New York City's Solar Energy Future

Part I:
The Market for Photovoltaic Systems in New York City

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Prepared by

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- The City University of New York began the Million Solar Roofs Initiative (MSRI) in partnership with the US Department of Energy's Million Solar Roofs program in summer 2005. Under the MSRI, CUNY has set a target of 500 solar roofs installed in New York City by 2010. To meet this target, CUNY has planned an outreach and education campaign that includes an assessment of the solar energy market in New York City, the identification of barriers to solar energy development, and the facilitation of solar projects throughout the City. The CUNY MSRI is being managed by the Center for Sustainable Energy at Bronx Community College.

- The Center for Sustainable Energy was founded in 2003 at Bronx Community College through a Congressional appropriation sponsored the Honorable José Serrano. The Center's mission is to promote a stronger economy and a healthier environment through education, training, and research focused on advanced and emerging energy technologies. These technologies include renewable energy systems like solar and wind power, energy efficiency technologies, and alternative fuel vehicles.

- Solar New York is an organization dedicated to accelerating New York's transition to a solar energy economy. Solar New York seeks to identify the barriers to solar energy development and develop policy strategies to address them. Solar New York has partnered with the Center for Sustainable Energy and CUNY to fund the Million Solar Roofs Initiative in New York City. Solar New York is a program of Clean Energy Clean Environment, a non-profit organization.

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Photos on the report cover courtesy of (from top to bottom) the New York Power Authority, Solar Energy Systems, Inc., and Curtis + Ginsberg Architects.

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Executive Summary

Solar energy is an unlimited and emissions-free source of power that can be quickly and seamlessly integrated into New York City's urban environment. The solar energy market is among the fastest growing energy markets in the world, and solar power has the potential to meet a significant portion of the City's future energy demand.

New York City is one of the largest urban centers in the world and requires a massive amount of electricity to power its economy and infrastructure. New York relies almost exclusively on fossil fuel power plants to generate electricity within the city limits. Recent studies have shown that local renewable energy sources could supply over a third of the city's energy within the next 20 years. However, New York City energy planning has not taken the city's renewable resource into account. As a result, New York City's renewable energy resource remains largely untapped.

According to recent studies, solar electric, or photovoltaic (PV), systems represent New York City's largest potential source of in-city renewable energy. The amount of solar energy that falls on the city each year is two times the energy that the city requires. The challenge for New York City is not whether there is enough sunlight to power the city, but how to best capture and use the available solar energy. It has been estimated that PV systems mounted on rooftops and building façades could supply 18% of the city's electricity by 2022.

In addition to meeting New York City's growing electricity demand, large-scale PV development would generate a broad range of environmental, social, and economic benefits for the city. New York City's reliance on centralized fossil fuel power plants has contributed to air pollution and global warming, created environmental justice challenges, and left the city vulnerable to spiking fuel prices and blackouts. Installing PV throughout New York City would decrease the environmental impacts of the city's electricity use, hedge fossil fuel price volatility, and create a more resilient electrical grid. Solar energy investment would also stimulate the local economy and create jobs.

New York City is home to some of the world's most innovative PV installations, but the total amount of PV installed within the city is quite small. As of November 2005, there were 45 in-city PV projects totaling approximately 1.1 megawatts (MW). These installations generated an estimated 0.002% of the city's electricity supply.

Despite this small base of installed PV, New York City's PV market has accelerated rapidly during the past several years. The PV market grew by 56% in 2005, and the average market growth rate during 2002-2005 was 31%. If the City's PV market continues to grow at its current pace, it is estimated that up to 52 MW of PV could be installed within the city by 2015. Whether this potential is met (or exceeded) will depend largely on the policies put in place during the next few years.

Introduction

There is a wide range of solar energy technologies that convert sunlight into useful energy. Commercially available technologies include solar electric, or photovoltaic (PV), systems that convert light directly into electricity, solar thermal electric systems that use the heat of concentrated sunlight to drive steam turbines or engines, solar water heaters, solar space heaters and air-conditioners, solar ventilation pre-heating systems, and architectural designs that maximize the capture of natural light. With the exception of solar thermal electric systems,[1] all of these technologies can be readily integrated into New York City's buildings and infrastructure. This report focuses on PV because it has the greatest potential to meet New York City's future energy demand.

Invented in the United States by Bell Labs in 1954, PV had its first major application in the space program. Today, PV's most familiar uses are as a power source for consumer products like calculators and for remote applications like highway equipment and weather stations. During the past 15 years, however, the use of PV as an alternative power source for buildings connected to the electricity grid has increased exponentially. While off-grid and consumer applications once comprised the majority of the PV market, the amount of grid-connected PV is now far greater than the amount of PV installed off-grid and in consumer products combined (Maycock & Bower, 2004). Solar electricity from on-grid PV systems has emerged as one of the world's fastest growing energy sources and has the potential to supply a large share of the world's future energy needs.

This report is the first in a two-part series that investigates solar energy's potential in New York City as part of the City University of New York's (CUNY) Million Solar Roofs Initiative. The CUNY Million Solar Roofs Initiative was launched in summer 2005 and is managed by the Center for Sustainable Energy (CSE) at Bronx Community College.

This report is intended as a background document for organizations interested in developing a comprehensive solar energy strategy for New York City. Section 1 reviews the city's electricity demand and generation portfolio. Section 2 provides an overview of the technical potential of PV to meet future electricity demand. Section 3 summarizes the potential environmental, social, and economic benefits of solar energy development. Section 4 discusses the current status of New York City's PV market.

A subsequent report will review existing policy support for PV, the barriers to PV development in New York City, and best practices from solar energy programs in other cities.

[1] Solar thermal electric systems require levels of direct solar radiation unavailable in New York's humid climate. Humidity diffuses sunlight and, while diffuse sunlight is captured by other solar technologies like PV, solar thermal electric systems function better in arid climates like the Southwest.

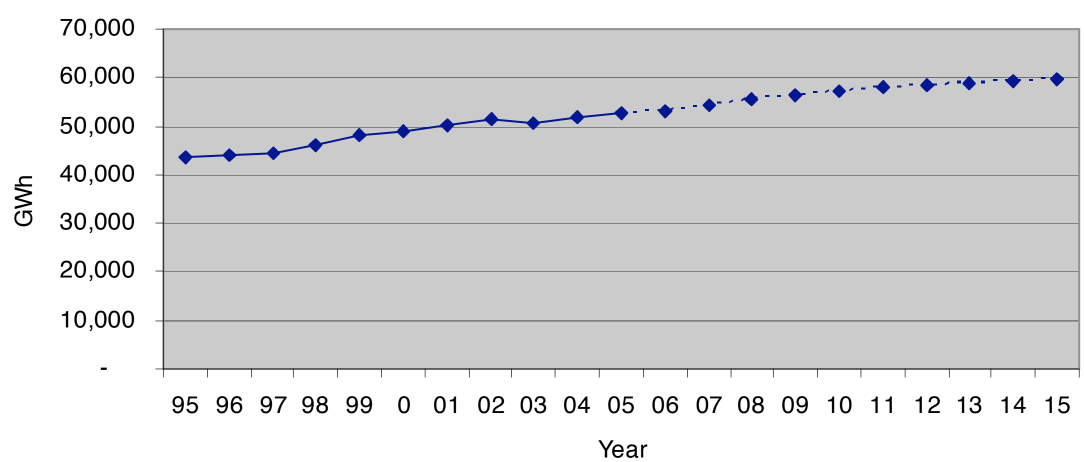
1. Background on Energy Use in New York City

New York City is one of the largest urban centers in the world and requires a massive amount of electricity to power its economy and infrastructure. New York relies almost exclusively on fossil fuel power plants to generate electricity within the city limits. Recent studies have shown that local renewable energy sources could supply over a third of the city's energy within the next 20 years. However, New York City energy planning has not taken the city's renewable resource into account. As a result, New York City's renewable energy resource remains largely untapped.

