolated the target values for 2012 and extrapolated the target value for 2022 in order to correspond with the study's analysis horizon, which produced GHG target values of 19,939 and 27,244 GWh for each year, respectively. To meet these electric energy targets at the lowest possible total cost to New York's economy, the analysis chooses the least-costly contributions first, moving progressively up the cost curve until the target is met or achievable resources are exhausted, whichever comes first.

Results

The technical and economic potentials (using both high and low avoided costs) for efficiency and electric energy from renewable resources are depicted in Figure 2. This figure represents the cumulative annual contributions from 2003 up to and including 2007, 2012, and 2022.

Technical potential from efficiency measures remains flat or grows only slightly over the study's 20-year horizon. This is attributable to two opposing influences. Projected growth in electricity use in new construction, and increasing electricity saturation of some end uses in existing buildings (e.g. residential air conditioning), both increase opportunities for efficiency savings. This growth in efficiency potential is at least somewhat offset by expected improvements in base-case efficiency levels. In contrast, technical potential from renewable energy resources grows substantially (as indicated by the bottom segment of the bars in Figure 2). There is greater growth in the technical potential for renewable energy because, unlike efficiency potential, the potential for renewable energy supply is largely independent of underlying electricity requirements. The technical potential for renewable energy depends much more on changes in manufacturing and delivery capacity over time. For example, the growth in technical potential for photovoltaic electricity is driven by the ongoing rapid expansion in worldwide photovoltaic cell manufacturing capacity.

The results represented in Figure 2 indicate that the relative shares of efficiency and renewable energy technical potential change over time. In 2007, efficiency resources comprise most of the technical potential for electric energy, with the greatest potential arising in the commercial sector. By 2022, however, the technical potential for renewable energy supply surpasses the potential for efficiency, as higher efficiency levels become increasingly embedded in the electricity forecast over time.

Figure 2. Technical and Economic Potential for Electric Energy from Efficiency and Renewables in New York State (Annual GWh)

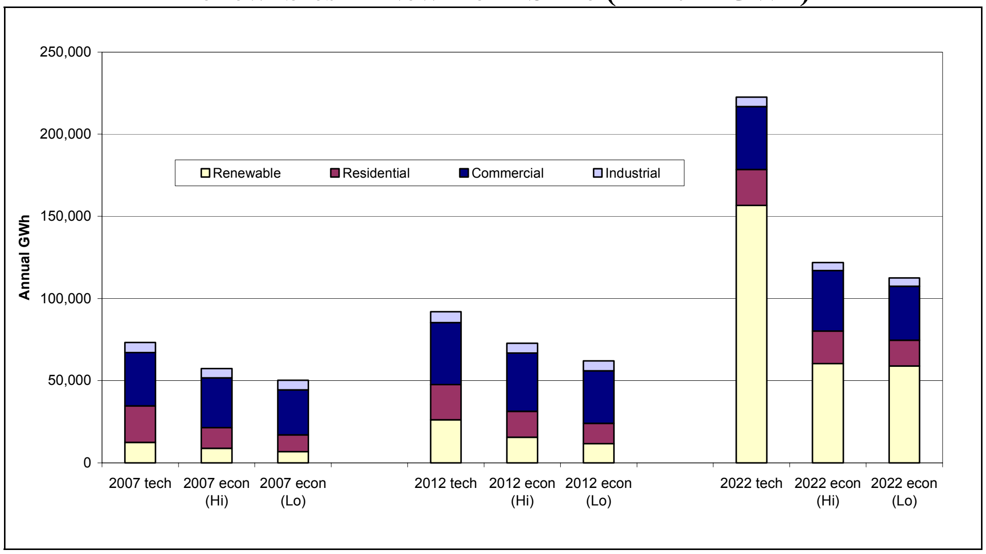


Figure 3 shows the breakdown of economic potential for renewable energy and efficiency in the residential, commercial, and industrial sectors in 2012, the mid-point of the study horizon.

