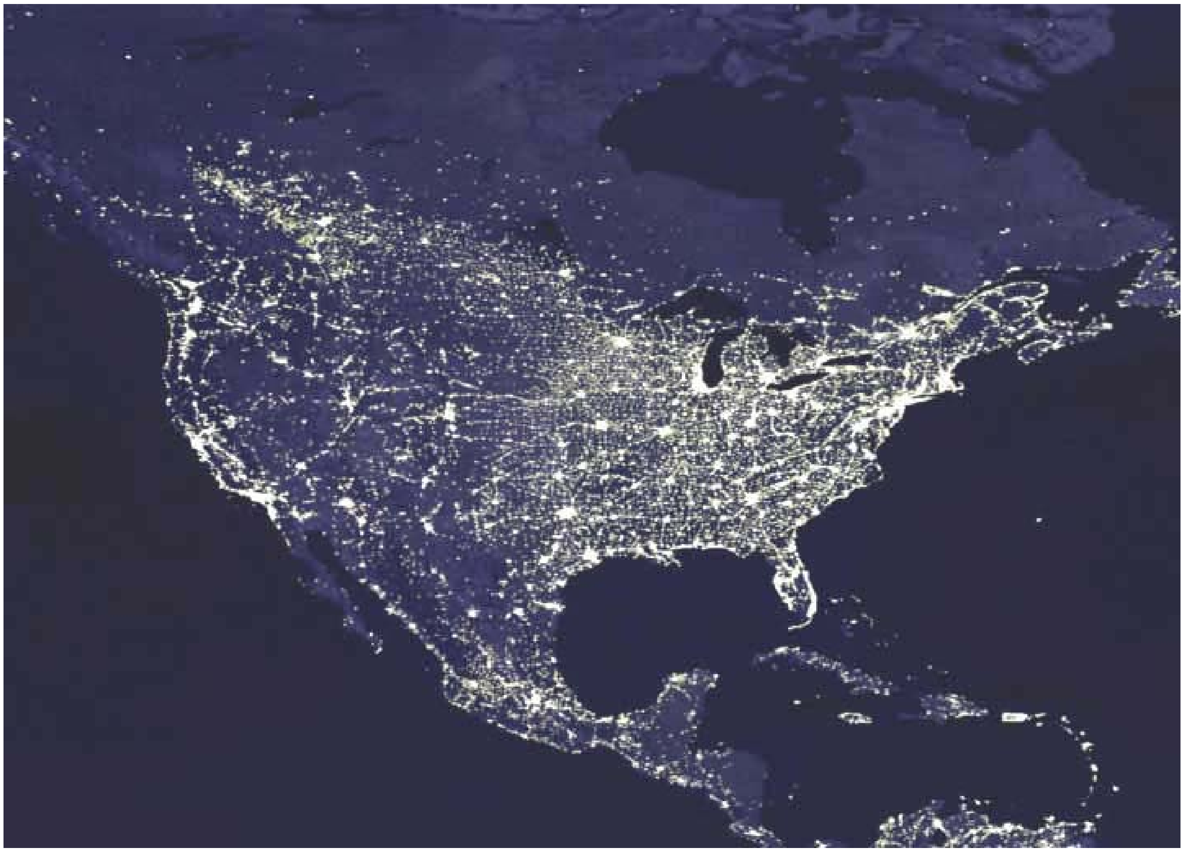
Energy Efficient Streetlights

-- Potentials for Reducing Greater Washington’s Carbon Footprint --



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Prepared by:

Robert T. Grow, ACCE Ford Fellow
Greater Washington Board of Trade

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Forward

In the challenge to reduce our world's greenhouse gas emissions the most tangible and perhaps the most easily accomplished opportunity is to become more energy efficient. This is the low hanging fruit.

Every reduction in kilowatt needs is energy that does not have to be produced -- and CO_2 that does not have to be emitted.

Energy efficient streetlights are one step in addressing this opportunity. The following analysis developed for the ACCE Ford Fellowship on Regionalism and Sustainable Development is an important step in the right direction.

Jonathan Lash
President
World Resources Institute

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Brian Bosworth, Principal, Futureworks

Mark Carter, Regional Manager, Echelon Corporation

Vijay Dhingra, Director, Product Marketing, Echelon Corporation

James C. Dinegar, CAE, President & CEO, Greater Washington Board of Trade

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Pamela L. Farrell, Director, Ecomagination, Government & Utility Initiatives, GE, Consumer & Industrial

Stuart Freudberg, Director, Environmental Programs, Metropolitan Washington Council of Governments

Stephen Michon, Principal, Futureworks

Emeka Moneme, Director, District of Columbia Department of Transportation

John Morrill, Energy Manager, Arlington County, Department of Environmental Services, Arlington, Virginia

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Victor Sousa, Chief of Utility Procurement, Montgomery County, Maryland

Stephen L. Sunderhauf, Manager, Program Evaluation Department, Pepco Holdings, Inc.

