Potential for Energy Savings from Combined Heat and Power in New York State

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STUDY OVERVIEW

The New York State Energy Research and Development Authority (NYSERDA) commissioned this study to estimate the technical and economic potential for new combined heat and power (CHP) systems in New York. This report describes our methodology and the results of the assessment.

The *technical potential* is the potential for CHP regardless of cost-effectiveness and ignoring market barriers to adoption. The technical potential therefore assumes CHP systems would be installed at all sites (buildings or complexes) having suitable electric and thermal loads that could be served by a CHP system. The *economic potential* is the subset of the technical potential limited to CHP installations that are deemed to be cost-effective (i.e., for which the benefits exceed the costs).

The technical and economic potentials for CHP in New York were assessed and reported in *Combined Heat and Power Market Potential for New York State, Final Report*, October 2002 (the "2002 CHP Potential Study"). The current study uses some of the data from the 2002 CHP Potential Study, but differs from that study in significant ways as described below under Methodology.

The 2002 CHP Potential Study also provides an overview of CHP technologies, the benefits of customer-sited CHP over conventional, centralized generation, and the barriers to adoption of CHP. Readers unfamiliar with CHP can find background information in the 2002 CHP Potential Study, or in other sources including those listed in the bibliography at the end of this report.

This study applies some of the methodology and assumptions of the recently completed *Energy Efficiency and Renewable Energy Potential Study of New York State*, April 2014 (the "2014 EERE Potential Study"), available on NYSERDA's web site. Specifically, this study makes use of the following approach and data from the 2014 EERE Potential Study:

- Regional analysis zones (Long Island, New York City, Hudson Valley, Upstate)
- Avoided energy supply costs for electricity and natural gas, by zone and year
- Use of the Total Resource Cost test for assessing cost-effectiveness of CHP systems
- Electric load shapes by zone and building type.

More detailed information on these data and the Total Resource Cost test can be found in the 2014 EERE Potential Study.

METHODOLOGY

CHP systems are complex with various types of technologies, a broad range of system sizes, the need for suitable electric and thermal loads, and a high degree of site-specific customization for many installations, among other factors. As such, assessing the numbers of sites that are good candidates for CHP systems is not a trivial task.

The 2002 CHP Potential Study included a detailed assessment of the number of sites (buildings or complexes) that could support new CHP systems. The numbers of sites were categorized by magnitude of average electric usage (in MW), building type or industrial segment type, and the average electric-thermal (E/T) ratios. After reviewing various CHP potential studies, reports, and associated data sets, we determined that we did not have adequate data to reliably refine the numbers of sites suitable for CHP systems. We therefore used the estimated numbers of sites from the 2002 CHP Potential Study as the basis for this study, applying revised assumptions for CHP system performance and cost assumptions to those sites.

It is important to note that both the technical and economic potential assessments ignore market barriers. Both assessments assume that all suitable customers will install CHP systems, with the economic potential being limited to cost-effective CHP measures. The actual number of CHP installations in future years will be limited by market barriers such as system cost, system complexity, a lack of information or understanding of system operations and benefits, the permitting process and general "hassle factor," risk aversion, access to financing, competition with other possible investments in business operations, physical site limitations, and various other market barriers. Methods for overcoming those market barriers and promoting the adoption of CHP were outside the scope of this study.

Study Boundaries

The scope of this study was bounded in the following ways:

- Limited to natural gas-fired CHP.
- Limited to sites with access to natural gas, but not constrained by gas distribution capacity. (The 2002 CHP Potential Study also assumed natural gas-fired CHP, but included all potential sites regardless of their access to natural gas.)
- Assumed all electric generation by CHP systems would be used on site, with no "export" to the grid. Including the option of exporting energy to the grid (e.g., with net-metering) as an option would increase the technical potential.
- Excluded community (district energy) systems and microgrids
- Limited to the commercial, institutional, and industrial sectors.
- We excluded absorption chilling as potential thermal load that would make a customer suitable for CHP. Likewise we did not include liquid and solid desiccants for dehumidification as a potential thermal load (used to refresh the desiccants). Including both of these would increase the technical potential. The 2002 CHP Potential Study was limited to thermal energy for hot water and steam, and we chose to be consistent with that study.
- Not limited by the eligibility criteria of NYSERDA's CHP Performance Program.