Figure 3. Statewide Economic Electric Energy Potential in 2012 (% total by Sector)

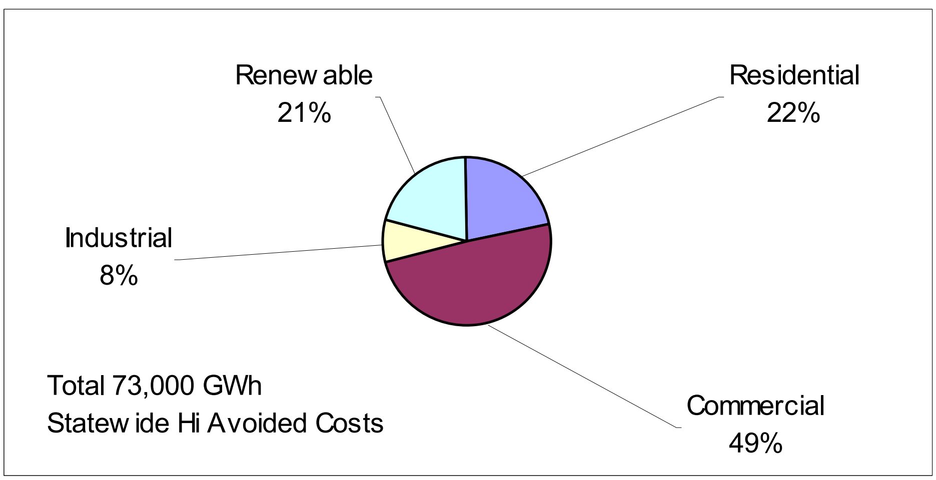
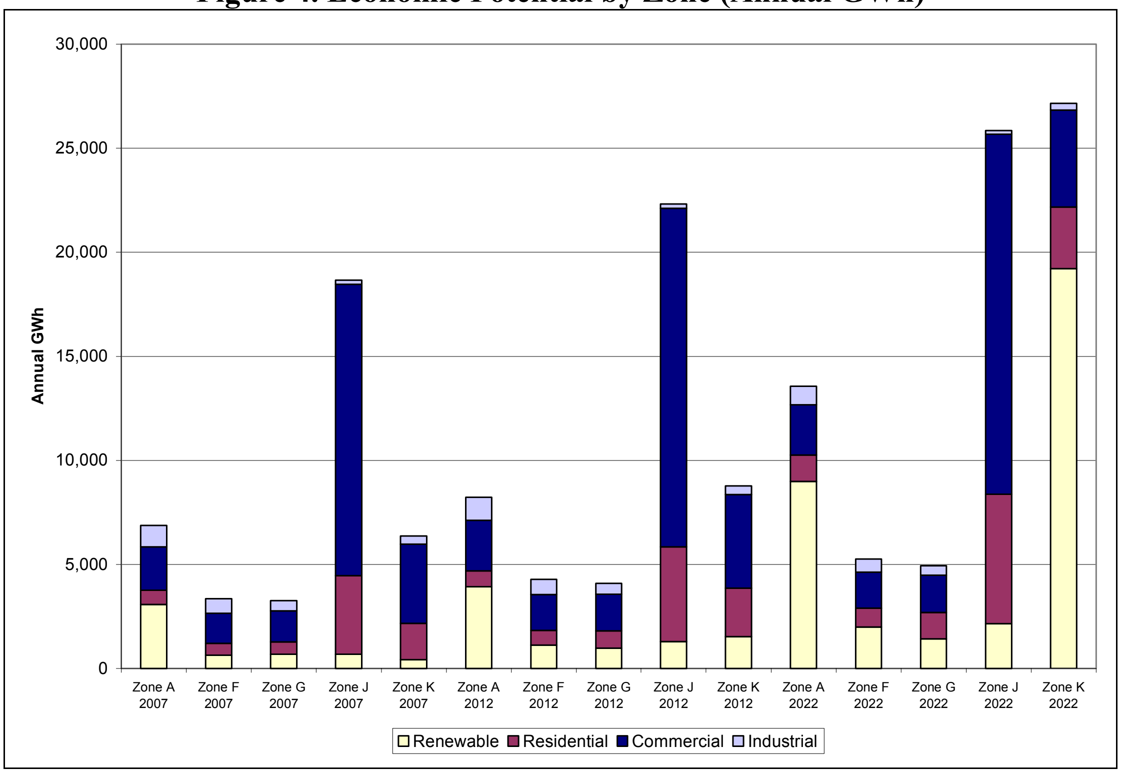