New York City is one of the largest and most densely populated urban centers in the world with over 8 million inhabitants living within 309 square miles. The city occupies only 0.6% of New York State's landmass, but is home to 42% of the state's population. The city's economy is one of the world's largest, and its $500 billion gross metropolitan product is larger than the gross domestic products (GDP) of all but 16 countries.

In order to support its inhabitants and its economy, New York City requires a massive amount of electricity. As can be seen in Figure 1, New York City's electrical consumption has grown at a fairly consistent rate during the past decade from 43,734 gigawatt-hours (GWh) in 1995, to 52,836 GWh in 2005. The New York Independent System Operator (NYISO) projects that consumption will continue to grow at an average rate of 1.15% through 2015 (NYISO, 2005a).

Figure 1. Historical and projected electricity demand in New York City

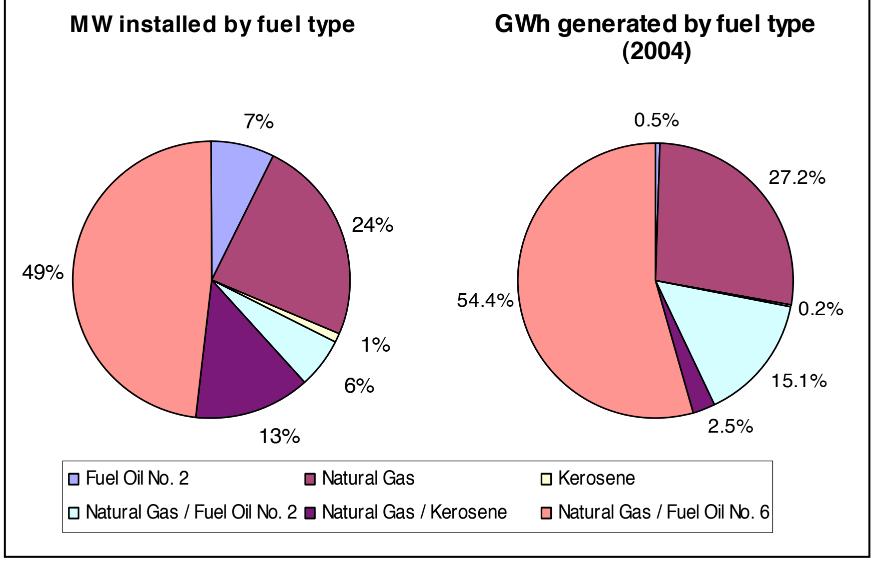


Source: (NYISO, 2005a)

While New York City accounts for 32% of New York State's total annual electricity demand, the city is unable to rely on power generated upstate to meet its electricity needs. Regional transmission lines can only carry 5,000 MW of power, or 44% of New York City's 11,315 megawatts (MW) peak demand, into the city. As a result, New York City is required by NYISO to generate 80% of its power within the city limits (New York City Energy Policy Task Force, 2004).

To meet this requirement, New York City relies on 8,981 MW of fossil fuel power plants installed throughout the five boroughs.[2] As can be seen in Figure 2, almost half of New York City's power plants are dual-fuel facilities that can burn either natural gas or fuel oil no. 6 (i.e. residual fuel oil). The remaining half of New York's generating fleet consists of single- and dual-fuel plants that burn natural gas, fuel oil no. 2 (i.e. distillate fuel oil), and kerosene.

Figure 2. Generating capacity and output in New York City (2004)



Source: (NYISO, 2005b)

While New York City relies almost exclusively on fossil fuels, renewable energy markets are growing extremely rapidly around the world, and opportunities exist for New York City to integrate renewable energy systems into its energy planning. According to recent forecasts, close to 3,000 megawatts of additional generating capacity will be needed by 2008 to meet demand and help control electricity prices (Chernick et al., 2003; New York City Energy Policy Task Force, 2004). The Mayor's Energy Policy Task Force recommends that the projected shortfall be met through a mix of new or repowered large-scale fossil-fuel plants, new transmission capacity, energy efficiency, small fossil-fuel generators, and peak load management programs. While a recent NYSERDA report concludes that New York City has the technical potential to install up to 694 MW of sustainable energy sources[3] within the City by 2007, the Energy Policy Task Force report states that, "By design, the scope of the report does not include such energy-related issues as… sustainable energy, clean air, [or] climate change policy."

In order to respond to the economic, social, and environmental challenges posed by our current energy system, New York City should integrate sustainable energy into its post-2008 energy plans. Sustainable energy could meet up to one third of New York's electricity needs by 2022 (Plunkett et al., 2003a) and could serve as a response to climate change, air pollution, rising energy prices, fuel supply diversity, and blackouts. As will be discussed in greater detail in Section 2, solar energy is by far New York City's largest in-

[2] This includes a 744 MW cogeneration plant sited in Linden, NJ, but connected to Staten Island by a dedicated transmission line.

[3] Defined as wind energy, solar energy, biomass, and fuel cells; NYC's energy efficiency potential is not included in this figure.

city energy resource. This report reviews the potential for solar energy in New York City, discusses the benefits that accompany aggressive solar energy development, and describes New York City's current solar energy market.

2. The Technical Potential for Solar Energy in New York City

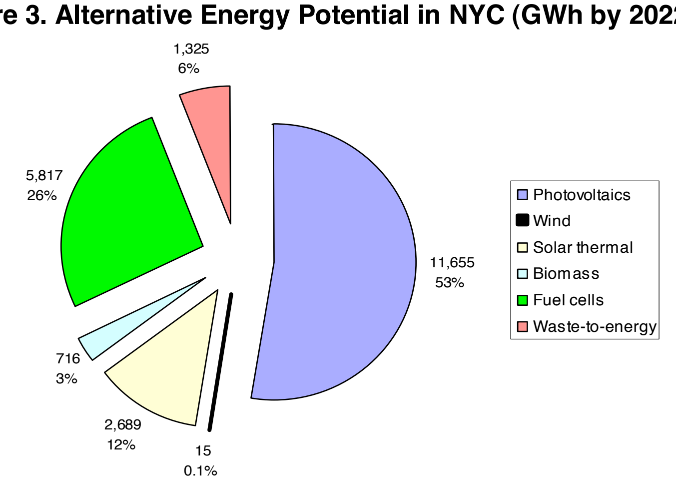
Solar electric, or photovoltaic (PV) systems represent New York City's largest potential source of in-city renewable energy. The amount of solar energy that falls on the city each year is two times the energy that the city requires. The challenge for New York City is not whether there is enough sunlight to power the city, but how to best capture and use the available solar energy. It has been estimated that PV systems mounted on rooftops and building façades could supply 18% of the city's electricity by 2022.

