PV INSTALLATION TRAINING AT CUNY
MARKET ASSESSMENT

Prepared for

THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
Albany, NY

Vicki Colello
Project Manager

Prepared by

BRIGHT POWER, INC.
New York, NY

Jeff Perlman
Project Manager

ENVIRONMENTAL BUSINESS ASSOCIATION OF NEW YORK STATE, INC.
Albany, NY

Ira Rubenstein
Project Manager

CITY UNIVERSITY OF NEW YORK
New York, NY

David Levine
James Quigley, Ph.D
Michael Seliger, Ph.D
Project Managers

[PROJECT NUMBER]

NYSERDA
Report [number] May 2006

NOTICE

ABSTRACT

The demand for solar photovoltaic installation training in New York City is growing. The City University of New York (CUNY) is developing a comprehensive training program for PV installers that will be accredited by the Institute for Sustainable Power (ISP). The demand for this training is driven by the increasing number of solar installations in NYC and surrounding areas. The necessity for training is driven by a desire to ensure that PV systems are installed correctly. Typical PV installations in NYC have certain characteristics that separate them from PV systems in many other places – in NYC they are more often on flat roofs and integrated into building facades. This demonstrates a need for NYC-specific PV training that addresses the basics as well as the issues peculiar to the city. Some of these issues include interconnecting with the local utility while obeying local electrical codes, as well as training needs for the different types of labor forces involved in PV installations in the city. Lastly, a marketing plan to attract students is outlined.

KEY WORDS

PV Installation Training, New York City, ISP, CUNY, Market Assessment

ACKNOWLEDGEMENTS

This study was funded by the New York State Energy Research and Development Authority (NYSERDA), Agreement #8833. The authors would like to thank Vicki Colello and Adele Ferranti for their support of this research. We would also like to thank the solar installers in NYC who contributed their thoughts on the PV industry: Anthony Pereira of AltPower, David Buckner and Chris Moustakis of Solar Energy Systems and Richard Klein of Quixotic Systems. Thanks to Gay Canough of ETM Solar Works for her help in preparing the initial proposal. Thanks to Prof. Yelleshpur Dathatri at SUNY Farmingdale for sharing his experiences and insights with PV training. Thanks to the following for sharing their thoughts about PV demand in NYC: Lee Smith of the National Photovoltaic Construction Partnership, Guy Sliker at the New York Power Authority, and Ariella Rosenberg at the NYC Economic Development Corporation. Thank you to Prof. Steve Hammer at Columbia University and Prof. Richard Perez at SUNY Albany for their comments on our NYC PV potential calculations. We would also like to thank the following engineers at New York City Transit: Stanley Karoly, P.E., Chief Electrical Engineer and Gabriel Reves, P.E., Principal Engineer, Electrical.

Thanks to: Joanne Derwin at NYC Apollo, Wilson Rickerson and Tria Case at the Center for Sustainable Energy at Bronx Community College, Carolyn Everett at CUNY, and Kelly Bennett at EBA/NYS.

Thank you to the staff at Bright Power for their help with research and proofreading: Andy McNamara, Sophie Nimmannit and Jennifer Veilleux.

TABLE OF CONTENTS

Section | Page

LIST OF FIGURES

LIST OF TABLES

OVERVIEW OF PHOTOVOLTAIC TECHNOLOGY

Photovoltaic devices convert the sun's light directly into electricity with no moving parts. They are based on semiconductor technology, and are typically made out of the element silicon.

The building block of a typical PV system is the *module*. Each module typically consists of many *cells* (generally 4"-6" diameter, often cut rectangular) soldered together and encapsulated with glass on the top and a waterproof sheet on the back. Other technologies, such as thin-films, are deposited onto substrates, which can be rigid (glass) or flexible (thin metal or plastic), and then encapsulated to form a module. A number of modules are wired together to form an *array*.

Photovoltaic (PV) systems are typically discussed in terms of watts, kilowatts (kW) and megawatts (MW). A watt (W) is a unit of power equal to $1/746^{th}$ of a horsepower.