Regional Analysis Zones

The analysis was carried out using four regional analysis zones: Long Island, New York City, Hudson Valley, and Upstate. These were the same analysis zones used for the 2014 EERE Potential Study. The figure below shows the geographical boundaries of the four analysis zones.

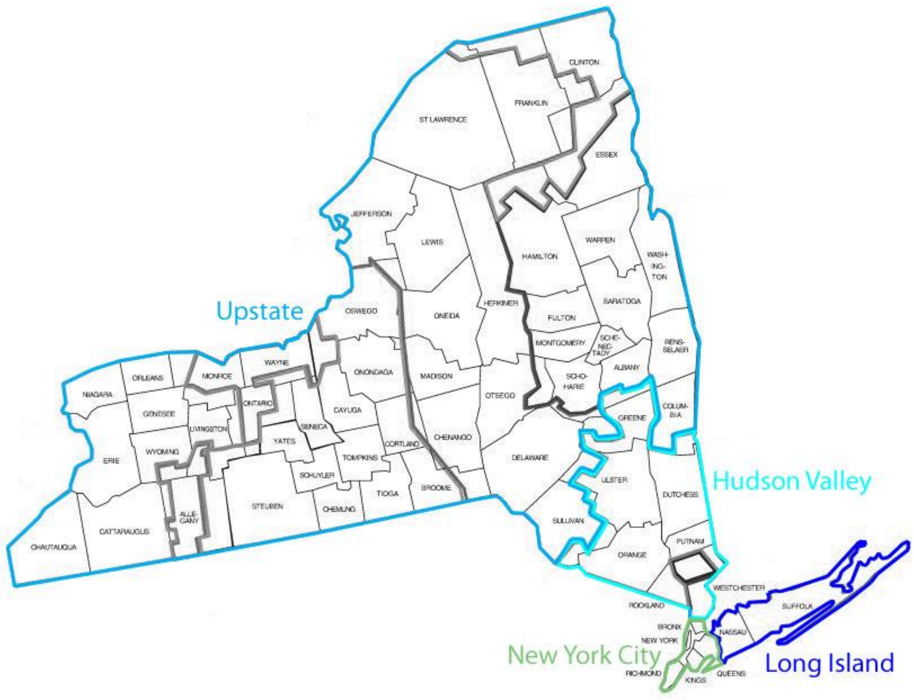

Figure 1.Regional Analysis Zones Geographic Boundaries.

The site data from the 2002 CHP Potential Study was organized by electric utility, which generally lined up with the zone boundaries. However, as shown in the following table there were several minor exceptions, which were ignored for this study.

Table 1. Electric Utilities and Regional Analysis Zones

Utility	Default Zone	Notes
ConEd	New York City (NYC)	A small portion falls in HV
LIPA	Long Island (LI)	
O&R	Hudson Valley (HV)	
Cent Hudson	Hudson Valley (HV)	
NYSEG	Upstate (UP)	A small portion falls in HV
Niagara Mohawk	Upstate (UP)	A very small portion falls in HV
RG&E	Upstate (UP)	

Use of the Total Resource Cost Test

Cost effectiveness of CHP measures was determined using the Total Resource Cost (TRC) test, consistent with the 2014 EERE Potential Study. The TRC test uses the avoided energy supply costs (electric and natural gas) for each zone to determine the benefits of saved electric energy that is now generated by the CHP system, saved natural gas offset by the CHP thermal generation, and the cost of increased gas usage to run the CHP equipment. CHP installation costs and operation & maintenance costs are also included in the TRC test. Future costs and benefits are discounted to the installation year so that the net present value (NPV) of costs and benefits can be compared. If the benefits equal or exceed the costs, the CHP measure is considered to be cost effective. The actual avoided costs are provided in Volume 4 (technical appendix) of the 2014 EERE Potential Study.