Every two days, more energy falls on New York State from the sun's rays than the total amount of energy consumed by the state all year (Perez, 2002). Each square foot of New York City receives the equivalent of 160 kWh of sunlight per year. This solar energy could be converted into over 125 thousand gigawatt-hours of electricity, or more than 2.5 times the city's 2005 demand (Perez, 2001).

The challenge for New York City is therefore not whether there is enough sunlight to power the city, but how to best capture and use the city's solar energy resource. According to recent estimates, there is enough commercial and residential roof space to host between 8,500 MW and 15,700 MW of photovoltaic (PV) installations within the New York City area (Chaudhari et al., 2005; Plunkett et al., 2003b). If the correct policy incentives were put in place and market barriers were removed, a recent report prepared for NYSERDA estimates that 7,736 MW of PV could be installed within New York City by 2022.[4]

As can be seen in Figure 3, this technical potential eclipses the potential of other in-city renewable energy resources[5] and is larger than the potential output of the city's wind energy, solar thermal, biomass, fuel cells, and waste-to-energy resources combined.

Figure 3. Alternative Energy Potential in NYC (GWh by 2022)



Source: (Plunkett et al., 2003a)

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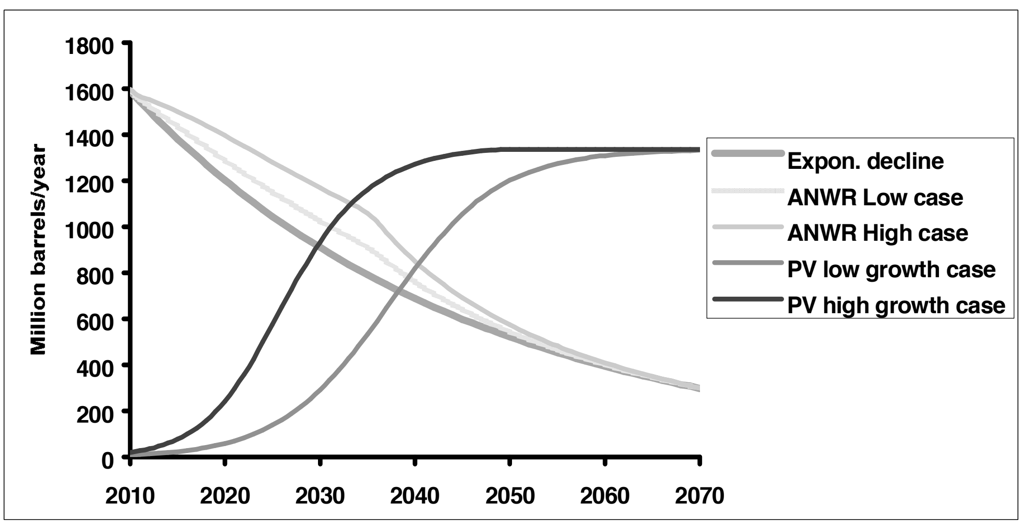
[4] Includes residential, commercial, and building-integrated PV (see Plunkett et al, 2003b, pp. 190-202)
[5] Solar thermal includes solar hot water heating, solar absorption cooling, and solar ventilation air heating.

Were this technical potential to be realized, PV would generate 11,655 gigawatt-hours of electricity, or 18% of New York City's projected electricity demand in 2022.[6] Part of the reason that PV's technical potential dwarfs that of other renewable systems is that it can be seamlessly integrated into New York's urban environment. Unlike most other conventional and renewable energy systems, PV panels can generate electricity without any noise, moving parts, or emissions. Moreover, PV systems can be sited on existing buildings and infrastructure without any of the aesthetic, regulatory, or environmental justice concerns associated with large power plant development.

A second reason that PV is projected to contribute far more to the city's electricity supply than other renewable energy sources is that it is among the fastest growing energy sources in the world. Solar energy market growth has been extremely rapid during the past two decades. On average, solar energy capacity has grown 36% annually over the past 8 years, reaching a high of 60% growth in 2004 (Osborn et al., 2005). In comparison, growth rates in the nuclear and fossil-fuel industries have been in the single digits. PV's growth rate is comparable to the growth rates of technologies like personal computers and cellular phones. As with these other technologies, PV's share of the global market could be enormous if current exponential growth rates continue. Recent analyses (Figure 4) project that if PV market growth continues at its current pace, solar electric power will constitute a larger share of US domestic energy production than oil by 2040 – even when oil from the Alaska National Wildlife Refuge (ANWR) is taken into account (Byrne et al., 2004; Byrne et al., 2005). These statistics are particularly compelling for New York City which, unlike the rest of the United States, continues to rely heavily on oil for electricity generation. A more thorough discussion of New York City's currently installed PV capacity and projected market growth can be found in Section 4.

Figure 4. Comparison of forecasts of potential US PV energy supply and US oil production from existing domestic reserves



Source: Byrne, et al., (2004)

[6] This technical potential does not take into account the physical limitations of New York City's electricity grid. PV is an intermittent resource, meaning that it only produces power during daylight hours. New York City's network grid configuration poses unique challenges to intermittent, customer-sited resources like PV. These limitations will be addressed in more detail in the next report in this series.

The primary drivers of PV's rapid market growth have been the environmental, social, and economic benefits of solar energy (Section 3), and the policies put in place to unlock those benefits. Projections like the one in Figure 4 are based on the assumption that policy will continue to drive PV markets in the near term, but that PV will become competitive with conventional generation as PV system costs continues to fall and the price of fossil fuel electricity continues to rise.

3. The Benefits of Large-Scale Solar Energy Development in New York City

In addition to meeting New York City's growing energy demand, large-scale solar energy development would generate a broad range of environmental, social, and economic benefits for the city. New York City's reliance on centralized fossil fuel power plants has contributed to air pollution and global warming, created environmental justice challenges, and left the city vulnerable to spiking fuel prices and blackouts. Installing PV throughout New York City would decrease the environmental impacts of the city's electricity use, hedge fossil fuel price volatility, and create a more resilient electrical grid. Solar energy investment would also stimulate the local economy and create jobs.

The challenges posed to New York City by its reliance on large-scale fossil fuel power plants have become increasingly apparent during the last decade. In this section, fossil fuel and renewable energy development paths for New York City are contrasted and the benefits of solar energy development are discussed in greater detail.

3.1 Air Pollution and Public Health

Power plants produce 67% of the sulfur dioxide (SO_2) emissions in the US, and 27% of nitrogen oxides (NO_x). These emissions contribute to asthma, acid rain, ground level ozone, and the formation of particulate matter. At present, New York's five boroughs are designated non-attainment areas by the EPA, meaning that they do not currently meet the National Ambient Air Quality Standards (NAAQS) for particulate matter and ground-level ozone.

The public health impacts of air emissions from the energy sector on New York City are significant, and it is estimated that power plant emissions contribute to over 1,000 deaths and 25,000 asthma attacks in the metropolitan area annually (Clear the Air, 2005). The cost of power plant emissions on public health in New York City is estimated to be over $6 billion each year.[7] Rather than trending downward, however, emissions from some of the City's largest generators have actually increased. The Ravenswood plant in Queens increased its NO_x and SO_2 emissions by 14% and 337%, respectively, between 1995 and 2003 (Corrigan & Figdor, 2005). The Astoria generating plant increased its SO_2 emissions by 65% during the same period.