- 1 kilowatt (kW) = 1,000 watts (W)
- 1 megawatt (MW) = 1,000 kW = 1,000,000 W
- 1 gigawatt (GW) = 1,000 MW = 1,000,000 kW = 1,000,000,000 W
- 1 kilowatt-hour (kWh) is the power needed to run a 1 kW load for 1 hour. The kWh is the unit of electricity in which utility bills are measured.

If a 1kW PV system is under the right sunlight and temperature conditions to continuously produce 1 kW of power for one hour, at the end of that hour, it will have produced 1 kilowatt-hour (kWh). Similarly, when a 1 kW load has been running for 1 hour, it has consumed 1 kWh of power. If a 100 W light bulb is on for 10 hours, it, too, will consume 1 kWh of power.

Typically, a PV system's wattage is expressed as maximum DC watts under Standard Test Conditions (STC) – $W_{DC\text{-}STC}$.[1] Unfortunately, the real world prefers to use AC power and rarely conforms to STC. A more realistic maximum power output is[2]

$$W_{AC\text{-}PTC} = W_{DC\text{-}STC} \times 0.83$$

In this report, "W" always refers to $W_{DC\text{-}STC}$ unless otherwise specified.

PV system cost data are expressed in this report in terms of dollars per DC watt ($/W). This is the common way in which PV system cost is expressed in the industry, and allows systems of different sizes to be more accurately compared.

---

1 Standard Test Conditions (STC) are 25°C, sunlight at intensity of 1 kW/m² and atmosphere of 1.5.
2 Sherwood, Larry. *U.S. Solar Market Trends*. Proceedings of the 2005 Solar World Congress, American Solar Energy Society, 2005.

SUMMARY

Both the global and local markets for solar energy are growing. Photovoltaic (PV) systems produce electricity from sunlight, and are becoming an increasingly attractive form of electricity generation in New York City (NYC) with rising prices and increasing constraints on the city's ageing electric system. In order to ensure that the PV systems will work as intended, it is vital that the installers of these systems are adequately trained.

The City University of New York is implementing a comprehensive training program for PV installers in NYC. The purposes of this study are to:

1. Assess the needs for CUNY to Achieve Accreditation in PV Installation Training from the Institute for Sustainable Power (ISP).
2. Determine the Current and Future Market for PV in NYC.
3. Define the Needs for NYC-Specific PV Training.
4. Outline a Marketing Plan for CUNY's PV Installation Training Program.

CUNY offers a wide variety of academic and vocational degrees, credit and non-credit courses and certificates, job training and worker re-training to meet New Yorker's changing workforce needs. University-wide initiatives as well as individual campuses have developed effective collaborations with employers, unions, community-based organizations and professional associations. The PV training program will consist of courses offered at several campuses, both for unionized and non-unionized labor. CUNY has a plan for achieving ISP accreditation for this program.

There is growing demand for PV systems in NYC – over the period 2002-2005 average annual market growth was 27%. Over 1 MW of PV is currently installed in the city, which is a small fraction of the technical potential.

The NYC market is unique for solar in many respects, in the types of buildings, the configuration of the electrical grid, the building code and the types of systems that are installed. Thus it makes sense to develop a PV training program with curricula that are specific to the city's needs, including:

- BiPV and flat roof grid-tie PV systems
- Specialized PV job training
- Spanish language materials.

There are a number of organizations producing a variety of programs and events in NYC around sustainability, renewable energy and energy efficiency. These organizations and events provide very attractive and inexpensive marketing channels for the CUNY PV training program.

Section 1

NEEDS FOR CUNY TO OBTAIN ISP ACCREDITATION

CUNY has a long and successful history of delivering affordable, accessible and high quality education to workers, job seekers, career changers and employers. CUNY offers a wide variety of academic and vocational degrees, credit and non-credit courses and certificates, job training and worker re-training to meet New Yorker's changing workforce needs. University-wide initiatives as well as individual campuses have developed effective collaborations with employers, unions, community-based organizations and professional associations. CUNY has a Sustainable Construction Industry collaborative initiative with which the PV training program dovetails nicely.