Figure 4 portrays the economic potential for efficiency and renewable energy within each zone analyzed.

Achievable Efficiency and Renewable Contributions Toward New York's GHG Reductions

The study produced two kinds of results from the analysis of achievable contributions toward GHG reductions. The first is a set of two cost "curves" for achieving reductions in fossil-fueled electric energy generation requirements that contribute toward meeting the statewide GHG reduction goals. The first curve (Figure 5) is for achieving a reduction of 19,939 GWh in 2012. The second curve (Figure 6) represents a reduction in 2022 of 27,244 GWh. These reductions would lower electricity use by 11.0% in 2012 and 14.1% in 2022 from the base-case forecast of electricity requirements.

Figure 4. Economic Potential by Zone (Annual GWh)

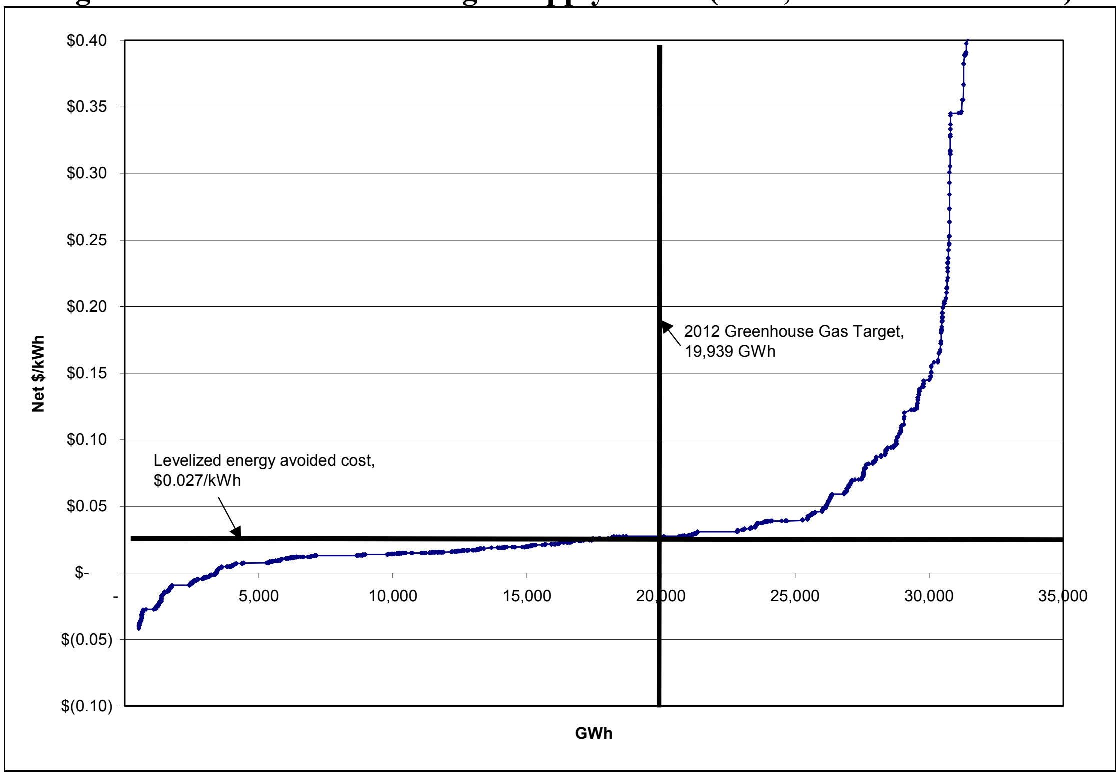


Each point on these two curves represents a particular amount of efficiency or electric energy supply (in GWh) at a specific levelized cost per kWh (over the life span of the resource, in 2003 real dollars, using a real discount rate of 4 percent). The points are sorted and presented in order of increasing cost per kWh.