In the short term, renewable energy systems like PV can be deployed to reduce the need for fossil-fueled electricity generation in the city and reduce air emissions. It is estimated that each megawatt of PV installed in New York will displace 100 pounds of SO_2 emissions and 44 pounds of NO_x emissions (Herig et al., 2005). In the longer term, it is

[7] Estimated using the values published by Abt Associates (2000).

estimated that the Clean Air Interstate Rule (CAIR), issued by the EPA in March 2005, will significantly reduce NO_x and SO_2 emissions in the eastern US. The CAIR rule establishes a cap-and-trade program that targets a 70% reduction in SO_2 and a 60% reduction in NO_x across 28 states by 2015 (EPA, 2005). In New York State, the EPA estimates that the cap-and-trade program will result in an 84% reduction in SO_2 and a 48% reduction in NO_x emissions over 2003 levels. It is likely that the costs of air emissions control equipment required by the CAIR regime will increase the costs of fossil-fueled electricity sited within New York City. By prioritizing the development of renewable energy resources like PV over new fossil fuel generation, New York City will limit its exposure to the regulatory risks of CAIR and its more stringent successors.

3.2 Climate Change and Greenhouse Gases

With only 5% of the world's population, the United States releases a disproportionate amount of carbon dioxide into the atmosphere by burning fossil fuels to produce energy. In 2003, the US emitted 24% of the world's energy-related carbon dioxide (CO_2). CO_2 is the most significant contributor to the greenhouse effect that causes global warming. There is overwhelming scientific consensus that global warming could have catastrophic ecological impacts if the greenhouse gas levels are not stabilized and reduced during the next several decades (IPCC, 2001a, 2001b).

In 2000, the Metropolitan East Coast (MEC) assessment projected the impacts of climate change on New York City using two different global climate models (MEC, 2000). According to the MEC, temperatures in the New York City area could increase by between 1.68 and 2.10 °F by 2020, and by between 6.25 and 6.47 by 2080.[8] This increase in temperature is projected to cause coastal erosion, rising sea levels, flooding of low-lying areas like East Harlem, and an increase in storm activity, heat-related deaths, and tropical diseases like malaria (Bloomfield et al., 1999; Kinney et al., 2000; Physicians for Social Responsibility, 2001).

Unlike SO_2 and NO_x emissions, which create regional air pollution, greenhouse gases emissions have created a global problem that will require both international cooperation and local action to address. State and local governments in the US have taken the lead in climate change policy in the face of federal inaction. New York State is one of seven participants in the Regional Greenhouse Gas Initiative (RGGI) whose goal is to establish a cap-and-trade program for CO_2 emissions from power plants in the Northeast (RGGI Staff Working Group, 2005).

At the local level, New York City has joined the International Council for Local Environmental Initiatives's (ICLEI) Cities for Climate Protection initiative and committed to a CO_2 reduction target of 20% below 1995 levels by 2010 (Mayor's Office of Environmental Coordination, 2005). The City has also signed the US Mayors Climate Protection Agreement and committed to meet or exceed the US Kyoto Protocol target (Seattle Office of the Mayor, 2005).

Photovoltaic systems have an important role to play in New York City's climate change strategy. First, PV systems can immediately reduce carbon dioxide emissions by reducing

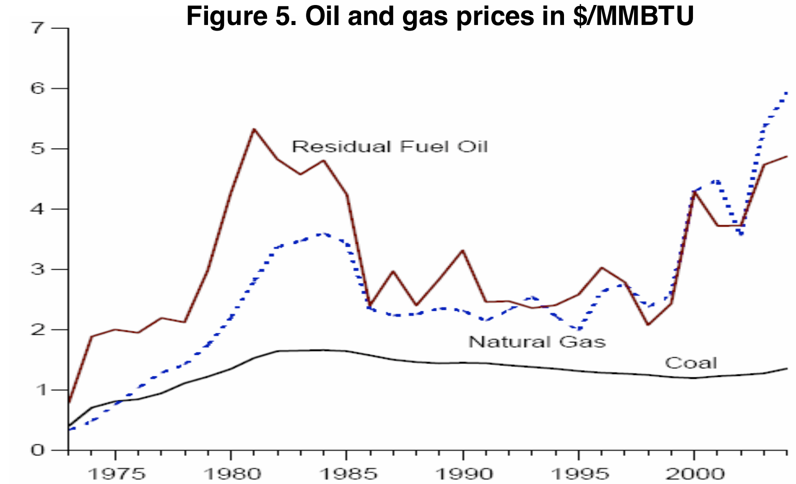
[8] Using the Canadian Centre for Climate Modeling and Analysis model and the Hadley Center model, with forcing from greenhouse gases and sulfate aerosols

the need for fossil fuel generation. Second, the city can use PV to adapt to global warming. It is projected that the number of cooling degree-days will increase by 43%-135% during the 21st century (MEC, 2000). In response to rising temperatures, it is expected that air-conditioning demand will spike. Traditional planning would dictate that more fossil fuel generation be installed to meet this demand, thereby further increasing greenhouse gas emissions. Because PV system output corresponds closely with periods when air conditioning demand is highest in New York (Perez et al., 1996), PV could be effectively employed as an energy management tool in response to rising temperatures.[9] Third, integrating PV systems into New York City's generation mix will help the city respond to local and regional climate change targets. In 2004, New York City's power plants released 14,345,000 metric tons of carbon dioxide, accounting for 25% of New York State's RGGI emissions baseline.[10] By aggressively developing its solar resource, New York City will decrease the cost of complying with CO_2 regulations and better position itself for future local, national, or international greenhouse gas regimes.[11]

3.3 Fuel Price Risk Mitigation

Integrating a significant amount of PV systems into New York City energy portfolio would also reduce the city's exposure to fuel price risks. As can be seen in Figure 5, the costs for both residual fuel oil and natural gas have risen dramatically during the past seven years. Because New York City must generate 80% of its power from within the city, and because the vast majority of New York's in-city generators burn either natural gas or oil, the city is particularly vulnerable to these upward price trends. New York already has some of the highest retail electricity rates in the country, and these rates are projected to rise as the cost of fuel increases. Because New York City is unable to diversify its in-city generation portfolio with nuclear, large hydropower, large wind farms, or coal, the city should give serious consideration to alternative power sources like PV.

Figure 5. Oil and gas prices in $/MMBTU



Source: (Tierney, 2005)

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[9] Though beyond the scope of this paper, it should be noted that energy efficiency technologies, and solar thermal technologies like solar absorption cooling, can also be deployed in response to rising temperatures

[10] This figure was calculated using methodology introduced by Madsen et al. (2005). Fuel consumed by each New York City power plant (as reported in US EIA forms 906 and 920) was multiplied by the CO_2 emission coefficients published by the EIA's Voluntary Reporting of Greenhouse Gases Program.

