Chapter 1: The Benefits of Converting to LED Street Lights in the Mid-Hudson Region

> **"Energy-saving improvements like LED lights are a common-sense way to cut costs and protect the environment at the same time." *–Mayor Mike Spano, City of Yonkers. The City completed an LED street light conversion in 2014, providing a gross savings of $1.8 million in the first year and cutting carbon emissions by nearly 3,000 metric tons annually.*[1]**

The light-emitting diode, or LED, is one of the most efficient lighting technologies on the market today, and is rapidly replacing other lighting technologies in many applications across residential, commercial, and public sectors. According to the U.S. Department of Energy, widespread use of LED lighting would have an enormous impact on energy consumption in the United States, potentially reducing energy use in 2027 by 348 terawatt hours,[2] or the equivalent electrical output of 44 large power plants, and saving more than $30 billion.[3]

In the Mid-Hudson Region, the focus of this report, the potential energy savings from conversions is nearly 34 million kwh per year, with an annual energy cost savings of more than $2.1 million and annual carbon dioxide emissions reductions of nearly 18,000 metric tons.

> **"The cost of street lighting services can be one of the more significant items in a municipal budget." *–Office of the State Comptroller, January 2008*.[4]**

Street lighting often accounts for a substantial share of municipal energy costs. For larger towns and cities in the Mid-Hudson region, street light bills can range from over $1 million dollars to close to $3 million dollars a year.[5] In the small city of Kingston (pop. 23,700), in Ulster County,

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[1] City of Yonkers, *LED Street Light Replacement Project*, http://www.yonkersny.gov/government/mayor-s-office/initiatives/led-street-light-replacement-project; VHB Engineering, Surveying and Landscape Architecture, "The City of Yonkers LED Streetlight Installation: Climate Smart Communities Anchor Project 2014," prepared for the NYS Department of Environmental Conservation Climate Smart Communities Program (n.d.).

[2] One terawatt hour (TWh) is equivalent to 1 million megawatt hours (MWh).

[3] U.S. Department of Energy, "LED Lighting," http://www.energy.gov/energysaver/led-lighting.

[4] Office of the New York State Comptroller, *Street Lighting Cost Containment*, 2007-MR-4, January, 2008.

[5] For instance, the Town of Clarkstown, in Orange County, spent $1.4 million on street light bills annually, and the City of Yonkers, in Westchester County, spent twice that much annually. Alex Taylor, "Clarkstown Buys 4,161 Street Lights; Others May Follow," *Lohud*, May 12, 2016: http://www.lohud.com/story/news/local/rockland/clarkstown/2015/05/12/clarkstown-buys-streetlights/27188883/; VHB Engineering, (n.d.).

public lighting has been responsible for a third of the City's energy costs.[6] Annual spending on street light bills exceeded half a million dollars in 2013.[7] Even in small rural communities, street lighting bills can be significant. In Dutchess County, the Village of Red Hook (pop. less than 2,000), had street light expenses of $50,000 in 2010.[8] These expenses increase over time, due to regular increases in utility charges.

Energy savings:
A conversion to LED street lights promises substantial energy savings--as high as 65-70 percent, although actual savings will vary depending upon the LED fixture model, the type of light that is being replaced, and locational factors affecting lighting level needs. The City of Los Angeles replaced 140,000 street lights between 2009 and 2013, and cut energy use by over 63 percent.[9] In Portland, Oregon, the City selected a low-wattage LED replacement for street lights in residential neighborhoods that resulted in a 75 percent energy savings, and higher wattage LED replacements for major roadways that resulted in a 64 percent reduction in energy use. [10] Here in New York State, the City of New Rochelle initiated an LED street light conversion that will result in a nearly 65 percent reduction in energy consumption.[11]

Several technological factors are responsible for the superior efficiency of LED street lights. Major improvements in LED technology over the last decade have greatly increased the luminous efficacy of LED lighting, a measure of the light output (lumens) per power input (watts)--in other words, lights are providing more illumination with less electricity. Today, the typical efficacy of LED street lights is 94 to 115 lumens per watt, as compared to an efficacy of 54 lumens per watt for the typical high-pressure sodium (HPS) fixture.[12] LEDs also have