Bob Warden, Vice President, Corporate Accounts, Echelon Corporation

Emil Wolanin, Chief Traffic Engineer, Montgomery County, Maryland

(Cover photo Courtesy of Defense Meteorological Satellite Program and National Aeronautics and Space Administration)

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Background

The North American Electric Reliability Council (NERC) estimates that demand for electricity in the U.S. will grow by over 19 percent during the next decade. At the same time, however, currently committed electric capacity is projected to grow by only six percent.[1] The Brattle Group in a recent analysis[2] of current and future electric needs observes that there is very little time to "build" our way out of the problem of a demand-supply imbalance by simply expanding the nation's generating capacity. The Brattle study notes a growing consensus that the best way to ensure reliability is to deploy an integrated approach that combines traditional supply-side solutions with demand-side solutions that gives customers the ability to control their electricity use.

One opportunity to address the demand-side of this issue is to save electricity via technological upgrades to municipal streetlighting. Electricity used for municipal streetlights accounts for up to 38 percent of electricity use in European cities[3] annually. In suburban Fairfax County, Virginia, streetlights account for 24 percent of general county electricity use (not including schools).[4]

Reducing the Energy Requirements of Streetlights

A number of companies have created applications to reduce the amount of electricity required by streetlights and other outdoor lighting. These include Echelon Corporation (San Jose, California www.echelon.com) which, in 2004, partnered with Philips Lighting (Oslo, Norway) and Kongsberg Analogic AS (Kongsberg, Norway) to install a managed streetlighting system in the City of Oslo, Norway. This is the first system in Europe to adopt such a system and has cut total electricity use by 50 percent with a five year return on investment (ROI).

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[1] North American Electric Reliability Council, *2006 Long-Term Reliability Assessment*
[2] The Brattle Group, *The Power of Five Percent*, May 16, 2007
[3] Echelon Corporation, *Monitored Outdoor Lighting: Market, Challenges, Solutions, and Next Steps*, March 2007
[4] County of Fairfax, Virginia Government

While energy savings is undoubtedly a key driver in the move to managed streetlighting systems and energy efficient lamps, converting a streetlight system to a managed one through the use of Echelon's control networking also has significant operational and environmental benefits. Consider a city that is already using energy efficient lamps and saving significantly on their energy bill. Some types of managed streetlighting systems can easily be extended with traffic monitoring capabilities. Therefore, during evening and night hours, the system can detect when traffic, as an average, is moving too fast which in turn triggers a slight dimming of the streetlights. The level of dimming would be imperceptible to motorists but they would slow regardless in response to the slightly diminished lighting. A five percent light reduction slows traffic but is not noticeable to motorists. [5]

The stream of data provided by the control system also enables the ability of cities to pinpoint lamp failures or malfunctions leading to lower maintenance costs, higher levels of customer service, increased safety, inventory reductions, and city beautification. These data also provide a level of reporting and performance auditing that could greatly impact a city's liability exposure. For example, in the event of lawsuit brought against the city for an accident, a managed streetlighting system can accurately report the status and light output of any area by time of day and date.

Other key benefits enabled by the control system include lowering light pollution from populated areas and improved security (due primarily to lamp performance monitoring).

Philips Lighting www.philips.com produces new streetlights that are more energy efficient. The Philips CosmoPolis offers savings of 50 percent or more compared to older and less energy efficient high pressure mercury vapor lamps. It offers more potential energy savings in the future with the addition of lighting controls

[5] Rijksuniversiteit Groingen, Dr. D de Waard

which can automatically adjust light levels to meet demand (e.g. Echelon managed streetlight technology).

GE Lighting Systems, Inc. www.gelightingsystems.com has for over fifty years been a recognized industry leader in roadway lighting. High Brightness LED (light emitting diodes) offers the first efficacy improvement since the introduction of High-Pressure Sodium (HPS) in the early 1970's. Current projects have validated energy reduction utilizing LEDs for specific roadway applications and have delivered other environmental and asset savings. Unlike the HPS light source, the High Brightness LEDs provide significantly improved color-rendering characteristics introducing the opportunity to reduce light levels in deference to vastly improved uniformity. Energy savings of up to 40% over a traditional magnetic High Intensity Discharge (HID) system can be realized while providing more uniform, consistent light levels.

LED offers significant customer advantages including reduction of capital investment in replacement parts inventories, reduced down time and service interruptions due to component failures, and enhanced photometric performance providing uniform light levels while reducing glare and light trespass. GE Lighting Systems is working on a solution that will provide municipalities with a more efficient streetlight system.

In November 2007 Cree, Inc., (Durham, North Carolina www.cree.com) a leader in LED solid-state lighting components launched a partnership with the City of Ann Arbor, Michigan to convert all of its downtown streetlights to LED technology cutting current electricity use by 50 percent.