[11] In addition to RGGI, cap-and-trade legislation for power plant CO_2 has been introduced in both the New York City Council (Intro 148-A) and the US Congress (McCain-Lieberman Climate Stewardship Act)

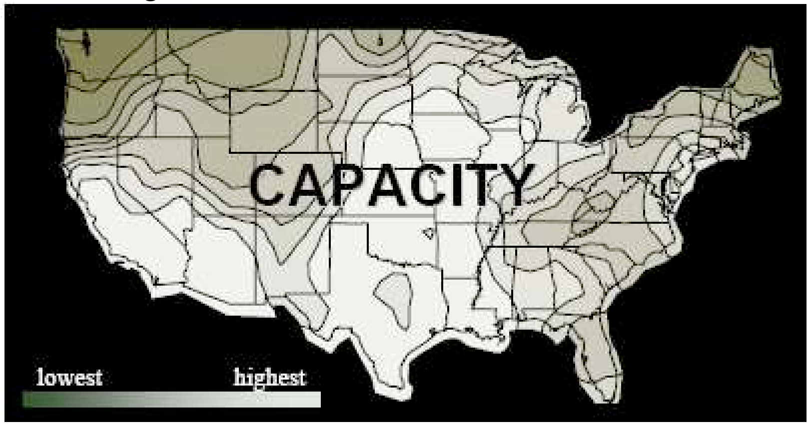
Technologies like solar energy can serve as a physical hedge against fossil fuel price volatility. Because solar energy is a cost-free fuel, it can supply electricity at a fixed-price. In terms of conventional energy risk management strategies, incorporating fixed price renewable energy into a generation portfolio is analogous to purchasing futures contracts for fossil fuels (Bolinger & Wiser, 2004). It has also been argued that solar energy is an effective hedge against electricity price spikes in New York because of the strong correlation between PV output and NYSIO peak market prices (Letendre et al., 2003). In addition to these direct hedge values, renewable energy can have an indirect impact on electricity costs by displacing demand for gas-powered generation and placing downward pressure on gas prices (Wiser et al., 2005). In planning to meet future energy demand, New York City should take the risk profiles of different generation technologies into account and promote large-scale solar energy investments that supplement or supplant fossil fuel investments.

3.4 Energy Security, Grid Reliability, and Disaster Recovery

Another important attribute of PV is that it can be deployed in distributed units. This modularity has important implications for energy security, energy planning, environmental justice, and energy service provision. First, the modular nature of distributed systems allows them to be built quickly and added to the grid incrementally. When fossil fuel plants are built, they must be sized to anticipate future load growth and growth that may occur during their lengthy construction periods. Because PV can be rapidly installed on an as-needed basis, it can keep pace with rising demand and avoid the risk of over-building (Hoff & Herig, 1997). Second, distributed PV can reduce the need for investments in the transmission and distribution system because PV systems are sited on the buildings they serve. Typically, 7-8% of the electrical output of fossil fuel generation is lost as it travels over the electrical grid. Onsite PV can dramatically reduce these losses. In New York City, roof-mounted and façade-mounted PV can also provide the unique benefit of reducing the distribution losses associated with transmitting electricity to the upper levels of skyscrapers (Chernick et al., 2003). Third, emissions-free PV systems distributed throughout the city would alleviate the environmental justice concerns posed by large, centralized fossil fuel plants sited in low-income neighborhoods (NYC Apollo, 2004). Finally, an electrical grid that integrates a large amount of distributed renewable generation is less vulnerable to large-scale failure. If a large nuclear or fossil fuel plant fails as a result of an accident, a natural disaster, a terrorist attack, etc., grid operators have to compensate for the loss of hundreds of megawatts. The failure of an easily reparable 2 kW PV array, in contrast, can be easily absorbed by more resilient distributed networks (Lovins & Lovins, 1982).

PV's potential grid reliability benefits go beyond the fact that small-scale failures can be easily absorbed. Studies conducted by the SUNY Atmospheric Sciences Research Center (ASRC) have demonstrated that solar irradiance, and therefore PV output, closely correlates with New York City's peak electrical demand (Perez et al., 2001; Perez et al., 1993). In other words, PV can be counted upon to generate power when the city needs it most. In the New York City metropolitan area, this correlation, known as the effective load-carrying capacity (ELCC), is as high as 60-70%. As can be seen in Figure 6, PV in the New York-New Jersey area has one of the highest ELCCs in the nation – even higher than that of "sunny" states like Florida and New Mexico.

Figure 6. Distribution of PV's ELCC in the US



Source: (Perez et al., 2004)

The practical implication of PV's load carrying capacity for New York City is that PV can reduce strain on the electrical grid and reduce the probability that blackouts will occur. ASRC studies have concluded that PV systems could have prevented both the July 6th, 1999 blackout in Washington Heights and the August 14th, 2003 blackout in the Northeast (Perez et al., 2004; Perez et al., 2001). Had the 2003 outage been prevented, it would have saved New York City an estimated $1 billion in related costs (Electricity Consumers Resource Council, 2004).

In the event that the power grid does fail, PV systems also have a role to play in providing emergency power to buildings and to disaster recovery operations (Byrne et al., 1998; Gordes, 2000). Mobile PV generators, for example, were recently dispatched to the Gulf Coast in the wake of hurricanes Katrina and Rita.

3.5 Job Creation

A final benefit of a large-scale commitment to PV in New York City is economic development. Investing in renewable resources like PV has a greater economic development impact than comparable investments in fossil fuels. First, New York City has to import fossil fuels for its power plants from other states or from abroad. Because solar energy is an inherently local resource, investments in solar energy are more likely to stay within the local economy than investments in imported fossil fuels are. Second, investments in solar energy generate 42% more job-years per dollar than comparable investments in coal (Singh & Fehrs, 2001). Third, fossil fuel industries are becoming less job-intensive over time as a result of mergers and increased mechanization (Kammen et al., 2004). PV can therefore be expected to have a greater job creation impact than fossil fuels in both the short- and long-term.

If New York City's technical potential for PV were to be realized, the economic benefits for the city and the state would be significant. Using the US Department of Energy's solar ASSET databank and the US Department of Commerce's RIMS II industry multipliers (Herig et al., 2005), it can be estimated that 7,736 MW of solar energy would create 719,400 in-state job years, and generate a $63 million increase in New York's gross state product, and a $37 million increase in earnings over 30 years.

In addition to creating new jobs, it is conceivable that a strong solar energy industry in New York would protect existing jobs. Between 2001 and 2004, New York State lost 148,500 manufacturing jobs. A recent study of New York State's manufacturing base concluded that there are currently 494 companies with 28,930 employees that could position themselves to supply solar energy system components if market demand were sufficient (Sterzinger & Svrcek, 2004). As of the writing of this report, county-specific data is unavailable, so it is unclear how many of these firms are located within the five boroughs. What is clear, however, is that New York City has an opportunity to use the rapidly growing renewable energy industry as a job creation engine. New York State's recently passed renewable portfolio standard (RPS) regulation is projected to create 43,000 renewable energy jobs over the next decade (Hevesi et al., 2005). By developing an ambitious PV strategy, New York City could capture a share of these jobs, and attract new businesses.

3.6 Quantifying the Benefits of PV Systems

As discussed in this section, PV systems can provide a wide range of benefits to society, to the environment, and to the economy. As an emissions-free energy technology that generates electricity where it is consumed, PV reduces system-wide peak demand, decreases air emissions, hedges natural gas prices, alleviates environmental justice concerns, improves grid efficiency and reliability, and avoids investments in transmission and distribution infrastructure. Because many of these values are difficult to monetize, however, the high upfront capital costs of PV remains a barrier to the widespread adoption of solar energy systems. Three recent have attempted to quantify these non-commodity benefits of PV, and have estimated that their value ranges between 7.8 ¢/kWh and 35.2 ¢/kWh (Americans for Solar Power, 2005; Duke et al., 2005; Smeloff, 2005). This paper assumes that the value of PV benefits for New York City likely falls within this range.