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[6] City of Kingston, Climate Action Plan: Appendix B: City of Kingston NY Local Government Operations Energy and Greenhouse Gas Emissions Inventory Report, September 2012.
[7] C.T. Male Associates, "Street Lighting Fixture Replacement Energy and Feasibility Analysis," prepared for the City of Kingston, January 2014: p. 3.
[8] Village of Red Hook, Minutes of the Public Hearing on Central Hudson/Street Lights, May 20, 2010.
[9] Ibid.
[10] U.S. Department of Energy, "Chronical of a City's LED Street Lighting Conversion," *SSL Postings*, October 6, 2015: http://energy.gov/sites/prod/files/2015/10/f27/postings_10-06-15.pdf.
[11] Mayor Noam Bramson, "LED Street Light Replacements Begin," Nov. 30, 2015: https://www.noambramson.org/2015/11/5449/; Christopher J. Eberhart, "New Rochelle to Install LED Bulbs in Every Streetlight," *Lohud*, December 6, 2015: http://www.lohud.com/story/news/local/westchester/new-rochelle/2015/12/04/new-rochelle-led-bulbs-in-streetlights/76731290/
[12] A 2013 study prepared for the U.S. Department of Energy identified a streetlight manufactured by Kenall Lighting to be the most efficacious at the time, with an efficacy of 110. However, LED technology has continued to improve even more, and in 2016, leading manufacturers offered products claiming efficacies of 115 to over 130. Navigant, "Adoption of

superior optics, compared to other lighting technologies: Because LEDs are better at directing the light where it is needed, on the roadway, they waste less of the lamp's lighting output.[13] Unlike with HPS or mercury vapor (MV) lights, the passerby will not see diffuse light emanating outward, above ground level. Finally, HPS lights lose approximately 35 percent of their output once they are placed in the street light fixture with the required reflectors and housing.[14] LEDs do not sacrifice any of their output to the fixture itself.

Maintenance savings:
In addition to savings through reduced energy consumption, LEDs can also save local governments money in reduced maintenance costs. Because of the new and rapidly evolving nature of LED technology, there is not yet sufficient historical experience to confirm manufacturers' projections; however, the common expectation is that a well-designed LED luminaire, when used in conjunction with long-life electronic drivers and photocells, will last at least 25 years—more than several times the life of HPS fixtures.[15] LEDs gradually grow dimmer over a longer period of time, rather than burn out altogether as HPS lights do. The older MV lights, like LEDs, grow dimmer over time; however, unlike LEDs, they lose a significant percentage of their output (over 35 percent) in the first three to four years. Initial failure rates for LEDs are also quite low—typically under one percent for LEDs on the market today. The City of Los Angeles experienced a failure rate of just .89 percent with over 170,000 LED lights installed, over a period of seven years.[16]

The short life of HPS lights relative to LEDs is a major contributor to their relatively high maintenance costs. The annual maintenance costs for these lights can be significant: In New York City, the average maintenance cost per HPS fixture was found to be approximately $35 for the lamp and $30 for photo-electrical controls per year. New York City is currently converting its

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Light-Emitting Diodes in Common Lighting Applications," prepared for the USDOE Solid-State Lighting Program, April 2013 (Revised May 2013): p. 52

[13] Anne Kimber et al., LED Street Lighting: A Handbook for Small Communities: Iowa Association of Municipal Utilities, 2012: p. 4.

[14] U.S. Department of Energy, DOE Solid-State Lighting CALiPER Program, "Summary of results: Round 7 of Product Testing," January 2009: p. 8.

[15] The Public Service Commission's modifications to LED fixture charges proposed by utilities include an estimated fixture life span of 25 year fixtures. NYS Public Service Commission, *Order Approving Tariff Amendments with Modifications*, In the Matter of the Tariff Filing by Orange and Rockland Utilities, Inc., to Update Service Classification No. 4 – Public Street Lighting – Company Owned – to Incorporate LED Options Contain in P.S.C. No. 3 – Electricity (Case 16-E-0226), Effective March 10, 2017; NYS Public Service Commission, *Order Approving Tariff Amendments with Modifications*, In the Matter of the Tariff Filing by Central Hudson Gas & Electric Corporation to Establish New LED Lighting Options under Service Classification No. 5 – Area Lighting Service and Modify Service Classification No. 8 – Public Street and Highway Lighting, P.S.C. No 15 – Electricity, Effective March 10, 2017.