City of Oslo Norway

The City of Oslo is using Echelon's technology to remotely control and monitor streetlights in the City. This intelligent outdoor lighting system is the first large scale implementation of a control network in a streetlighting application in a city in Europe, and is expected to reduce energy usage by over 50 percent, improve roadway safety, and save money by minimizing maintenance costs.

Oslo is replacing older, inefficient mechanical ballasts in the City's 55,000 streetlights with "smart" electronic ballasts from SELC Ireland Limited that include Echelon's power line communication technology. Data from the streetlights will be collected by approximately 1,000 segment controllers, which manage the streetlights and communicate with the City of Oslo monitoring center. Internet servers will log and report energy consumption, collect information from traffic and weather sensors, and calculate the availability of natural light from the sun and the moon. This data is used to automatically dim street lights based on the season, local weather, and traffic density. Significant energy savings result from this highly efficient method of controlling lighting, which also extends lamp life and reduces replacement costs by avoiding unnecessary lamp operation. This system has the capacity to control and save electricity on even the newer energy efficient LED lamps.

This technology provides total control of the streetlighting system, will lower energy, operations, and maintenance costs while ensuring proper roadway illumination required for public safety. As is the case with all energy management systems that leverage a distributed control network, the City of Oslo is able to calculate a return on investment that includes energy and operational savings. In Oslo's case, energy and maintenance savings that will be achieved will pay for the new system within five years.

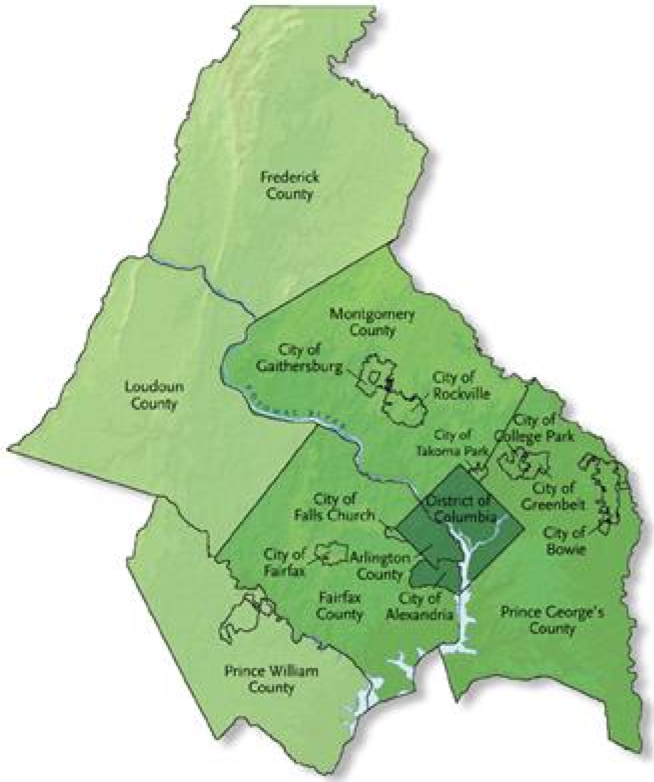
Other Applications

The City of Milton Keynes in the United Kingdom is using managed streetlight technology including over 400 streetlights as a trial project with 10,000 additional planned to be installed over the next three years. In October 2007 Ville de Quebec, Canada became the first North American installation of a managed streetlight system having installed 200 streetlights in its historical district as a trial project and expects to convert at least 1,000 lamps per year to the new system over the next ten years.

Potentials for Reducing Electricity Consumption in the Greater Washington, DC Region

It is possible to both conserve scarce municipal revenues and reduce CO2 emissions through more efficient streetlight systems. What are the potentials for Greater Washington? For purposes of estimation, it will be assumed that 50 percent can be saved annually in electricity use in Greater Washington based on Oslo's experience and the findings on new energy efficient lamps. For purposes of regional estimates, it is also assumed that municipal electricity costs $0.06 cents per kWh and than each streetlight uses 675.5 kWh annually.

Greater Washington Region



Source: Metropolitan Washington Council of Governments

Arlington County, Virginia

There are about 13,000 streetlights in Arlington County varying from 100-watt mercury vapor to 400-watt high pressure sodium lamps depending on age and location. Dominion Virginia Power owns and maintains most (> 10,000) of these lights, and the County owns and maintains the others.

These 13,000 streetlights use an estimated 8.78 million kWh of electricity annually requiring an expenditure of approximately $527,000 in electricity.

If Arlington County were able to achieve a 50 percent increase in efficiency, it could drop its electricity use from 8.78 million kWh to 4.39 million kWh -- a saving of 4.39 million kWh annually. This is a dollar saving of $263,000 and an equivalent reduction in carbon footprint of 3,413 metric tons of CO_2.