The annual avoided costs are the same for all customers in a given zone. In contrast, there is great variation in customer rates between and within the utility service territories. Standby charges also a significant factor in deciding whether CHP will be cost-effective from customer's point of view, as detailed in the 2002 CHP Potential Study. However, because we used the TRC test, we have not accounted for variations in customer rates in this study (as would be needed for the Participant Cost Test). Note that the 2002 CHP Potential Study assessed cost-effectiveness from the customer's point of view, based on an analysis of retail electric rates.

General Inputs and Assumptions

The following general inputs and assumptions were employed in the analysis:

- Avoided energy supply costs (electric and natural gas) were from the 2014 EERE Potential Study, inflated to 2014 real dollars assuming 2% inflation per year.
- A real discount rate of 5.5% was used to assess the present value of measure costs and benefits, which is consistent with New York's standard process for assessing cost-effectiveness of energy efficiency and renewable energy initiatives.
- The average electric line loss factor was 10.96% of the customer meter, as used in the 2014 EERE Potential Study.
- RSMeans factors were used to convert national average costs to average costs by zone:

Table 2. RSMeans Cost Factors by Zone

Zone	RSMeans Factor
NYC	129.8%
LI	122.6%
HV	114.0%
UP	96.9%

- For electric load shapes, we used the "electric total" load shapes by building type from the 2014 EERE Potential Study.

- As for the 2002 CHP Potential Study, we assumed thermal demands were based on conversion efficiency of 85% (e.g., for a gas-fired boiler).

CHP Measure Characterizations

We updated the CHP measure costs and savings characteristics for various CHP technologies using the 2008 *Catalog of CHP Technologies*, from the EPA.[1] Outreach to an industry expert showed high confidence in these system performance assumptions. Measure costs included both the full installation cost of CHP systems and annual operation and maintenance costs, adjusted by the RSMeans cost factors shown in Table 2, above.

We assumed the same capacity factors as for the 2002 CHP Potential Study: 80% for all measures except for Gas Turbines with 40 MW capacity, for which we assumed 90%.

Measure lives were estimated based on several sources, as summarized in the following table.

Table 3. CHP Measure Life by Technology

Technology	Size	Life (years)	Source*
Reciprocating Engine	All	18	1, 2
Gas & Micro-Turbine	Large (>500 MW)	18	1, 2
Gas & Micro-Turbine	Small (<=500 MW)	15	1, 2
Fuel Cells	Large (>150 kW)	12	1, 2, 3
Fuel Cells	Small (<= 150 kW)	10	1, 2, 3
Steam Turbine		25	2, 3

* 1 = EIA Technology Road Map (2011), 2 = SENTECH (2010), 3 = EPA Catalog (2008). See the bibliography for full citations.

The CHP measures that were screened for cost-effectiveness, by zone and by installation year, included:

- Reciprocating Engine : 100 kW, 300 kW, 800 kW, 3000 kW, 5000 kW
- Microturbine : 30 kW, 65 kW, 250 kW
- Gas Turbine : 1150 kW, 5457 kW, 10239 kW, 25000 kW, 40000 kW
- Steam Turbine : 500 kW, 3000 kW, 15000 kW
- Fuel Cell : 10 kW, 125 kW, 200 kW (PAFC), 200 kW (PEM), 300 kW, 1200 kW

The cost-effectiveness results for these measures are provided in Appendix A.