4. Current Status of the New York City PV Market

As of November 2005, there were 45 solar energy projects totaling approx. 1.1 MW installed in New York City. These installations accounted for an estimated 0.002% of New York City's electricity supply. The PV market grew by 56% in 2005, and the average market growth rate during 2002-2005 was 31%. If the City's PV market continues to grow at its current pace, it is estimated that up to 52 MW of PV could be installed within the city by 2015.

New York City is home to some of the world's most innovative solar energy installations. The PV installation at the Rikers Island compost facility, for example, integrates photovoltaic cells directly into a glass skylight. The skylight provides the facility with natural light while simultaneously generating electricity. The 4 Times Square building, meanwhile, helped pioneer the practice of installing PV panels in building façades as a substitute for traditional façade materials (see Eiffert & Kiss, 2000). High-profile projects like these have given New York City an international reputation for solar energy innovation. As a result, there have been a number of recent case studies and publications that focus on projects in the city (Pereira & Jürgens, 2003; Radoff, 2004). To date, however, there has been no comprehensive study done on the size of the New York City market and the contribution of PV to New York City's electricity demand.

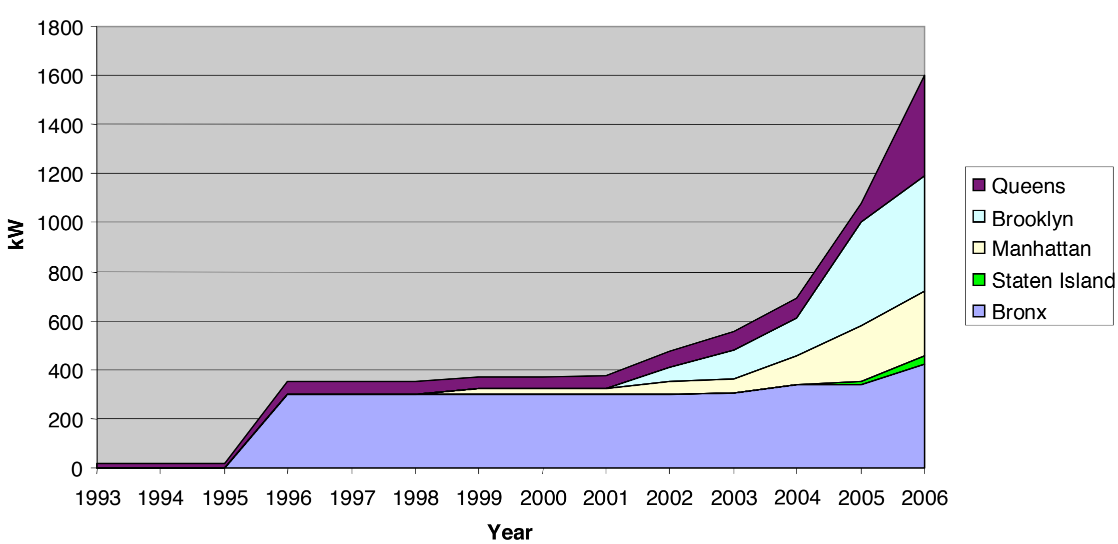
In the summer of 2005, the City University of New York (CUNY) joined the US Department of Energy's Million Solar Roofs (MSR) Initiative and launched a campaign to promote solar energy development. CUNY set an initial goal of 500 solar roofs within the city by 2010.

The CUNY MSR program is managed by the Center for Sustainable Energy (CSE) at Bronx Community College. In order to measure progress towards CUNY's goal, CSE interviewed solar energy stakeholders to determine the baseline amount of PV installed in New York City. CSE conducted over 40 interviews, and 18 organizations provided CSE with data on existing and pending solar energy installations. These data were then used to characterize the city's solar energy market and project future growth trends.

4.1 Installed Capacity (1993-present)

According to the CSE study, there are currently 45 solar energy projects installed in New York City with a total capacity of 1,097 kilowatts (kW). These installations generate an estimated 1,230 megawatt-hours of electricity each year, or approximately 0.002% of the electricity consumed in New York City during 2005.[12] In 2006, it is expected that at least 18 more projects totaling 519 kW will be added to the grid. As can be seen in Figure 7, the cumulative amount of PV installed has increased exponentially since 2002 when New York State first introduced its PV rebate program.

Figure 7. PV installed in New York City by Borough (kW), projected through 2006



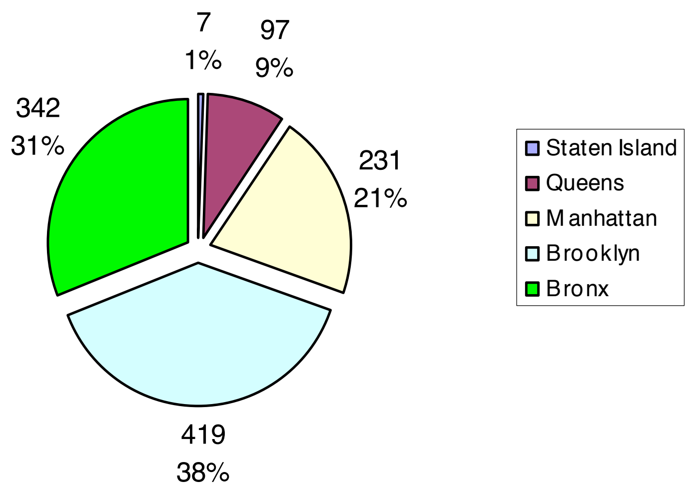
During the 1990s, New York City's PV capacity was limited to the 4 Times Square building and to three installations financed by the New York Power Authority and installed on New York City agencies. These public projects included a 16 kW system installed on the NYC Transit Authority's Maspeth Warehouse, a 36 kW system installed

[12] Total MWh output of PV was calculated by summing the MWh output of individual installations. Performance projections for many of NYC's PV installations can be found in press releases. Where projected output data were not available, CSE staff used the National Renewable Energy Laboratory's PVWATTS software program (http://rredc.nrel.gov/solar/codes_algs/PVWATTS/) to estimate output.

at the Rikers Island compost facility, and a 300 kW system installed on the Gun Hill bus depot in the Bronx.

Since the introduction of the NYSERDA PV rebate in 2002, installed PV capacity has almost tripled, and installations have now been completed in all five boroughs. As can be seen in Figure 8, the majority of PV capacity is located in Brooklyn and the Bronx. Assuming that the projects currently under development are completed next year, however, the amount of capacity installed in Queens will draw even with that of the two leading boroughs. The only borough that has yet to see significant development is Staten Island, which had its first installation in 2005.