[16] Email communication with Ed Ebrahimian, Director, Bureau of Street Lighting for the City of Los Angeles, January 13, 2017.

250,000 street lights, and once completed the conversion is expected to see $14 million a year in combined energy and maintenance savings.[17] Los Angeles is realizing a savings of $9 million a year in maintenance and energy costs.[18]

Beyond the Energy and Financial Savings of LEDs: Other Benefits

While the financial savings from reduced energy use and maintenance costs could alone justify the switch to LED street lights, an LED conversion offers many additional benefits.

Improved Lighting Uniformity:
Uniform lighting along a roadway or in a neighborhood is desirable for both aesthetic and safety reasons. With more uniform lighting, LEDs reduce hot spots and intermittent areas of darkness between lights, improving visibility and causing less eye strain.[19] Consistent lighting is also more pleasing to look at. The LED consists of arrays of many LED chips that each produce a point source of light, distributing that light more effectively.[20] Finally, uniform LED lighting has been shown to further decrease lighting level needs because viewers perceive the lighting to be brighter when it is more uniform, providing additional energy and cost savings.[21]

The comparative lighting advantages of LEDs over HPS lights in terms of light quality can be seen in Figures 3 and 4, below. In this example of a street in Los Angeles, 200-watt HPS lights were replaced with 64-watt LEDs that provide much more uniform and better quality lighting. In this example, the average foot candles (a measure of light intensity) on the road decreased from 1.59 to 1.08; however, the decrease had no impact on roadway visibility because of the improved uniformity ratio: The average to minimum ratio dropped from 2.3 to 1.71 and the maximum to minimum ratio dropped from 5.23 to 1 to 2.52 to 1, indicating much greater uniformity.[22]

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[17]Matt A.V. Chaban, "New York's LED Streetlights: A Crime Deterrent to Some, a Nuisance to Others," *The New York Times*, July 11, 2016: http://www.nytimes.com/2016/07/12/nyregion/new-yorks-led-streetlights-receive-a-lukewarm-reception.html?_r=0

[18] Teena Maddox, "How LA is Now Saving $9M a year with LED Streetlights and Converting Them into EV Charging Stations," *Tech Republic*, July 7, 2016: http://www.techrepublic.com/article/how-la-is-now-saving-9m-a-year-with-led-streetlights-and-converting-them-into-ev-charging-stations/

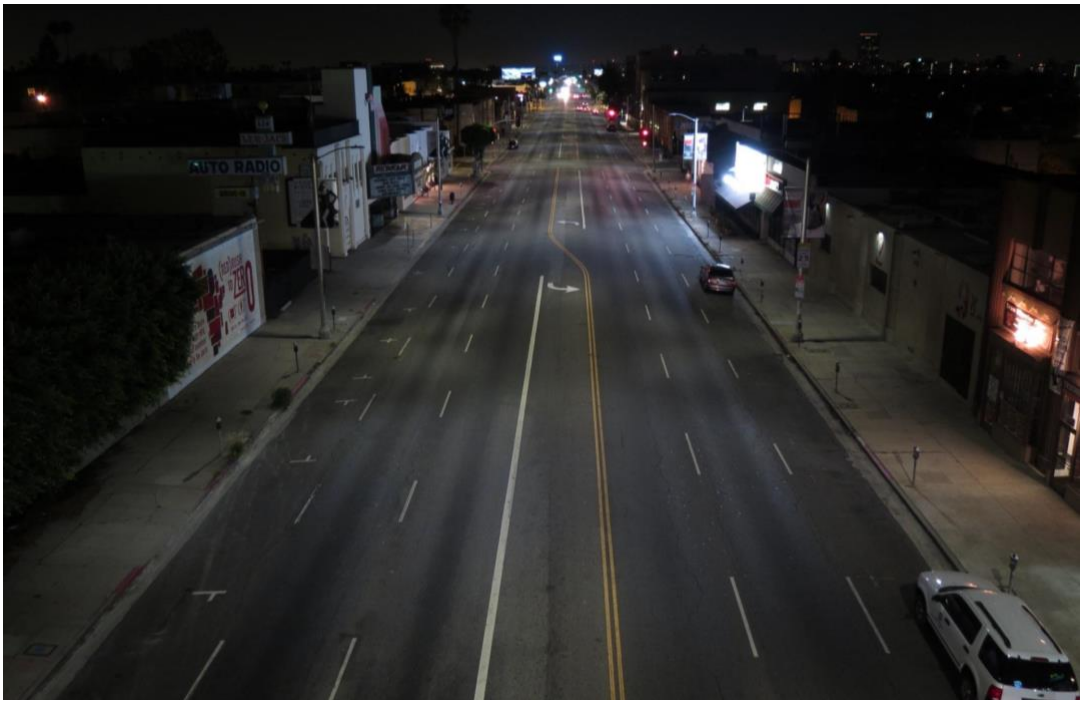
[19] LEDs also have lumen distribution patterns appropriate to the distance between poles in order to achieve more consistent lighting on the roadway.