[1] http://www.epa.gov/chp/technologies.html

Methodology Steps

Applying the assumptions described above, our methodology included the following steps:

1. Use the 2002 CHP Potential Study site-level data as the starting point for the analysis.
2. Adjust the number of suitable CHP sites based on availability of natural gas in New York, using the ratio of natural gas sales to petroleum fuels sales (using values from the 2014 EERE Potential Study), by sector and analysis zone.
3. Adjust the number of suitable CHP sites for growth between 2000 and 2015, based on population growth by analysis zone.
4. Seven systems were selected as prototypes for their representativeness of the most economically and technically appropriate combined heat and power systems for a given size range. These prototype systems fell into two technologies: reciprocating gas and gas turbine. The reciprocating gas systems are smaller, at 300 kW, 800 kW, 3 MW, and 5 MW. For higher-capacity systems, gas turbines were identified as having the greatest benefit-cost ratios, and are thus used as prototypes for higher-capacity systems.
5. Measure penetrations, based on the numbers of sites in each size category and building or industrial segment type, were spread out evenly over the 20-year study period. We did not account for the practical time that would be needed for CHP system planning and permitting, which would typically delay large-scale implementation of CHP systems.
6. For the technical potential we included all CHP measures in the analysis, regardless of cost-effectiveness. For the economic potential we only included CHP measures that were cost-effective, as assessed for each CHP technology and system size, for each installation year and analysis zone.

RESULTS

The results for the technical and economic potential provided below are based on the numbers of sites suitable for CHP as identified in the 2002 CHP Potential Study, adjusted for economic growth and limited to sites having access to natural gas, as described above. Therefore, these results represent the potential for new CHP since 2001. The results have not been adjusted for actual installed CHP capacity since 2001, as described further below in the section on "New CHP Installations Since 2001."

Technical Potential

The table below shows the technical potential for energy savings, and increased customer natural gas usage, using the above methodology and data sources. Note that the increased gas usage is at the customer site, and does not include the associated decreased gas usage for electric generation at central power plants.

Table 4. Technical Potential for CHP Energy Savings

		Installed Capacity (MW)			Electric Generation (GWh)			Increased Gas Usage (BBtu)		
Sector	**Zone**	**2015**	**2025**	**2034**	**2015**	**2025**	**2034**	**2015**	**2025**	**2034**
Com	UP	96.8	1065.2	1743.0	681	7,491	12,258	5,146	56,603	92,622
Com	HV	18.2	200.3	327.7	129	1,414	2,314	932	10,247	16,768
Com	NYC	124.8	1373.2	2247.0	878	9,660	15,807	6,756	74,315	121,607
Com	LI	38.8	427.3	699.2	273	3,008	4,922	2,297	25,267	41,345
Com	**Total**	**278.7**	**3065.9**	**5017.0**	**1,961**	**21,573**	**35,301**	**15,130**	**166,432**	**272,343**
Ind	UP	61.2	673.5	1102.2	434	4,776	7,816	2,645	29,092	47,606
Ind	HV	3.3	36.8	60.2	23	258	422	165	1,819	2,977
Ind	NYC	7.7	84.9	139.0	54	595	974	434	4,778	7,818
Ind	LI	5.3	57.8	94.5	37	405	662	339	3,733	6,109
Ind	**Total**	**77.5**	**853.0**	**1395.9**	**549**	**6,034**	**9,874**	**3,584**	**39,423**	**64,510**
C&I	**Total**	**356.3**	**3919.0**	**6412.9**	**2,510**	**27,607**	**45,175**	**18,714**	**205,854**	**336,852**

The table below shows the costs and cost-effectiveness associated with the technical potential. The costs and benefits have been discounted to 2014 real dollars.

Table 5. Technical Potential Costs, Benefits, and Cost-Effectiveness

Sector	**Zone**	**Benefits ($Million)**	**Costs ($Million)**	**Net Benefits ($Million)**	**BCR**
Com	UP	$11,115	$12,023	$(908)	0.92
Com	HV	$2,544	$2,945	$(401)	0.86
Com	NYC	$20,838	$21,982	$(1,144)	0.95
Com	LI	$5,933	$6,870	$(937)	0.86
Com	**Total**	**$40,430**	**$43,821**	**$(3,391)**	**0.92**
Ind	UP	$6,827	$6,574	$253	1.04
Ind	HV	$478	$580	$(103)	0.82
Ind	NYC	$1,361	$1,571	$(210)	0.87
Ind	LI	$850	$1,113	$(263)	0.76
Ind	**Total**	**$9,516**	**$9,838**	**$(322)**	**0.97**
C&I	**Total**	**$49,946**	**$53,659**	**$(3,713)**	**0.93**

Economic Potential

The table below shows the economic potential for energy savings, and increased customer natural gas usage, using the above methodology and data sources.