To obtain more achievable electric energy from efficiency and renewable resources, it is necessary to move to the right on the curve and choose progressively more costly sources. The area under the curve represents the total costs of obtaining any given amount of electric energy supply. The vertical line represents the GWh reduction goal for each year. Thus, the area under the cost curve up to the vertical line of the GWh reduction goal indicates the total cost of meeting it. The dark horizontal line represents the average energy avoided cost per kWh. The total area under the horizontal line represents the total benefits to New York from achieving the GWh reductions. Consequently, the area below the horizontal line and above the cost curve represents the net economic benefits to New York from pursuing the least-cost strategy.

Figures 5 and 6 demonstrate the study's finding that achievable efficiency and renewable energy resources would be more than enough to meet New York's long-range GHG reduction goals for the electricity sector. These figures also demonstrate the study's finding that New York could do so economically, that is, at costs below the avoided conventional electric generation displaced by efficiency and renewable energy. These achievable contributions could be realized at net costs below three cents/kWh.

Figure 5. Greenhouse Gas Target Supply Curve (2012, Low Avoided Costs)

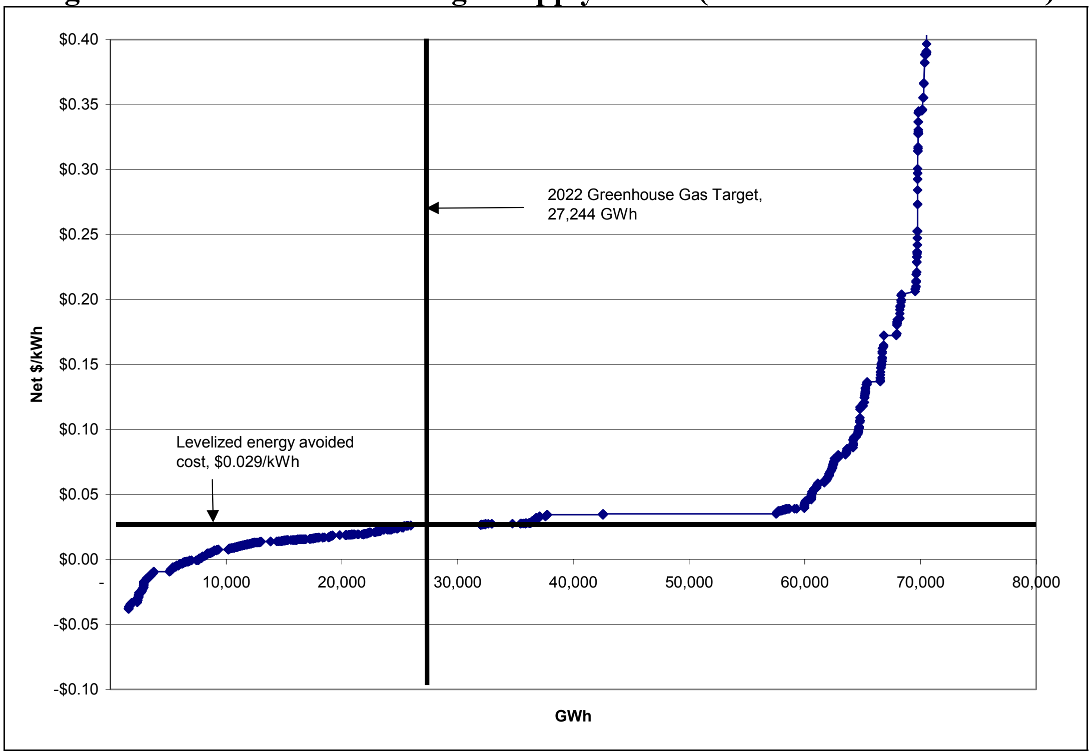


The study found that achievable costs of these contributions start at a negative $1.24/kWh of savings from industrial efficiency improvements. The most expensive analyzed achievable measure costs $6.87/kWh for a residential well water pump upgrade. The study obtained negative values for some efficiency and renewable energy resource costs because it subtracts the value of non-electric resource savings (such as fossil fuel) as well as avoided generating capacity costs from the achievable costs of the technologies.