District of Columbia

Washington, DC has a total of 62,394 street lights and uses 60.7 million kWh annually. A 50 percent reduction in electricity will save 30.4 million kWh annually translating into a dollar savings of $1,824,000 and a reduction in carbon footprint of 23,596 metric tons of CO2. (Appendix A for details).

Fairfax County, Virginia

Fairfax County, Virginia, a suburban jurisdiction outside of Washington, DC, has a total of 56,542 streetlights using 38.2 million kWh annually or 675.5 kWh per light (Appendix B for details). Most streetlights in Fairfax County belong to Dominion Virginia Power and Dominion is therefore responsible for any change in lighting architecture or application of new technology.

A reduction of 50 percent decreases its annual need for electricity by 19.1 million kWh resulting in a dollar savings of $1,146,000 annually and a decrease in its carbon footprint by 14,849 metric tons or CO2.

Montgomery County, Maryland

Montgomery County is another suburban jurisdiction outside of Washington, D.C. with 66,000 streetlights, using 44.6 million kWh of electricity annually at a cost of $2,674,980 annually. A similar reduction in electricity use will save 22.3 million kWh in electricity and approximately $1,338,000 of taxpayer dollars.

See Tables 1 and 2 for a summary of these local estimates.

Table 1
Data on Streetlights -- Selected Jurisdictions

Jurisdiction	Streetlights	Streetlights Per Capita	kWh Used Annually (Million)	CO2 Emissions (Metric Tons)
Arlington County, VA	13,000	0.065	8.78	6,826
District of Columbia	62,394	0.107	60.7	47,192
Fairfax County, VA	56,542	0.056	38.2	29,699
Montgomery County, MD	66,000	0.071	44.6	34,675

Source: Number of streetlights from local governments. Per capita, kWh use and CO2 emissions are government and author estimates.

Table 2
Annual Energy and Environmental Savings
Selected Jurisdictions

Jurisdiction	kWh of Electricity Saved (Mil)	Cost of Electricity	CO2 Emissions (Metric Tons)	Automobile Equivalency Removed from Roads	Gallons of Gasoline Equivalency
Arlington, VA	4.39	$263,000	3,413	625	387,405
District of Columbia	30.4	$1,824,000	23,596	4,329	2,682,713
Fairfax County, VA	19.1	$1,146,000	14,849	2,720	1,685,520
Montgomery County, MD	22.3	$1,338,000	17,337	3,175	1,967,911

Source: CO2 and equivalency estimates from U.S. Climate Technology Cooperation Gateway (U.S.-CTC Gateway) Greenhouse Gas Equivalencies Calculator

Estimates for the Greater Washington, DC Region --

Assuming a 2006 population of 5,290,400 for Greater Washington and using the number of streetlights per capita (0.056) for Fairfax County as a conservative proxy value for all jurisdictions provides an estimate of 296,262 streetlights in the Greater Washington region. Table 3 reveals a total of 200 million kWh of electricity used and resulting in an expenditure of $12 million annually.

Table 3
Streetlights in the Greater Washington, DC Region

Number of Streetlights	Current kWh (Mil)	Cost for kWh (Mil)	CO2 Emissions (Metric Tons)	Passenger Car Equivalent	Gallons of Gas Equivalent
296,262	200	$12	155,491	28,478	17,649,428

Source: CO2 and equivalency estimates from U.S. Climate Technology Cooperation Gateway (U.S.-CTC Gateway) Greenhouse Gas Equivalencies Calculator

Applying a 50 percent savings, total electric use can be reduced by 100 million kWh annually, saving $6 million and reducing our region's CO2 emissions by 77,746 metric tons of CO2, the equivalent of removing 14,239 passenger cars from our roads for one year or 8,824,714 gallons of gasoline.[6]

Table 4
Annual Energy and Environmental Savings
Washington, DC Region

kWh (Mil)	Electricity Cost (Mil)	CO2 Emissions (Metric Tons)	Passenger Car Equivalent	Gallons of Gasoline Equivalent
100	$6	77,746	14,239	8,824,714

Source: CO2 and equivalency estimates from U.S. Climate Technology Cooperation Gateway (U.S.-CTC Gateway) Greenhouse Gas Equivalencies Calculator

Implementation Costs for a Managed Network -

A rough estimate of the costs of implementing a managed intelligent streetlight network for 300,000 streetlights in Greater Washington would include:

[6] Calculations of CO2 produced and equivalents are from the U.S. Climate Technology Cooperation Gateway sponsored by the U.S. Environmental Protection Agency (EPA) and the U.S. Agency for International Development (U.S.AID)

Installation of new “smart” electronic ballasts in each streetlight. A smart electronic ballast is a ballast that can communicate with the managed system to send and receive information and commands to and from the lamp. The ballast will also provide the proper starting and operating electrical conditions to power HID lamps such as high pressure Sodium Vapor (SV) lamps.