Table 6. Economic Potential for CHP Energy Savings

		Installed Capacity (MW)			Electric Generation (GWh)			Increased Gas Usage (BBtu)		
Sector	**Zone**	**2015**	**2025**	**2034**	**2015**	**2025**	**2034**	**2015**	**2025**	**2034**
Com	UP	69.0	759.1	1242.1	486	5,345	8,747	2,357	25,930	42,431
Com	HV	7.0	142.1	245.4	50	1,006	1,737	236	5,019	8,676
Com	NYC	90.2	992.2	1623.8	635	6,990	11,439	3,017	33,184	54,309
Com	LI	25.5	280.4	458.9	180	1,979	3,238	831	9,146	14,966
Com	**Total**	**191.7**	**2173.7**	**3570.1**	**1,352**	**15,320**	**25,161**	**6,441**	**73,279**	**120,382**
Ind	UP	51.0	562.7	925.7	362	3,999	6,579	1,688	18,638	30,686
Ind	HV	0.8	11.6	31.0	5	81	217	22	361	1,055
Ind	NYC	4.6	51.1	86.7	32	358	607	157	1,751	3,013
Ind	LI	2.5	27.6	45.3	17	193	318	83	928	1,525
Ind	**Total**	**58.8**	**652.8**	**1088.7**	**417**	**4,631**	**7,721**	**1,950**	**21,677**	**36,279**
C&I	**Total**	**250.5**	**2826.6**	**4658.7**	**1,769**	**19,952**	**32,882**	**8,391**	**94,956**	**156,661**

The table below shows the costs and cost-effectiveness associated with the economic potential.

Table 7. Economic Potential Costs, Benefits, and Cost-Effectiveness

Sector	Zone	Benefits ($Million)	Costs ($Million)	Net Benefits ($Million)	BCR
Com	UP	$6,987	$5,670	$1,317	1.23
Com	HV	$1,603	$1,469	$134	1.09
Com	NYC	$13,085	$10,254	$2,831	1.28
Com	LI	$3,269	$2,660	$609	1.23
Com	**Total**	**$24,944**	**$20,054**	**$4,891**	**1.24**
Ind	UP	$5,318	$4,254	$1,064	1.25
Ind	HV	$179	$172	$7	1.04
Ind	NYC	$708	$587	$121	1.21
Ind	LI	$321	$281	$40	1.14
Ind	**Total**	**$6,527**	**$5,294**	**$1,233**	**1.23**
C&I	**Total**	**$31,471**	**$25,348**	**$6,123**	**1.24**

New CHP Installations Since 2001

Because the results provided above are based on the numbers of suitable CHP sites from the 2002 CHP Potential Study, they represent the new potential CHP since that time. Therefore, to estimate the future potential, this study's results should be adjusted by subtracting the new CHP installations known to have taken place since that time.

We identified the new CHP installations since 2001 in the database of CHP installations maintained by ICF.[2] We assumed that installations that went into operation after 2001 were not represented in the 2002 CHP Potential Study. The data did not identify each site's sector, so we assigned the sector based on the facility name and application. We only included natural gas-fired systems in our assessment (excluding biomass facilities), and we excluded district heating systems (one large system) as district heating was not included in our analysis.

The table below summarizes the known CHP installations in New York since 2001, and the percentage of the technical and economic potentials provided above for new CHP potential since 2001.