[20] Kimber et al.: p. 3.

[21] Lighting Research Center, Rensselaer Polytechnic Institute, "Parking Lot Lighting with Improved Uniformity," 2015: http://www.lrc.rpi.edu/programs/solidstate/parkingLotUniformity.asp

[22] A lower uniformity ratio means more evenly distributed light. The uniformity ratio can be either the ratio of the illuminance in the brightest-lit spots to that in the dimmest areas

Figure 1 - A Los Angeles street illuminated by 200w HPS, just prior to LED conversion.



(max/./min),.), or of the average illuminance of the whole area to that of the dimmest spots (avg/./min),.), as in this case. The best results for visual acuity occur when the uniformity ratio is close to one.

Figure 2 - The same street converted to 64-watt LED street lights.

Enhanced Pedestrian, Traffic, and Community Safety:

Several technical characteristics of LED street lights combine to improve the quality of lighting and enhance safety. The superior optics of LED lights better directs light to where it is needed while reducing glare that can obscure visibility. There is also growing evidence that the higher Color Rendering Index of LEDs compared to HPS, low-pressure sodium, and MV street lights improves visibility.[23] Finally, LEDs are far better than HPS street lights at showing the true colors of the objects they are illuminating ("color rendering"). Together, these characteristics improve drivers' ability to see pedestrians and other vehicles. They can also enhance neighborhood security by making it easier to identify potential threats or problems, and by reducing dark areas between lights.

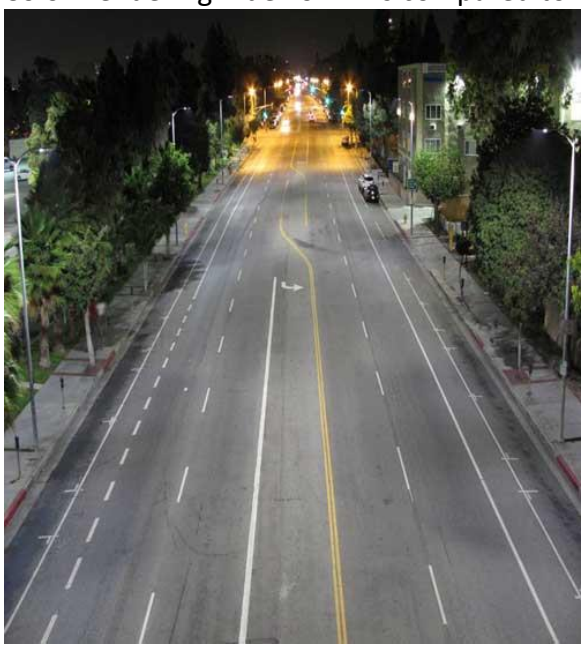


Figure 3 - A street in Los Angeles, California, in the process of street light conversion

Reduced Light Trespass:

Because LEDs direct light downward rather than all around the fixture, they can significantly reduce light trespass. However, it is critical that LEDs be properly sized to maximize this benefit. As mentioned above, LEDs can provide comparable or better illumination than the lights they are replacing at much reduced lower wattages. A common mistake, especially among the early adopters of LED street lights, has been to select fixtures at a higher wattage level than necessary, leading to public complaints about the lights being overly bright and producing glare. The City of Seattle, for instance, which began its conversion to LEDs in 2009, reduced the setting of its street lights to a lower wattage in response to complaints about brightness. In New York City, Department of Transportation installed lower-wattage fixtures after receiving similar complaints about brightness.[24] Wattage levels that are too high can create problems with glare, particularly in inclement weather, negating some of the potential road safety benefits of LEDs. If properly sized, however, a conversion to LEDs can mitigate light pollution

[23] Kimber et al.: p. 3.