CUNY plans to become accredited both as a Training Institution and as a Continuing Education Center. CUNY already meets base-level ISP requirements:

- The organization is a legal educational institution
- Non-discriminatory policy.
- Resources to address liability issues.
- A record-keeping system.
- Links with industry and the community.
- A job placement program.

In order to obtain ISP accreditation, CUNY will need to:

- develop courses and curricula in accordance with ISP quality criteria
- train PV industry leaders to be instructors, and electrical instructors to be PV instructors
- obtain training equipment and resource materials
- finalize and prepare training sites
- fit PV installation trainings into existing programs.

ISP ACCREDITATION PROCESS FOR CUNY PHOTOVOLTAIC TRAINING PROGRAMS

(Note: This section was written and supplied by CUNY.)

The accreditation process for photovoltaic training programs is now managed for the Institute for Sustainable Power (ISP) by the Interstate Renewable Energy Council (IREC). This process is lengthy and exacting. CUNY has already engaged IREC in discussions and meetings about its plans for accreditation and anticipates close collaboration with IREC as it proceeds.

The IREC ISPQ Handbook (January 2006 edition) makes an important distinction between the accreditation of a program or institution, and the certification of an individual (instructor). The process requires that CUNY must first certify its instructors in order that it qualifies for accreditation. Thus, CUNY's first step must focus on recruitment and training of qualified individuals whose credentials and experience make them suitable instructors who can be assured of securing ISP certification from IREC. The ultimate goal of CUNY is to secure certification for at least one Master Trainer, which requires a minimum of 900 hours of teaching experience and 380 hours of practical experience in the field. Before this goal can be achieved, it is CUNY's plan to secure status for its instructor candidates as Certified Instructors, requiring a minimum of 220 hours of teaching experience and 250 hours of practical field experience. In each case, the specified candidates will follow the Task Analysis for attaining proper qualifications that is approved by the North American Board of Certified Energy Practitioners (NABCEP).

CUNY begins this process with several promising candidates, two of whom (Jonathan Lane of Quad State Solar; and Anthony Pereira of Alternative Power, Inc.) already have logged enough hours to qualify for more than the minimum Master Trainer requirement in practical experience, but still do not have sufficient experience serving as instructors. CUNY will enable them to gain that teaching experience by hiring them to teach PV installation training at CUNY campuses and move them on a track that will first qualify them as Certified Instructors. Courses in both introductory and advanced PV instruction are being scheduled now for this purpose. The third candidate (Robert Polchinski of the NYC College of Technology) will receive additional training so that he may gain sufficient practical experience that will qualify him to begin instructing classes as well.

We are moving forward on the training a labor representative from Local 3 of the International Brotherhood of Electrical Workers. We are working on the integration of a photovoltaics curriculum into the existing training and apprentice program of Local 3.

We are examining various curricula in order to select one that can most easily be adapted to New York City. Existing curricula are satisfactory for basic instruction but New York City's peculiar circumstances require additional attention in order to adequately prepare installers who may work in New York City.

We are quite convinced that our instructional equipment should have mobility to enable us to cover a larger geographic area in the offering of training programs. The procurement of the equipment that will meet the demands of the classroom while staying within the budget allowed for this purpose should also enable mobility.

While the ultimate goal is to attain Program Certification, CUNY will, when appropriate, first apply for Continuing Education Provider Accreditation since this is the most immediate credential that can be attained along the way. Once this is achieved, entailing the necessary audit process, CUNY would be authorized to use the IREC Continuing Education Provider logo in its marketing efforts.

This process is a highly interactive one requiring close coordination between instructional staff, CUNY project managers, and IREC. We continue to have the full support of the City University of New York as well as the representative component institutions in helping us to achieve our accreditation goals. A schedule is being developed between these various parties so that curriculum and instructional technology choices serve project expectations. Progress on this process will be detailed in the next report to NYSERDA.