HID lamps – the second new hardware component of the managed system -- are much more energy efficient than the widely used older gaseous-discharge Mercury Vapor (MV) lamps which are being phased out by EPA.

Next installed are segment controllers. Segment controllers are electronic devices that manage the streetlights’ schedules, track failures, collect appropriate data from each light, and ensure communications from streetlights to the enterprise software system. For purposes of this illustration it will be assumed that one segment controller is needed for every 50 streetlights. This general rule may vary depending on the particular architecture of each streetlight system.

Once smart electronic ballasts, HID lamps, and segment controllers are installed, it is possible to control streetlights from a central command post at the local public utility office. This works through an Internet link over a wireless modem. The public works office can therefore use one site to control the timing of when all city streetlights are on or off (or streetlights in sections of the city or a neighborhood) and can control the intensity of lighting depending on the time of day, on road conditions, or on the natural lighting conditions at the moment.

Before -- No HID lamps or managed streetlight system

After – HID lamps and managed system installed resulting in reduction in energy use and carbon footprint yet better lighting and control of intensity to attain “dark skies” goals.

Photo illustrations courtesy of Echelon Corporation

Project Costs

The project implementation costs amount to an estimated $232 per streetlight based on the assumptions below.

300,000 “smart” electronic ballasts @ $200 each =	$60,000,000
300,000 HID lamps @ $10 each =	3,000,000
6,000 segment controllers @ 600 each =	3,600,000
6,000 segment controllers software costs @ 400 each =	2,400,000
6,000 segment controllers installation cost @ 100 each =	600,000
Total cost for a 300,000 streetlight system =	$69,600,000

A managed streetlight system for the Greater Washington region will eliminate 77,746 metric tons of CO_2 annually with direct cost savings $6 million in electricity. Additional savings are derived by extending the life of existing lamps by approximately 50% as well as by eliminating the need to monitor streetlight failures through patrolling and staffing call centers and the elimination of photo control caps which are subject to frequent failure.

Industry estimates of non-energy savings range between $10-$15.00 per lamp annually. Assuming an average of $12.50 savings per lamp, this would result in an additional savings of $3,750,000 for a total system savings of $9.75 million. The return on investment of a $69.6 million dollar upgrade for all streetlights in the Greater Washington region would be approximately seven years based on conservative assumptions. Again, the Oslo case study represents a five year ROI and may be more representative. This figure does not include the monetary value of the CO_2 reductions which, if valued at $30 per metric ton, amounts to an additional benefit of $2.3 million annually.

The energy saving benefits of new more efficient lamps from GE, Philips, or others will be further enhanced under a managed streetlight system. The managed system will extend lamp life, eliminate the energy needs of old ballasts, eliminate the need to maintain and replace photo control caps, and eliminate the need for road crews to make site visits to check for lamp failures. Finally the managed system will allow for dimming all or only sections of a city's streetlights to comply with local dark skies goals.

Estimates for the Top Ten Largest U.S. Metropolitan Areas

For illustrative purposes, an extension of these basic assumptions can be applied to the nation's top ten metropolitan areas included in Tables 5 and 6.

Table 5
Streetlight Characteristics
Top Ten U.S. Metropolitan Statistical Areas

Metropolitan Area	Population 2006	Number of Streetlights	kWh / Yr (Mil)	CO2 Emissions (Metric Tons)
New York-Northern New Jersey-Long Island, NY-NJ-PA	18,818,536	1,053,838	711.8	553,394
Los Angeles-Long Beach-Santa Ana, CA.	12,950,129	725,207	489.8	380,799
Chicago-Naperville-Joliet, IL-IN-WI	9,505,748	532,321	359.5	279,496
Dallas-Fort Worth-Arlington, TX	6,003,967	336,222	227.1	176,561
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	5,826,742	326,297	220.4	171,352
Houston-Sugar Land-Baytown, TX	5,539,949	310,237	209.6	162,955
Miami-Fort Lauderdale-Miami Beach, FL	5,463,857	305,975	206.7	160,700
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,290,400	296,262	200.0	155,491
Atlanta-Sandy Springs-Marietta, GA	5,138,223	287,740	194.3	151,060
Detroit-Warren-Livonia, MI	4,468,966	250,262	169.0	131,390
Total	**79,006,517**	**4,424,361**	**2,988.5**	**2,323,431**

Source: U.S. Census Bureau, 2006 population estimates for Metropolitan Statistical Areas; number of streetlights and kWh estimates by author; CO_2 estimates from U.S. Climate Technology Cooperation Gateway (U.S.-CTC Gateway) Greenhouse Gas Equivalencies Calculator

The 4,424,361 streetlights in our nation's ten largest metropolitan statistical areas use an estimated 2,988,500,000 kWh of electricity annually producing the equivalent of 2.3 million metric tons of CO_2. A 50 percent reduction on kWh used amounts to a savings of 1,494,250,000 kWh or 1,161,716 metric tons of CO_2.