Figure 5 indicates that the most expensive resource selected to meet the GWh reductions would cost $0.026/kWh for 2012, which is the achievable cost for retrofitting office lighting with high-efficiency fixtures along with better layout design. In Figure 6, the most expensive resource deployed to meet the target in 2022 would be wind farm installations, also costing $0.026/kWh.

Significantly, the study found that even the most expensive resources chosen to meet the targets could be achieved for less than the average avoided cost of electric energy. This indicates that the least-cost greenhouse gas solution would be cost-effective for New York. Figures 5 and 6 further demonstrate that additional efficiency and renewable energy contributions could be achieved beyond these GWh reduction goals at costs that would still be economical compared with conventional electricity supply they would avoid. Observe that the cost curve extends beyond the vertical line while remaining below the horizontal line representing the average annual avoided cost over the period in question (2012 or 2022).

Figure 6. Greenhouse Gas Target Supply Curve (2022 Low Avoided Costs)



The second set of results indicates the mix of efficiency and renewable energy resources that would be part of a least-cost portfolio to achieve the GHG reductions. This second set of results also projects and compares the benefits and costs of the least-cost portfolio. Figure 7 shows the resource composition of the least-cost greenhouse-gas solutions found in the study for meeting the 2012 GWh reductions. The least-cost solution for the 2012 goal would consist primarily of efficiency resources, which are dominated by commercial sector savings. Biomass, hydropower, MSW, and solar thermal would be the renewable energy resource contributions to the least-cost GHG solution in both 2012 and 2022, with a large amount of windpower added to the mix in 2022.

Tables 3 and 4 present the benefit and costs values underlying the achievable GWh reductions for 2012 and 2022, assuming low avoided costs. They indicate the least-cost solutions would be economically advantageous for New York.

The study found that the net economic benefits to New York from pursuing this least-cost approach to meeting GHG reductions for 2012 are estimated at between $4.5 billion and $9.4 billion (using low and high avoided costs respectively). This means that New York would be better off economically if it pursued a least-cost portfolio of efficiency and renewable resources to meet its GHG targets, compared to the base case of doing nothing in the future to increase efficiency and renewable development. The net economic benefits of the least-cost GHG solution also significantly exceed those estimated by the study from currently planned initiatives. The lower and upper ends of this range of net benefits from least-cost GHG reductions is the result of valuing efficiency and renewable energy benefits at the lowest and highest zonal avoided supply costs, and subtracting the total resource costs of achieving them. By 2022, net benefits from pursuing economically achievable efficiency and renewable energy contributions toward New York's GHG reductions would range between $9.1billion and $16.6 billion. Thus, as stated in the abstract, the total net economic benefits of achieving these reductions are estimated to exceed $4.5 billion in 2012, and $9.1 billion in 2022, even if low statewide avoided costs are used in the analysis.