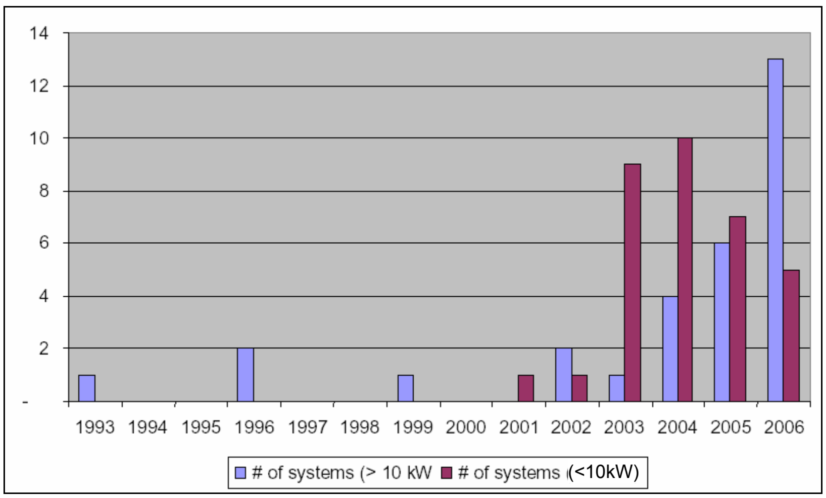
Section 2
PHOTOVOLTAIC INSTALLATIONS IN NYC

CURRENT INSTALLATIONS IN NYC

> *As of November 2005, there were 45 solar projects totaling approximately 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 48% in 2005 and average market growth during 2002-2005 was 27%. If the city's PV market continues to grow at its current pace, it is estimated that up to 54 MW of PV could be installed within the city by 2015.*
>
> -- The Center for Sustainable Energy at Bronx Community College, 2006

The market for solar electric photovoltaic (PV) systems on buildings in NYC has grown in fits and spurts. Since 2002 it has begun to experience more consistency, and growth in the number of installations of larger size, as shown in Figure 2-1.

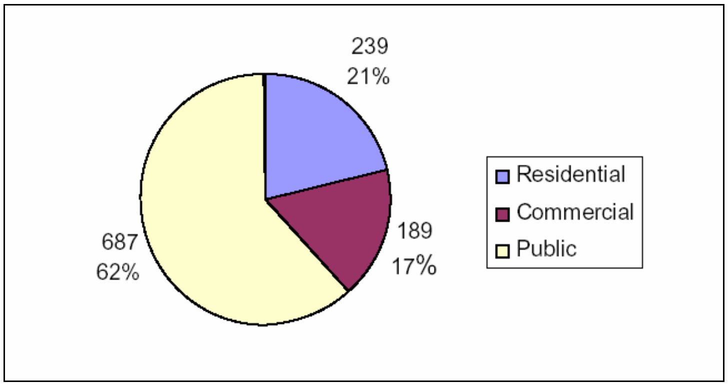
Figure 2-1. **Number of PV Systems Installed by Size and Year**



Source: Center for Sustainable Energy at Bronx Community College, 2006

The first three PV systems in NYC were installed by the New York Power Authority (NYPA), the first in 1993 at a New York City Transit Authority Warehouse in Maspeth, Queens. The public sector, whose buildings receive their power from NYPA, continues to have the largest amount of PV installed in NYC, as shown in Figure 2-2. This is largely attributable to two big MTA installations – a 360 kW system at the Gun Hill Bus Depot in the Bronx and a 210 kW installation at the Stillwell Avenue Subway Terminal in Brooklyn.