Table 6
Top Ten U.S. Metropolitan Statistical Area
Energy and Environmental Savings

Metropolitan Area	**kWh (Mil)**	**CO2 Emissions (Metric Tons)**	**Automobile Equivalent**	**Gallons of Gasoline Equivalent**
New York-Northern New Jersey-Long Island, NY-NJ-PA	355.9	276,697	50,677	31,407,158
Los Angeles-Long Beach-Santa Ana, CA.	244.9	190,399	34,872	21,611,725
Chicago-Naperville-Joliet, IL-IN-WI	179.8	139,787	25,602	15,866,836
Dallas-Fort Worth-Arlington, TX	113.6	88,319	16,176	10,024,875
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	110.2	85,676	15,692	9,724,835
Houston-Sugar Land-Baytown, TX	104.8	81,478	14,923	9,248,300
Miami-Fort Lauderdale-Miami Beach, FL	103.4	80,389	14,723	9,124,754
Washington-Arlington-Alexandria, DC-VA-MD-WV	100	77,746	14,239	8,824,714
Atlanta-Sandy Springs-Marietta, GA	97.1	75,491	13,826	8,568,798
Detroit-Warren-Livonia, MI	84.5	65,695	12,032	7,456,884
Total	1,494.2	1,161,716	212,768	131,863,292

Source: kWh estimates by author; CO2 and equivalency estimates from U.S. Climate Technology Cooperation Gateway (U.S.-CTC Gateway) Greenhouse Gas Equivalencies Calculator

Conclusions and Recommendations:

1. Managed streetlight networks represent a major opportunity for local governments to reduce their electricity use and carbon footprint. As referenced previously, streetlights account for 24-38% of local governments' electricity budget (not including school systems). Greater Washington should set an example for the rest of the nation by establishing a system of energy efficient streetlights. The Washington DC region is an ideal venue for the demonstration of new technologies to address energy savings as it is the backyard of Congress and the national associations dealing with energy conservation and the environment.

   Recommendation: A pilot managed streetlight program or other energy efficiency initiatives should be considered for the Greater Washington region.

2. In addition to municipal streetlights, the technology of managed networks and more efficient lamps can save electricity in outdoor lighting in the quasi-public and private sectors including major complexes such as colleges and universities, hospitals, shopping centers, apartment complexes and other major users of outdoor lighting. For example, the American College and University Presidents Commitment initiative www.presidentsclimatecommitment.org is a high visibility effort to make campuses more sustainable and address global warming by garnering institutional commitments to reduce and ultimately neutralize greenhouse gas emissions on campus. Applying outdoor lighting efficiencies to our nation's major universities alone would have an important impact on energy savings and would set an example for students and the broader community.

   Recommendation: Additional major opportunities of outdoor lighting should be examined.

3. An initiative by local governments in this area sets a tangible, easily implemented, and high profile example for local governments to be greener. While particularly important as a means of reducing a local government's carbon footprint, in the broader picture of CO2 emissions the projected reduction of 77, 460 metric tons of CO2 annually is only a portion of our region's total of 65.6 million metric tons emitted from *all* sources (i.e. electric generation, automobiles, airplanes, home heating systems etc.) as recently reported by the Metropolitan Washington Council of Governments.[7]

   Recommendation: Streetlights and other outdoor lighting should be made more efficient as part of a comprehensive strategy to reduce CO2 emissions including cleaner options for electricity generation, vehicle emissions, more energy efficient buildings, and smart electric meters combined with smart appliances which shift electricity use from peak to off-peak periods.

   In regard to the above, energy savings initiatives for buildings have been launched through the Energy Efficiency Partnership of Greater Washington, www.eep.ncr.vt.edu/ a partnership of Virginia Tech, Hannon Armstrong and Pepco Energy Services. This is a landmark program to address the problem of global warming by retrofitting existing buildings with energy efficient products designed to decrease energy use significantly and cut carbon emissions. The program's goal is to reduce greenhouse gas emissions 20 to 50% from existing buildings – which globally account for nearly 40% of greenhouse gas emissions.

   Hannon Armstrong will finance the retrofitting and has committed to $500,000 annually for the next five years at no capital cost to building owners and county governments. The company will see a return on its

[7] . "D.C. Area Outpaces Nations in Pollution,"*The Washington Post*, 30 September 2007, sec C p.1.

investment over a long-term period via the accrued electricity savings.

Pepco Energy Services will conduct energy audits, supply materials, and perform building retrofits and guarantee the energy savings of the implemented retrofit projects. They will also provide renewable energy options to interested parties. Associate partners in this project are Arlington County, Virginia, Leo A Daly, GVA Advantis, the JBG Companies and The National Building Museum.

Recommendation: The Virginia Tech model should be explored as a means to implement a region-wide managed streetlight system.