Table 8. New CHP Installations in New York Since 2001

	Total Sites		Commercial		Industrial	
MW Range	**Count**	**Total MW**	**Count**	**Total MW**	**Count**	**Total MW**
0-0.5	165	31.9	158	30.5	7	1.4
0.5-1	28	20.6	25	18.4	3	2.2
1-5	28	55.7	23	49.2	5	6.4
5-20	8	51.8	8	51.8	0	0.0
>20	2	63.0	2	63.0	0	0.0
Total	**232**	**223.0**	**216**	**212.9**	**16**	**10.0**
% of 2034 Technical Potential		3%		4%		1%
% of 2034 Economic Potential		5%		6%		1%

In comparing installed CHP capacity since 2001 to this study's estimates of CHP potential, several aspects of this study (as detailed in the methodology section) should be kept in mind:

- The current study assumed CHP systems were sized for relatively low thermal demand that would be available year round, as was assumed for the 2002 CHP Potential Study. In practice, many CHP installations are sized for higher kW capacity, and operate at times when their thermal output cannot be used. For example, CHP systems are sometimes installed, in part, to serve as backup power, and are thus sized for higher electric capacity than needed to meet the thermal load. In some cases excess power is available to be sold into the grid system. While beyond the scope and available data for this study, including CHP systems sized for higher capacity, but with associated unused thermal heat or lower capacity factors, would provide additional opportunities for cost-effective CHP systems.
- The current study did not include absorption chilling and desiccants for dehumidification as potential thermal loads, consistent with the 2002 CHP

[2] http://www.eea-inc.com/chpdata/States/ny.html, accessed September 25, 2014.

Potential Study. Including those would have increased the potential, as they require thermal loads during the summer to balance the winter heating load. Some of the actual installed CHP capacity is for systems of these types.

- The current study is based on average avoided energy supply costs for four analysis zones, with cost-effectiveness based on a Total Resource Cost (TRC) test. In practice, customer rates vary considerably within and between service territories. Standby charges and high demand ratchets can also affect the customer economics of CHP systems. In practice, the decision to install a CHP system is typically based on customer economics, including benefits that may not be captured in the TRC test.

CONCLUSIONS

This study provides an update of the 2002 CHP Potential Study, applying the numbers of suitable CHP customers by market segment from that study, but with several key revisions:

- Applied current CHP technology costs and performance
- Limited to customers with access to Natural Gas
- Applied a Total Resource Cost test based on current avoided energy supply costs, rather than assessing the customer economics.

Within this framework, the assessment found that there remains a large potential for installation of cost-effective CHP systems. The technical potential by 2034 is estimated at 6.4 GW, or 18% of the State's summer peak demand forecast for 2024.[3] The cost-effective economic potential by 2034 is estimated at 4.7 GW, or 13% of the State's summer peak demand forecast for 2024.

Additional cost-effective CHP potential would be provided, in particular, by district energy systems, which are typically larger than most of the single-customer systems included in this study. As well, including systems sized to export excess electric power to the grid system would substantially increase the CHP potential.

In conclusion, there remains a large potential for cost-effective CHP installations that operate more efficiently than conventional power supply, serving a wide variety of market segments and customer profiles. In an evolving energy market, CHP will continue to have significant potential as a component of New York's clean energy policies and goals.

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[3] NYISO, *2014 Load & Capacity Data, "Gold Book"*, April 2014, http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Documents_and_Resources/Planning_Data_and_Reference_Docs/Data_and_Reference_Docs/2014_GoldBook_Final.pdf

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APPENDIX A. CHP MEASURE BENEFIT-COST RATIOS BY INSTALLATION YEAR

Gray shading indicates the measure is not cost-effective based on the Total Resource Cost test.