Figure 7. Greenhouse Gas Scenario 2012 GWh Savings by Sector

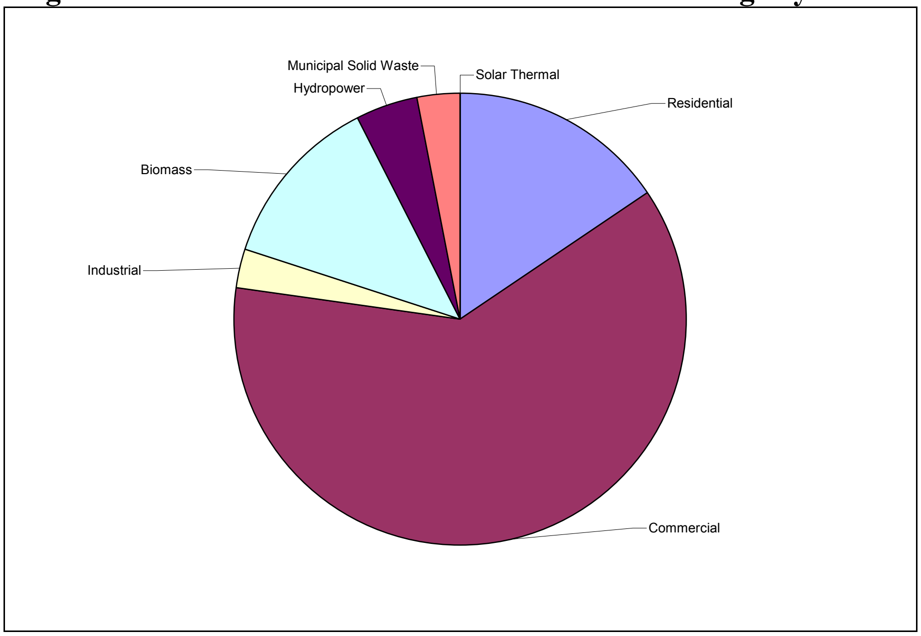


Table 3. Benefits and Costs of Least-Cost Efficiency and Renewable Achievements Toward 2012 Greenhouse Gas Target (Statewide Low Avoided Costs)

			Total Resource			
	Annual GWh	Lifetime net cost per kWh saved	Benefits	Costs	Net Benefits	BCR
Energy Efficiency Savings						
Residential	3,105	$ (0.0224)	1,281,359,428	(26,107,167)	1,307,466,595	-49.08
Commercial	12,454	$ 0.0160	4,068,573,146	2,555,343,290	1,513,229,856	1.59
Industrial	538	$ (0.0164)	139,598,928	(3,325,355)	142,924,283	-41.98
Total Efficiency	16,096	$ 0.0084	5,489,531,502	2,525,910,768	2,963,620,734	2.17
Renewable Supply						
Biomass	2,520	$ (0.0122)	728,546,676	(162,757,236)	891,303,911	-4.48
Fuel Cells	-	NA	-	-	-	
Hydropower	859	$ 0.0075	440,421,346	135,787,348	304,633,997	3.24
Landfill Gas	-	NA	-	-	-	
Municipal Solid Waste	633	$ (0.0093)	329,616,958	(46,022,347)	375,639,305	-7.16
Photovoltaics	-	NA	-	-	-	
Solar Thermal	7	$ 0.0039	2,569,889	352,112	2,217,777	7.30
Windpower	-	NA	-	-	-	
Total Renewable	4,019	$ (0.0055)	1,501,154,868	(72,640,123)	1,573,794,990	-20.67
Total Efficiency Savings & Renewable Supply	20,115,208	$ 0.0050	6,990,686,370	2,453,270,646	4,537,415,724	2.85

Note: Benefits are Cumulative Through 2012 and stated in Present Worth 2003 Dollars

Tble 4. Benefits and Costs of Least-Cost Efficiency and Renewable Achievements Toward 2022 Greenhouse Gas Target (Statewide Low Avoided Costs)