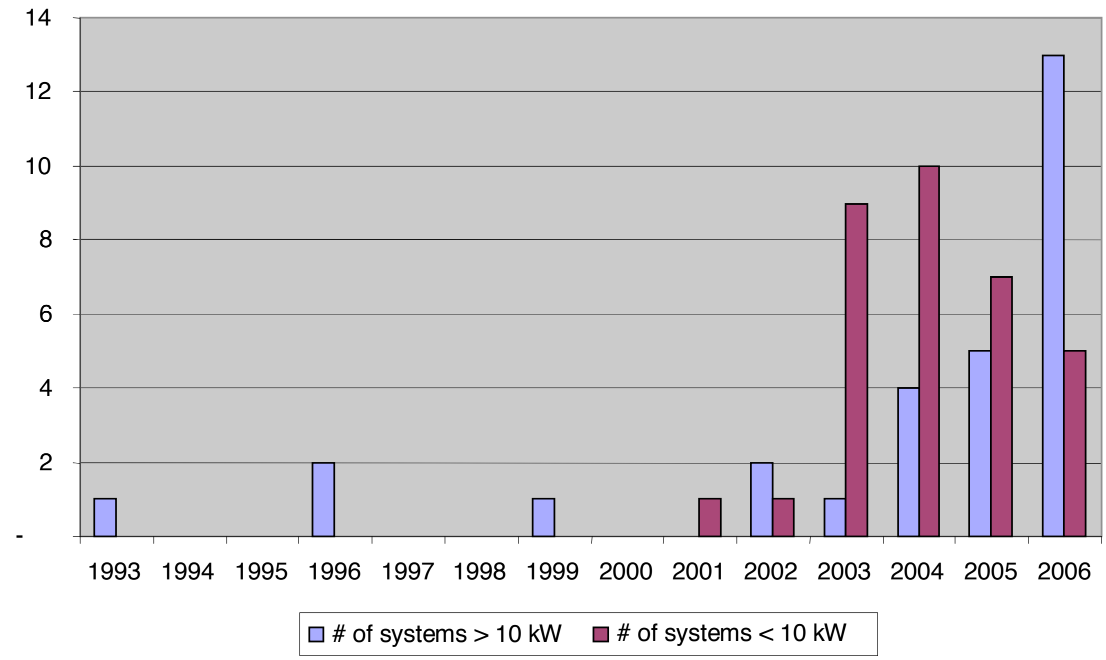
Figure 8. Kilowatts of PV capacity by Borough as % of NYC total (2005)



4.2 System Size

During the 1990s, most of the PV systems installed in the city were over 10 kilowatts. With the introduction of the state rebates, however, a number of small systems (i.e. under 10 kW in size) were installed between 2002-2005. During the first two years of the rebate program, the majority of systems installed in New York City were under 10 kW. The number of large systems installed has risen each year, however, and it is projected that the majority of the systems installed in 2006 will be larger than 10 kilowatts. While the data set may be too small to draw broad conclusions from, the apparent trends highlight some of the challenges to market growth in New York City.

Figure 9. Number of systems installed by size, by year



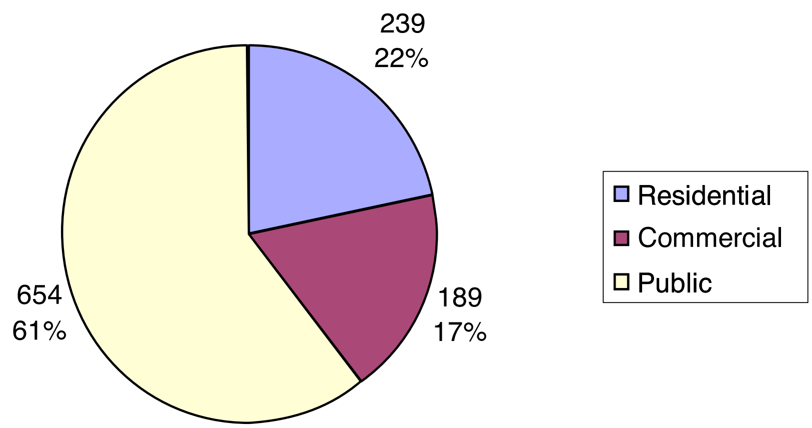
First, the downward trend in small residential installations may reflect the higher costs of doing business New York City. Anecdotal evidence from CSE's industry survey suggests that it is more difficult and expensive to get projects permitted and completed in New York City than elsewhere in the region. As a result, it is significantly more cost-effective to install one 20 kilowatt project, than it is to install 10 two kilowatt systems.

If the New York City market is shifting to larger installations, then future market growth may be stunted by the lack of incentives for commercial installations in New York State. New York's solar energy tax credit, solar energy sales tax exemption, and net metering laws are only available to residential customers, and New York State's rebate is only available to systems up to 50 kW in size (Solar New York, 2005). The implications of these policy limitations and strategies to address them will be discussed in greater detail in the next report in this series.

4.3 PV Installations by Sector

When broken down by sector, it appears that public installations have driven New York City's PV market. As can be seen in Figure 10, 61% of the PV in New York City has been installed on public buildings. These figures do not provide an accurate portrait of New York City market growth, however. As discussed above, much of this capacity is from the three New York City government projects installed between 1993 and 1996. After 1996, investment in grid-connected public sector PV systems in New York City ceased and the city's PV market was sustained by growth in the commercial and residential sectors.

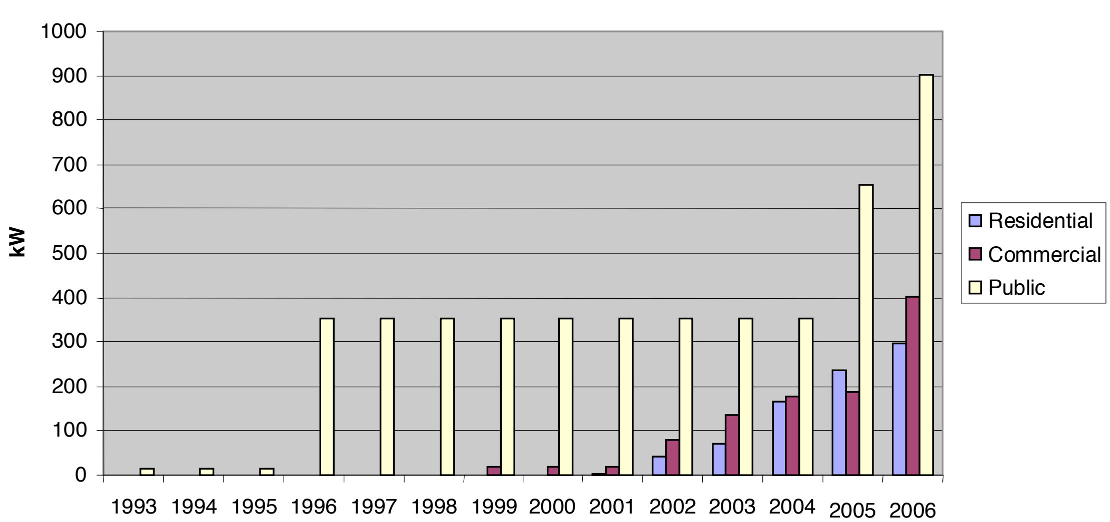
Figure 10. **Kilowatts of PV capacity by sector as % of NYC total (2005)**



In 2005, public sector capacity again expanded with the installation of the 250 kW Stillwell Avenue subway station system. Over 200 kW of additional public sector capacity are planned for 2006 (Figure 11). Despite these impressive statistics, the record of public sector investment in solar energy is mixed. On the one hand, New York City government, in partnership with the New York Power Authority, has played a pioneering role in the solar energy market. On the other hand, public sector investment in PV has consisted primarily of a few large systems clustered a decade apart and has not contributed to sustained PV market growth.