4. This study is designed to *raise awareness of the potentials* for saving electricity, taxpayer dollars, and reducing the carbon footprint of the Greater Washington region and of our nation’s major metropolitan areas through energy efficient streetlights. The estimates are designed to be conservative and use the number of streetlights per capita (0.056), cost per kWh (0.06 cents), and kWh per streetlight annually (675.5 kWh) in suburban Fairfax County, Virginia as a proxy for other streetlight systems. (Appendix C provides data on number of streetlights for cities and counties across the U.S.) These factors, will vary depending on the mix of lamps, electricity prices by region, dependency of the grid on coal fired vs. nuclear generation and other variables. The data in this report should be used as a guide regarding potential savings for the areas identified.

Recommendation*: *Jurisdiction-specific data on streetlight systems should be evaluated by individual local governments, environmental organizations or others to determine specific benefits and costs.

5. Most municipal streetlight systems are a confusing mix of ownership, maintenance and control responsibilities split between the local jurisdiction, maintenance contractors and the local utility. For example, a

local government may own some of its streetlight poles and lamps while others are owned by the local utility and leased to the local government. Whether the poles are government or utility-owned, the utility is responsible for distribution and sale of electricity for the streetlights. Responsibility for maintenance such as changing lamps, repairing damage due to collision with vehicles etc. falls either to the government, an independent contractor or the local utility.

Recommendation: Local governments should examine the most efficient management options for their streetlights in order to provide better coordination and control when considering an upgrade to a managed streetlight system or other energy efficiency measures.

-APPENDIX-

Appendix A
Streetlights in the District of Columbia

Approximate Lumens	Quantity	Input Wattage/Light	Monthly KWH/Light	Total Yearly KWH
INC				
2,500	5,338	189	51.78	3,316,820
4,000	6,940	295	80.8	6,729,024
Subtotals	**12,278**			**10,045,844**
MV				
3,300.00	89	100	35.62	38,042
7,000.00	1,961	175	57.54	1,354,031
11,000.00	968	250	79.45	922,891
20,000.00	1,359	400	140.2	2,286,382
Subtotals	**4,377**			**4,601,346**
MH				
	16	150	50.68	9,731
5,000	394	400	123.84	585,516
Subtotals	**394**			**585,516**
HPS				
5,000	5,482	70	23.28	1,531,452
8,000	8,043	150	32.88	3,173,446
14,000	14,536	250	80.82	14,097,594
23,000	17,284	400	128.78	26,710,002
42,000	0			0
Subtotals	**45,346**			**45,512,494**
Total	**62,395**			**60,745,200**

Source: District of Columbia Government, Department of Transportation, Washington, DC
INC – Incandescent MV – Mercury vapor MH – Metal Halide HPS – High pressure sodium

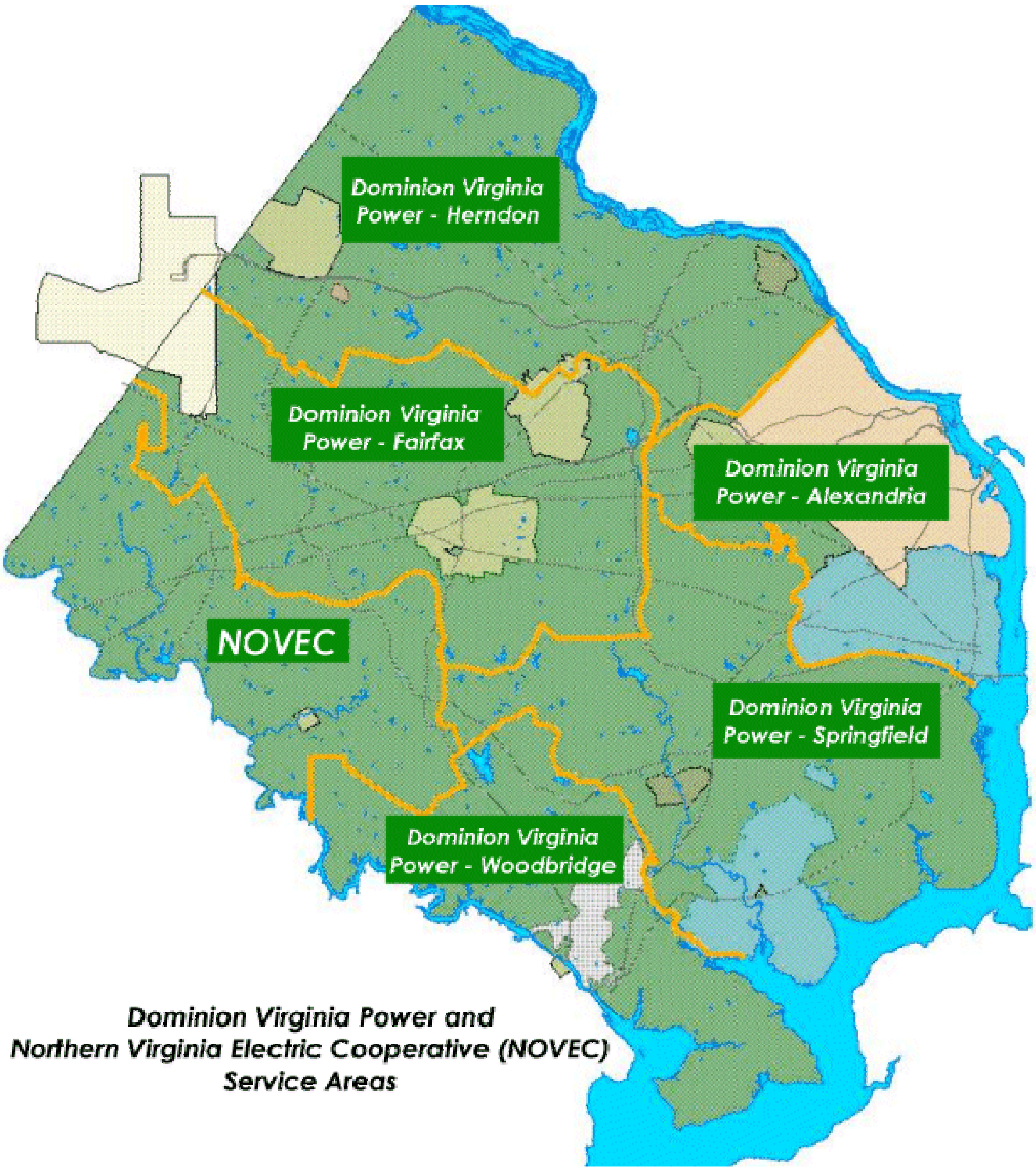
Appendix B
Streetlights in Fairfax County, Virginia