			Total Resource			
	Annual MWh	Lifetime net cost per kWh saved	Benefits	Costs	Net Benefits	BCR
Energy Efficiency Savings						
Residential	6,817,904	$ (0.0286)	2,711,421,735	(369,786,348)	3,081,208,084	-7.33
Commercial	12,845,503	$ 0.0121	5,263,693,023	2,751,613,298	2,512,079,725	1.91
Industrial	2,381,309	$ (0.0175)	659,641,264	(42,566,669)	702,207,933	-15.50
Total Efficiency	22,044,716	$ (0.0002)	8,634,756,023	2,339,260,281	6,295,495,742	3.69
Renewable Supply						
Biomass	1,716,998	$ (0.0236)	870,486,934	(483,331,405)	1,353,818,339	-1.80
Fuel Cells	-	NA	-	-	-	
Hydropower	858,900	$ 0.0075	440,421,346	135,787,348	304,633,997	3.24
Landfill Gas	-	NA	-	-	-	
Municipal Solid Waste	1,324,862	$ (0.0093)	627,719,813	(83,651,065)	711,370,879	-7.50
Photovoltaics	-	NA	-	-	-	
Solar Thermal	9,234	$ 0.0029	3,405,550	353,885	3,051,665	9.62
Windpower	6,048,728	$ 0.0264	1,888,941,797	1,456,403,115	432,538,682	1.30
Total Renewable	9,958,722	$ 0.0067	3,830,975,439	1,025,561,878	2,805,413,561	3.74
Total Efficiency Savings & Renewable Supply	32,003,438	$ 0.0022	12,465,731,462	3,364,822,159	9,100,909,303	3.70

Several clarifying observations are in order regarding the results presented in Tables 3 and 4. The first column indicates the GWh achievements from each resource that are part of the least-cost resource solution to the GHG reduction for each year. These figures do not represent all the achievable potential for each resource, nor do they necessarily represent that total achievable potential that would be economical. Rather, they indicate the contribution from each resource given the costs of achievable potential from other resources. For example, the absence of wind energy in the least-cost solution to the 2012 greenhouse gas target does not mean that wind is not achievable or economic; it merely indicates that other resources can be obtained at lower achievable costs. If a lower-cost resource was for some reason removed from its position in the order of achievable costs, then wind would improve its position, i.e., move to the left on the supply curve.

Expected Contributions from New York's Currently Planned Initiatives

Finally, the report provides independent estimates of the expected contribution by New York's currently planned efficiency and renewable energy program initiatives. Figure 8 presents the study's estimate of expected impacts by 2007, 2012, and 2022.

Table 5 reports the study's estimates of expected benefits and costs applying low zonal avoided costs to statewide achievements from currently planned initiatives. The study finds that currently planned initiatives will achieve cost-effective contributions from both efficiency and renewable energy resources. The economic value to New York from currently planned initiatives is estimated at between $0.5 billion and $2.0 billion by 2012 and between $1.7 billion and $5.4 billion by 2022, depending on whether electricity is valued at the lowest or highest zonal avoided costs in the State.

Figure 8. Currently Planned Initiatives Savings (Annual GWh)

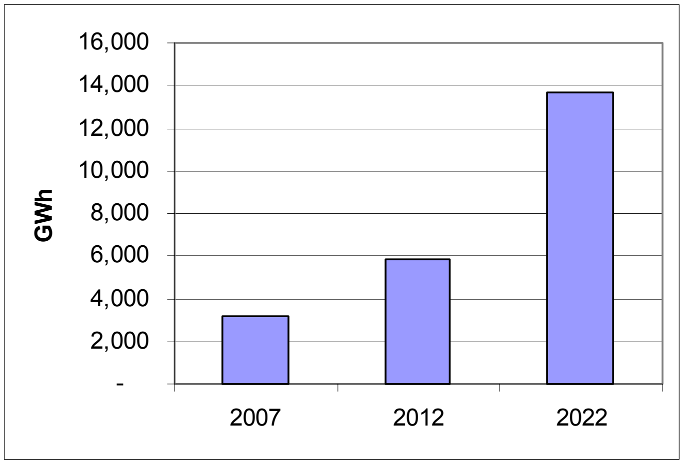


Table 5. Expected Achievements under Currently Planned Initiatives -- Benefit/Cost Analysis Results: Low Avoided Costs (Millons of $2003)