At present, New York City's large public sector installations are compelling demonstration projects. In order to contribute to a sustainable in-city PV market, however, these demonstration projects must become readily replicable. A more detailed review of public sector investment in PV projects will be contained in the next report in this series.

Figure 11. PV capacity installed by sector, by year

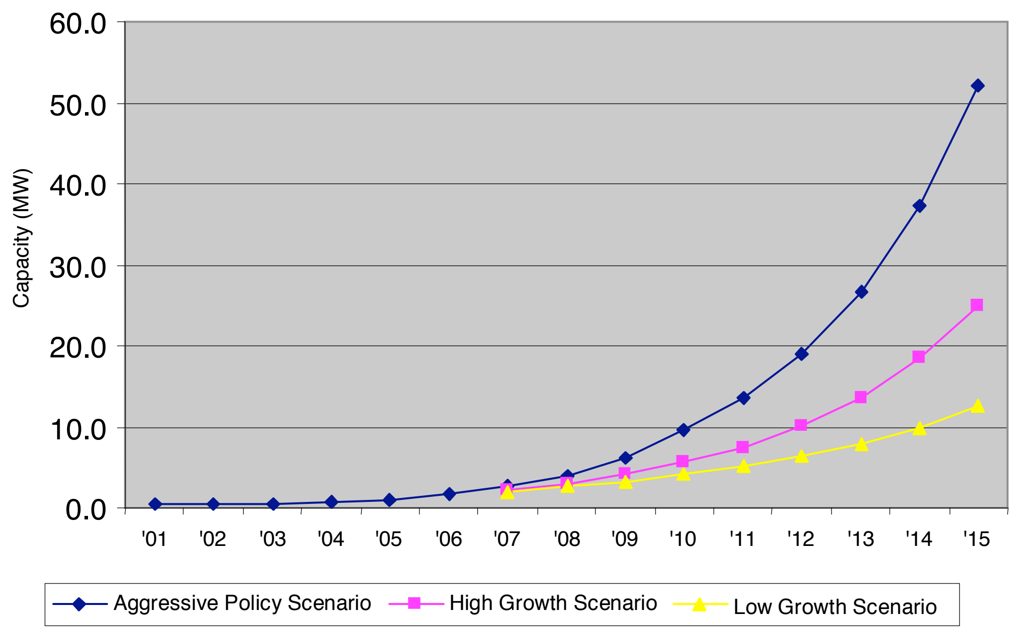


4.4 Market Growth

The average market growth rate for the city was 31% during 2002-2005, and 56% in 2005. Assuming that currently planned projects are completed, the market is projected to grow at least another 48% in 2006. This figure may be conservative because it is based on projects already underway in 2005 and does not take into account projects that will be developed next year.

The current growth rates in New York City are consistent with those of the global PV market. In Figure 12, future market growth within New York City is projected through 2020 under three different scenarios. The low growth scenario is based on the 25% growth rate used by the Brookhaven National Laboratory to model PV market growth through 2030 (Fthenakis & Morris, 2002). The high growth scenario is based on the 35% growth rate used in the recent Solar Energy Industry Association (2004) roadmap. The aggressive policy scenario is based on a federal study that assumes New York will establish an incentive program comparable to Japan's. Under the aggressive policy scenario, it is assumed that the PV market will grow by 55% in 2006-2010 and then grow by 40% in 2011-2015. It is interesting to note that the growth rates used in the low, high, and aggressive policy scenarios correspond closely to New York City's five-year average PV market growth rate, four-year average growth rate, and 2005 growth rate, respectively.

Figure 12. NYC PV Market Growth Scenarios



Under the aggressive policy scenario, 52 MW of PV are installed in the city by 2020, 25 MW are installed in the high growth scenario, and only 12.5 MW are installed within the city under the low growth scenario. These installations would supply an estimated 0.85% and 0.13% of New York's projected energy demand in 2020, respectively.

As with any projection, these scenarios are subject to a great deal of uncertainty. The installed capacity in New York City market remains very small and the market could experience growth rates far higher than 50% during the next few years. At the borough level, for example, growth rates for Manhattan and Brooklyn in 2005 were 106% and 167%, respectively. In 2006, installed capacity in Queens is expected to expand by at least 403%.[13]

New York City short term market growth could also temporarily level out as a result of an international shortage of silicon, the raw material used to make photovoltaic cells. The PV market has grown too rapidly during the past several years for global silicon manufacturing to keep pace. As a result, a silicon shortage is projected to last through 2008. A recent study by Piper Jaffray Equity Research projected that this shortage could limit global market growth to 3% in 2006 (Pichel & Yang, 2005). Once silicon manufacturers catch up to global demand, however, the same report predicts that the global PV industry will expand rapidly to 4,800 MW of PV per year by 2010. This would equate to roughly quadruple the amount of PV modules produced in 2004.

Looking beyond the short term, the key question for New York City will be whether an exponential growth rate can be sustained during the next 10-40 years. As demonstrated by the acceleration of the New York's market after 2002, PV development is policy-driven and it is expected to remain so at least through the next decade. As silicon and PV module manufacturing continues to expand, however, and as energy prices continue to rise, PV will approach the point of being cost competitive without incentives. This has already occurred in Japan, where PV cells are now cost-competitive with retail electricity and the government has a goal to install over 100,000 PV systems per year by 2010.

New York City would be better positioned to take advantage of cost-competitive PV in the future if a strong local market were created in the short term. The lessons from leading markets like Germany and Japan are that local market creation requires an ambitious vision for solar market development backed up by long-term policy commitments. The German and Japanese incentives are substantial, long-term, consistent, and predictable. The stability of the German and Japanese incentives has allowed manufacturers, investors, and suppliers to plan ambitiously and lower the costs of PV production (Osborn et al., 2005). The next report in this series will discuss how the current mix of federal, state, and local policies measure up to these standards and how New York City can make solar energy development a focal point of future energy planning.

Conclusion

New York City relies heavily on imported natural gas and oil to meet its rising energy demand. As a result, New York City is vulnerable to a range of environmental and economic risks. Solar irradiance is the city's single largest potential source of local energy, and it can be harnessed to generate electricity while mitigating the risks of air pollution, climate change, fuel price volatility, inequitable power plant siting, and blackouts. New York City could benefit from taking these attributes into account and integrating PV into future energy plans. In addition, New York City can use solar energy

[13] For the purpose of comparison, New Jersey's renewable portfolio standard requires that 0.16% of the state's electricity come from solar energy by 2008. To reach this goal, the New Jersey PV market will have to grow at an average rate of 200% between 2005 and 2008 (Kling, 2003).

investment as an economic development tool and position local companies to compete in the emerging local, national, and global PV markets.

While New York City has played a pioneering role in urban PV installations, solar energy currently accounts for only 0.002% of New York City's electricity supply. New York City has the technical potential to install several thousand times more PV capacity than currently exists within the city. If current growth rates are sustained, it is conceivable that PV will supply a significant portion of New York City's electricity by the middle of this century. Whether New York will be able to fully realize its technical potential will depend on the resources that can be mobilized in support of the local PV market.

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