	Benefit-Cost Ratio (BCR)				
Measure, by Zone	**2015**	**2020**	**2025**	**2030**	**2034**
Reciprocating 100 kW -UP	0.70	0.75	0.78	0.79	0.80
Reciprocating 100 kW -HV	0.61	0.64	0.66	0.68	0.69
Reciprocating 100 kW -NYC	0.71	0.74	0.78	0.84	0.87
Reciprocating 100 kW -LI	0.66	0.71	0.74	0.77	0.78
Reciprocating 300 kW -UP	1.07	1.13	1.17	1.19	1.20
Reciprocating 300 kW -HV	0.98	1.01	1.04	1.06	1.08
Reciprocating 300 kW -NYC	1.10	1.13	1.18	1.25	1.29
Reciprocating 300 kW -LI	1.04	1.09	1.13	1.16	1.18
Reciprocating 800 kW -UP	1.16	1.23	1.26	1.29	1.30
Reciprocating 800 kW -HV	1.05	1.09	1.12	1.14	1.15
Reciprocating 800 kW -NYC	1.19	1.22	1.27	1.34	1.38
Reciprocating 800 kW -LI	1.12	1.18	1.22	1.25	1.26
Reciprocating 3000 kW -UP	1.24	1.31	1.34	1.37	1.37
Reciprocating 3000 kW -HV	1.10	1.13	1.16	1.18	1.20
Reciprocating 3000 kW -NYC	1.26	1.29	1.34	1.41	1.46
Reciprocating 3000 kW -LI	1.20	1.25	1.29	1.32	1.34
Reciprocating 5000 kW -UP	1.29	1.35	1.39	1.41	1.42
Reciprocating 5000 kW -HV	1.13	1.17	1.20	1.22	1.23
Reciprocating 5000 kW -NYC	1.30	1.33	1.39	1.47	1.51
Reciprocating 5000 kW -LI	1.23	1.29	1.34	1.37	1.38
Microturbine 30 kW -UP	0.92	0.96	0.99	1.01	1.02
Microturbine 30 kW -HV	0.84	0.86	0.89	0.90	0.91
Microturbine 30 kW -NYC	0.94	0.95	0.99	1.04	1.08
Microturbine 30 kW -LI	0.89	0.93	0.96	0.98	1.00
Microturbine 65 kW -UP	1.03	1.07	1.11	1.12	1.13
Microturbine 65 kW -HV	0.94	0.96	0.99	1.01	1.02
Microturbine 65 kW -NYC	1.05	1.06	1.10	1.16	1.19
Microturbine 65 kW -LI	0.99	1.04	1.07	1.10	1.11
Microturbine 250 kW -UP	0.95	1.00	1.03	1.05	1.06
Microturbine 250 kW -HV	0.86	0.89	0.91	0.93	0.94
Microturbine 250 kW -NYC	0.97	0.98	1.03	1.09	1.12
Microturbine 250 kW -LI	0.92	0.96	1.00	1.02	1.04
Gas Turbine 1150 kW -UP	0.84	0.88	0.90	0.92	0.92
Gas Turbine 1150 kW -HV	0.79	0.81	0.83	0.84	0.85
Gas Turbine 1150 kW -NYC	0.86	0.88	0.91	0.95	0.97
Gas Turbine 1150 kW -LI	0.82	0.85	0.88	0.90	0.91
Gas Turbine 5457 kW -UP	1.14	1.19	1.22	1.23	1.24
Gas Turbine 5457 kW -HV	1.02	1.05	1.07	1.09	1.10
Gas Turbine 5457 kW -NYC	1.15	1.18	1.22	1.27	1.31
Gas Turbine 5457 kW -LI	1.10	1.15	1.18	1.20	1.21
Gas Turbine 10239 kW -UP	1.14	1.19	1.22	1.24	1.24
Gas Turbine 10239 kW -HV	1.02	1.05	1.07	1.09	1.10
Gas Turbine 10239 kW -NYC	1.15	1.17	1.22	1.27	1.31