[24] Matt A.V. Chaban, "New York's LED Streetlights: A Crime Deterrent to Some, a Nuisance to Others," *The New York Times*, July 11, 2016: http://www.nytimes.com/2016/07/12/nyregion/new-yorks-led-streetlights-receive-a-lukewarm-reception.html?_r=0

from street lights, as illustrated by these “before” and “after” photos taken of the City of Los Angeles.

Figure 4 - A view of Los Angeles in 2002, before the LED street light conversion

Figure 5 - The same view in 2012, after the conversion [29]

The color of LED lighting is typically cooler (appears whiter) than the lights they are replacing, and the impact of the technology’s higher correlated color temperature (CCT) on human health and environmental health has been the subject of some debate. CCT is the measure of a balance of energy in a spectrum, and a lower CCT indicates less blue content. A 2016 report of the American Medical Association (AMA) suggested various potential health impacts of short-wave (bluer) light, and the International Dark Sky Association has recommended a CCT level for outdoor lighting no higher than 3,000 Kelvin.[25] The Illuminating Engineering Society, the

[25] The human health concerns relate to potential impacts on melatonin levels and sleep patterns. See American Medical Association, Council on Science and Public Health, “Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting,” 2016. The U.S. Department of Energy (DOE) responded to this guidance issued by the American Medical

Lighting Research Center at Rensselaer Polytechnic Institute, and the U.S. Department of Energy's Pacific Northwest Laboratory have disputed the conclusions of the AMA report, arguing that CCT is an inadequate basis for the purpose of evaluating health impacts. They point to a number of other factors that should be considered in the analysis, including the relative spectral power of the wavelengths in question, duration of exposure, relative exposure from other sources within the home, and nighttime visibility and reaction times. Research on the broader questions of how outdoor lighting affects human and environmental health are on-going, and the best steps that communities can take to minimize risks are to avoid over-lighting, and to consider shielding for lights that are located in close proximity to buildings.

Demonstrating Environmental Leadership:

Many local governments are taking action in an effort to reduce the severity of climate change. In New York State, some 190 municipalities have adopted the Climate Smart Communities Pledge, partnering with the State government to build resilient, low-emissions communities.[26] NYSERDA's Clean Energy Communities Program includes conversion to LED street lights as one of 10 High-Impact Actions local governments can take to save money, foster a vibrant economy, and improve the environment.[27] Upgrading to LED street lights is one of the most visible energy efficiency projects a local government can undertake, demonstrating to the community a municipal commitment to reducing energy use and modeling environmental leadership. Converting to LED street lighting can help encourage residents, businesses and schools to invest in more efficient lighting technologies for their homes and buildings, spreading the benefits throughout the community.

The climate benefits of street light conversion can be substantial: The City of Yonkers, in Consolidated Edison territory, reduced its greenhouse gas emissions (GHG) by 10 percent through its LED street light conversion, for a total reduction of nearly 3,000 metric tons of GHG emissions annually.[28] The potential GHG emissions reduction from street light conversion across the Mid-Hudson region is nearly 16,500 metric tons per year (see Chapter 5).

Once municipalities have converted to LED street lights, they can capitalize on the financial savings from reduced energy use and maintenance costs to ramp up GHG emissions reductions

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Association, seeking to clarify some of the facts on this question: http://energy.gov/eere/ssl/articles/get-facts-led-street-lighting. See also the response of DOE's Municipal Solid-State Street Lighting Consortium in *The Light Post,* https://mail.google.com/mail/u/0/#search/AMA+/155ff99ac64a304d?compose=15ae7d9f7df8a8ca

[26] For information about the Climate Smart Communities Program, go to http://www.midhudsoncsc.org/join.html.