Approximate Lumens	Quantity	Input Wattage/Light	Monthly KWH/Light	Total Yearly KWH
MV				
3,300	18,484	125	40	8,872,320
7,000	6,500	208	70	5,460,000
11,000	1,437	294	100	1,724,400
20,000	1,364	452	150	2,455,200
33,000	10	765	250	30,000
Subtotals	27,795			18,541,920
HPS				
5,000	5,555	82	30	1,999,800
8,000	12,025	120	40	5,772,000
14,000	6,367	202	70	5,348,280
23,000	4,063	315	105	5,119,380
42,000	737	490	160	1,415,040
Subtotals	28,747			19,654,500
Total	56,542			38,196,420

Source: Fairfax County Government, Department of Public Works and Environmental Services, Streetlight Engineering, Fairfax, Virginia

MV – Mercury vapor   HPS – High pressure sodium

Appendix C
Utility Service Area



Appendix D
Streetlights Per Capita
Selected U.S. Cities and Counties
2007

Jurisdiction	Population	Number of Streetlights	Streetlights Per Capita
Los Angeles, CA	3,819,951	242,000	0.063
Chicago, IL	2,869,101	234,200	0.082
Sacramento City and County	1,820,059	30,150	0.016
Fairfax County, VA*	1,010,400	56,542	0.056
San Francisco City and County	744,041	43,000	0.058
District of Columbia*	581,530	62,394	0.107
City of Seattle, WA	569,101	100,000	0.176
Las Vegas, NV	517,017	52,000	0.101
Mesa, AZ	432,376	30,840	0.071
City of Oakland, CA	398,844	32,219	0.081
Forsyth County, NC*	332,355	32,104	0.097
Norfolk, VA	241,727	28,000	0.116
Lincoln, NE	235,594	25,196	0.107
Ft. Wayne, IN	219,495	27,966	0.127
Chandler, AZ	211,299	24,200	0.115
Arlington, Co., VA*	199,776	13,000	0.065
Durham, NC	198,376	13,269	0.067
Winston-Salem, NC	190,299	27,938	0.147
Worcester, MA	175,706	12,972	0.074
Knoxville, TN	173,278	30,000	0.173
Peoria, AZ	127,580	11,829	0.093
Flint, MI	120,292	11,182	0.093
Charleston, SC	101,024	8,935	0.088
Newton, MA	84,323	8,400	0.100
Albany, GA	76,202	10,472	0.137
Asheville, NC	69,045	9,854	0.143
Lakewood City, OH	54,378	3,554	0.065
Chapel Hill, NC	49,301	3,008	0.061
Normal, IL	48,649	2,897	0.060
Smyrna, GA	45,610	2,700	0.059
Charlottesville, VA	39,162	4,150	0.106
Aiken, SC	26,456	3,429	0.130
Average Streetlights Per Capita			**0.095**

Source: Population estimates, U.S. Census, 2003; Street lights from city or county records 2007.
* Arlington County, VA, Fairfax County, VA, District of Columbia and Forsyth County, NC are 2006 population estimates.