Measure, by Zone	Benefit-Cost Ratio (BCR)				
	2015	2020	2025	2030	2034
Gas Turbine 10239 kW -LI	1.10	1.15	1.18	1.20	1.21
Gas Turbine 25000 kW -UP	1.25	1.29	1.30	1.32	1.32
Gas Turbine 25000 kW -HV	1.10	1.11	1.13	1.14	1.15
Gas Turbine 25000 kW -NYC	1.27	1.28	1.32	1.37	1.40
Gas Turbine 25000 kW -LI	1.20	1.23	1.26	1.27	1.28
Gas Turbine 40000 kW -UP	1.34	1.38	1.39	1.40	1.41
Gas Turbine 40000 kW -HV	1.17	1.18	1.19	1.21	1.21
Gas Turbine 40000 kW -NYC	1.35	1.36	1.40	1.45	1.49
Gas Turbine 40000 kW -LI	1.28	1.32	1.34	1.36	1.37
Steam Turbine 500 kW -UP	1.09	1.10	1.10	1.11	1.11
Steam Turbine 500 kW -HV	1.05	1.06	1.06	1.06	1.07
Steam Turbine 500 kW -NYC	1.09	1.10	1.11	1.12	1.13
Steam Turbine 500 kW -LI	1.08	1.09	1.09	1.10	1.10
Steam Turbine 3000 kW -UP	1.11	1.12	1.12	1.12	1.12
Steam Turbine 3000 kW -HV	1.07	1.07	1.07	1.07	1.07
Steam Turbine 3000 kW -NYC	1.12	1.12	1.12	1.13	1.14
Steam Turbine 3000 kW -LI	1.10	1.10	1.11	1.11	1.11
Steam Turbine 15000 kW -UP	1.15	1.15	1.16	1.16	1.16
Steam Turbine 15000 kW -HV	1.09	1.09	1.09	1.10	1.10
Steam Turbine 15000 kW -NYC	1.15	1.15	1.16	1.17	1.18
Steam Turbine 15000 kW -LI	1.13	1.14	1.14	1.14	1.14
Fuel Cell 10 kW -UP	0.28	0.31	0.34	0.36	0.37
Fuel Cell 10 kW -HV	0.28	0.30	0.32	0.34	0.35
Fuel Cell 10 kW -NYC	0.31	0.32	0.34	0.38	0.41
Fuel Cell 10 kW -LI	0.27	0.30	0.33	0.35	0.36
Fuel Cell 125 kW -UP	0.32	0.36	0.40	0.42	0.43
Fuel Cell 125 kW -HV	0.31	0.34	0.37	0.39	0.41
Fuel Cell 125 kW -NYC	0.36	0.37	0.40	0.45	0.49
Fuel Cell 125 kW -LI	0.31	0.35	0.38	0.41	0.42
Fuel Cell PAFC 200 kW -UP	0.43	0.48	0.52	0.54	0.55
Fuel Cell PAFC 200 kW -HV	0.43	0.46	0.49	0.51	0.52
Fuel Cell PAFC 200 kW -NYC	0.47	0.48	0.53	0.58	0.61
Fuel Cell PAFC 200 kW -LI	0.42	0.46	0.50	0.53	0.54
Fuel Cell PEM 200 kW -UP	0.40	0.44	0.48	0.50	0.51
Fuel Cell PEM 200 kW -HV	0.39	0.41	0.45	0.47	0.48
Fuel Cell PEM 200 kW -NYC	0.43	0.44	0.49	0.54	0.57
Fuel Cell PEM 200 kW -LI	0.38	0.42	0.46	0.49	0.50
Fuel Cell 300 kW -UP	0.37	0.42	0.46	0.48	0.49
Fuel Cell 300 kW -HV	0.35	0.38	0.41	0.43	0.45
Fuel Cell 300 kW -NYC	0.41	0.42	0.46	0.52	0.56
Fuel Cell 300 kW -LI	0.36	0.40	0.44	0.47	0.48
Fuel Cell 1200 kW -UP	0.40	0.46	0.49	0.52	0.53
Fuel Cell 1200 kW -HV	0.38	0.41	0.44	0.46	0.48
Fuel Cell 1200 kW -NYC	0.44	0.45	0.50	0.56	0.60
Fuel Cell 1200 kW -LI	0.39	0.43	0.47	0.50	0.52