[27]New Your State Energy Research and Development Authority, "Clean Energy Communities Program: Guidance Document," Program Opportunity Notice (PON) 3298, https://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-3298-Clean-Energy-Communities-Program :p.3.

[28]VHB Engineering: p. 9

still further: The City of Los Angeles, for example, used some of the resulting financial savings and excess capacity at power plants from its street light conversion to support the build out of 100 electric vehicle charging stations throughout the city.[29]

A conversion to LED street lights in the Mid-Hudson region can make an important contribution to New York State's goal to reduce GHG emissions by 80 percent by 2050 and 40 percent by 2030 below 1990 emissions levels.[30] As demonstrated in the foregoing discussion, it is also one of the most cost-effective actions local governments can take to reduce emissions, promising substantial long-term financial returns.

Capitalizing on Smart Cities Technologies:

With advances in communications technology and new opportunities to network street light systems, LED street light systems can provide much greater control over lighting than older technologies. Street lights can be set to dim in the late night/early morning hours when the streets are quiet, saving energy and reducing unwanted nighttime lighting. Or they can be set to provide brighter lighting levels at certain hours when traffic volumes are highest at particular locations to reduce the incidence of accidents. Lighting levels can be adjusted in real time or they can be set to change at specified times. While utility tariffs do not currently accommodate advanced functionality in LED street lighting for either customer-owned or company-owned lights, the Public Service Commission has stated that tariff provisions for advanced controls will be considered in the future.[31]

As "Smart Cities" technologies (also referred to as the "Internet of Things,") develop, local governments can use street lights as a communications platform. As an example, a number of water meter companies and electric meter companies are using the same communications platform to enable remote meter reading. In Paris, France, a major initiative was undertaken to link traffic monitors and traffic signals through a communications system to allow real time synchronization of traffic signals for managing traffic flow in the city. Instead of using a separate communications platform, the traffic signal control box simply "talks" to the nearest street light. An intelligent street light system will likely be a conventional feature in the Internet of Things in the years ahead.

The Challenges

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[29] Alex Davies, "LA's Using Energy Savings from LED Streetlights to Charge Electric Vehicles," *Wired*, June 8, 2016: https://www.wired.com/2016/06/las-using-energy-savings-led-streetlights-charge-electric-vehicles/

[30] See the *2015 New York State Energy Plan* at https://energyplan.ny.gov.

[31] NYS Public Service Commission, *Order Approving Tariff Amendments with Modifications*, In the Matter of the Tariff Filing by Orange and Rockland Utilities, Inc., to Update Service Classification No. 4 – Public Street Lighting –Company Owned – to Incorporate LED Options Contain in P.S.C. No. 3 – Electricity (Case 16-E-0226), Effective March 10, 2017: p. 16-17.

While the economic, environmental and other benefits of an LED street light conversion are substantial, local governments can face challenges to moving forward. Perhaps the biggest challenge is a lack of knowledge and information about their options and the steps involved in converting the lights. Utility LED options are very new, and local governments are unlikely to be aware of what their utility is offering, how much the LEDs cost, and what the procedures and requirements are for installing them. Much of this information is contained in each utility's **tariff**, which sets out a utility's policies, procedures, and schedule of rates that have been approved by the PSC. These documents, available on the utility and Department of Public Service (DPS) websites, are quite voluminous and can be daunting to those unfamiliar with the language of utility regulation.

In addition to new utility LED options, utilities now also have new tariff provisions that streamline the process for municipalities to purchase the street light system and convert to LEDs on their own, thanks to 2015 State legislation amending Section 70 of New York State Public Service Law. As with utility LED options, it is unlikely that most local governments are familiar with the steps and requirements of this process. Local governments will naturally want to understand the relative costs, risks, and benefits of utility-ownership and municipal-ownership models before deciding how to move forward.

That is where this report comes in. To help local governments in the Mid-Hudson region evaluate which pathway to LED conversion is right for them, the report will:

- Describe and evaluate the current and proposed utility LED street light options in the three service territories—Central Hudson, O&R, and NYSEG (Chapters 2).

- Examine the costs, risks and benefits of a municipal ownership model (Chapters 3).

- Provide a cost comparison of the utility- and municipal-ownership pathways to LED conversion (Chapter 5).