Expected Achievements under Currently Planned Initiatives Benefit/Cost Analysis Results: LOW Avoided Costs (Millons of $2003)	2007				2012				2022			
	PV Benefits	PV Costs	Net Benefits	BCR	PV Benefits	PV Costs	Net Benefits	BCR	PV Benefits	PV Costs	Net Benefits	BCR
Energy Efficiency												
Residential	175	197	(21)	0.89	232	197	35	1.18	359	180	180	2.00
Commercial	409	324	85	1.26	958	755	203	1.27	2,996	2,122	874	1.41
Industrial	9	2	7	3.92	9	2	7	3.92	9	2	7	3.92
Total Efficiency	594	523	71	1.13	1,199	954	245	1.26	3,364	2,304	1,060	1.46
Renewable Energy												
Biomass	224	(135)	360	-1.66	271	(356)	627	-0.76	480	(696)	1,176	-0.69
Fuel Cells	20	74	(54)	0.27	79	265	(186)	0.30	177	530	(353)	0.33
Hydropower	-	-	-		-	-	-		-	-	-	
Landfill Gas	47	74	(27)	0.64	54	84	(30)	0.64	63	96	(33)	0.66
Municipal Solid Waste	-	-	-		-	-	-		-	-	-	
Photovoltaics	9	76	(67)	0.12	14	105	(91)	0.14	47	232	(185)	0.20
Solar Thermal	3	11	(8)	0.29	16	34	(18)	0.47	26	49	(23)	0.53
Windpower	312	363	(50)	0.86	596	651	(55)	0.92	920	905	15	1.02
Total Renewable	616	462	154	1.33	1,030	783	247	1.32	1,713	1,115	598	1.54
Total Efficiency & Renewable	1,210	985	224	1.23	2,229	1,737	492	1.28	5,077	3,419	1,658	1.48

This study's conclusions on the economic potential for efficiency and renewable energy resources are not definitive because the avoided costs used to value electricity savings are estimates of generation costs only; therefore the analysis probably understates the true economic value of electricity potential from efficiency and renewable technologies. In particular, the avoided costs used to value electricity resources in this study exclude:

- Avoided transmission and distribution (T&D)capacity costs
- Avoided environmental externalities
- Demand-induced price effects (i.e., lower electricity demand due to efficiency and renewables will tend to lower market-clearing prices)
- Economic development impacts (net benefits from efficiency and renewable energy stimulate economic activity, increasing the New York's gross state product)

Had the study included the additional value of these effects, it would have affected results in the following general direction:

- Economic potential analysis: A higher fraction of the technical potential for all efficiency and renewable energy resources would have been found to be economic.
- Achievable contributions toward GHG reductions: Incorporating the value of avoided T&D costs would lower the net achievable cost of electric energy, since the analysis subtracts the value of capacity from the total achievable cost of electric energy. The estimated benefits to New York's economy from achieving the least-cost solution to New York's GHG reductions would therefore increase.
- Expected contributions from currently planned initiatives: The estimated net benefits to New York's economy would increase from policies and strategies contained in the State Energy Plan to promote efficiency and renewable energy resources.

Caveats

The authors offer several caveats about the use of this study, which are summarized here:

It would be a mistake to confuse technical and economic potential with other types of potential analysis. Technical potential is not achievable potential, and therefore cannot be applied directly to represent the efficiency and renewable resources that New York could actually realize through policy or program initiatives. Doing so would be a misuse of the study's analysis.

The study's technical and economic potential analysis can and should be used to inform other analysis of policy, program, and resource options. The technology costs and performance characteristics developed from this analysis can be applied in the planning and design of programs, policies, and resource acquisition.

If using the study's technical and economic potential analysis results in efficiency and renewable energy program or resource planning, then such additional analysis should account for future market acceptance, specific program strategies for realizing market acceptance, and the administrative costs of such programs.

Zonal technical and economic potential should be used with caution. The quality and reliability of supplemental information used to characterize markets within zones is limited, particularly in the industrial sector. The zonal technical and economic potential results are readily applicable in conjunction with more accurate information about zonal market characteristics (e.g., if more information is available regarding the location of specific industries within the State).