In the Mid-Hudson region, municipalities typically have a mix of street light types that includes HPS and less efficient MV lamps, as well as some even less efficient incandescent fixtures. This mix varies by service territory, because utilities have purchased different models and types in different quantities, and have followed different upgrade plans over time. This report provides local governments with an estimate of potential savings for a representative municipality in each of the three Mid-Hudson service territories in which the utilities own the street light system.

Another challenge to conversion that local governments face is financial. Municipalities, especially small rural towns and villages, typically operate within very lean budgets and face competing infrastructure demands that cannot all be met with existing savings. Although upgrades to LED street lights promise long-term financial savings, the initial cost of a conversion, particularly if it involves purchase of the existing street lights from the utility, can appear daunting. This report will help municipalities understand the financing options available

to them, and the costs, benefits and risks of each (Chapter 4). The good news is that a variety of options are available to suit the different needs of local governments and the different financial conditions and pressures they confront.

Finally, for those municipalities that own their street lights or are considering purchasing their lights from the utility, a lack of information about the various design, cost, and planning considerations involved in an LED conversion can present a barrier to moving forward. This report will help fill this gap by providing a step-by-step guide to converting to LED street lights (Chapter 6) and by identifying additional resources that municipalities can draw on as they develop their conversion plans (Appendix A).

Choosing a Pathway to LED Street Light Conversion

LED street lighting technology has rapidly improved in the last decade, promising substantial benefits to local governments and communities in terms of financial and energy savings and better quality lighting. The question for local governments is no longer *whether* to convert to LEDs but *how* to implement this major improvement. This report is meant to aid local governments in their decision-making process by assessing utility LED options; comparing the costs, benefits, and risks of the different pathways to LED conversion; and identifying the issues and steps that local governments should consider when developing their LED conversion plans. With this information, local governments can make an informed decision about the pathway to LED street light conversion that is right for them.

Although this guide focuses on LED conversion opportunities in the Central Hudson, O&R, and NYSEG territories, where street lights are generally utility-owned, Westchester municipalities in Con Edison territory that already own their lights will benefit from this report's discussion of financing and procurement options. And because the Mid-Hudson region reflects the diversity of New York State, with large urban centers as well as numerous smaller towns and villages in more rural areas, local governments outside of the Mid-Hudson region will also find this guide to be useful in their decision-making.

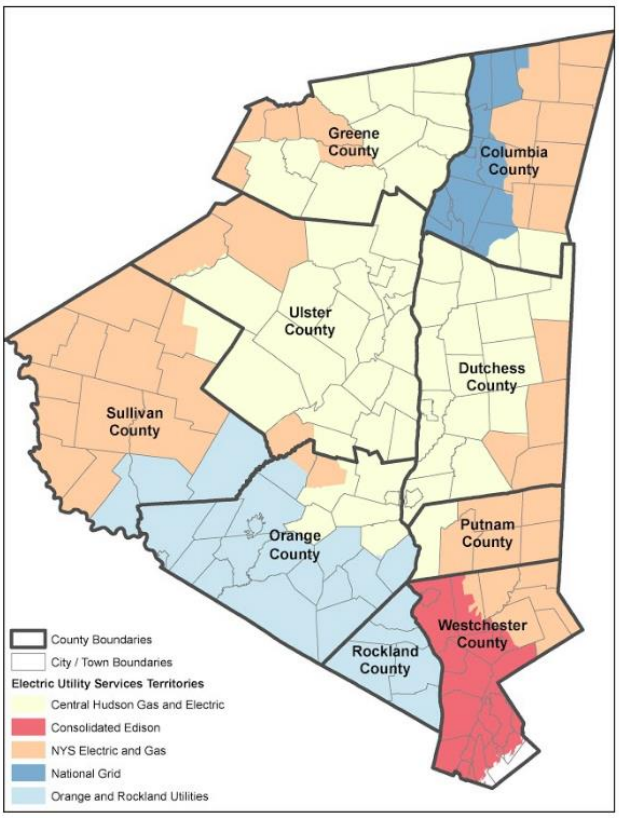

Figure 6 - Mid-Hudson region map

The Mid-Hudson region, as defined in this report, includes all of Dutchess, Orange, Putnam, Rockland, Sullivan, Ulster and Westchester counties and the parts of Greene and Columbia counties located within