Figure 2-2. **kW of PV capacity by sector as % of NYC total (2005)**

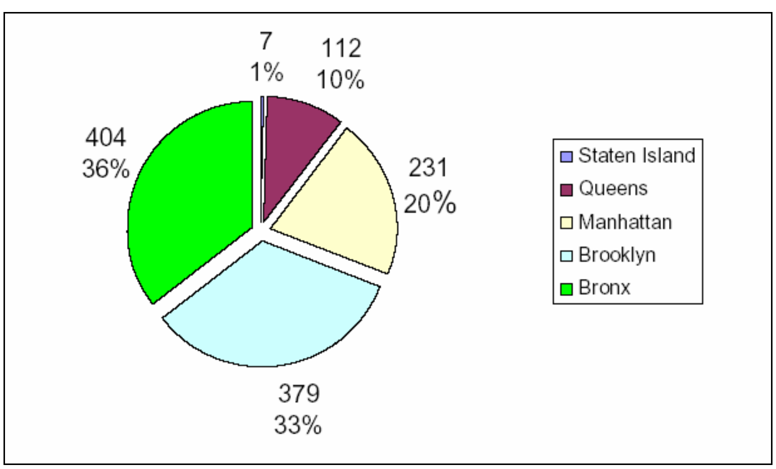


Source: Center for Sustainable Energy at Bronx Community College, 2006

The private sector began installing PV with the ground-breaking building-integrated PV installation at Four Times Square in 1999. With the introduction of a state incentive program from NYSERDA, a number of residential and commercial installations began being installed in 2001. Lately, as shown in Figure 2-1 above, the number of smaller (largely residential) new installations has been declining, while the number of larger installations (> 10 kW) has been increasing.

The current borough leader in PV installed capacity is the Bronx, as shown in Figure 2-3. However, a few large installations in any borough could allow it to take the lead in this young market. Queens, for example, has a few installations planned for 2006 that will bring it into the same league as the leading boroughs. The only borough that has yet to see significant PV development is Staten Island (CSEBCC, 2006).

Figure 2-3. **kW of PV capacity by Borough as % of NYC total (2005)**



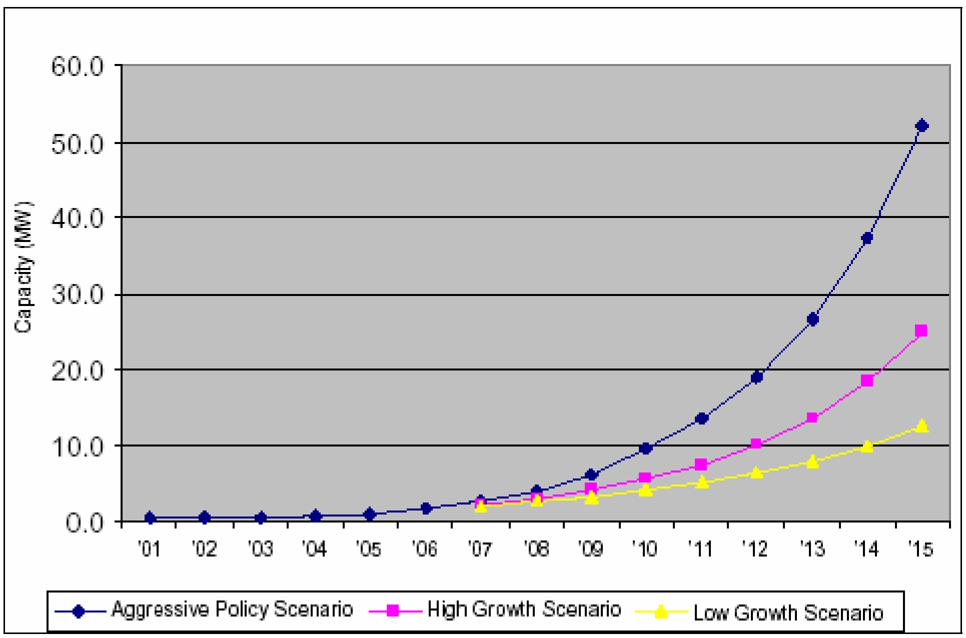
Source: Center for Sustainable Energy at Bronx Community College 2006

PROJECTED FUTURE INSTALLATIONS

The PV market in NYC is growing, averaging 31% annually from 2002 to 2005 and 56% in 2005. In 2006 it is expected that 18 more projects, totaling 519 kW, will be added to the electrical grid. (CSEBCC, 2006) This is a projection of over 40% growth for at least another year. These growth rates are consistent with those of the global PV market (see later section).

In a recent Million Solar Roofs Initiative report, the Center for Sustainable Energy at Bronx Community College envisioned three possible PV market growth scenarios for NYC, as shown in Figure 2-4. The low growth scenario is based on a 25% growth rate. The high growth scenario is based on a 35% growth rate. The aggressive policy scenario assumes that New York that 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. (CSEBCC, 2006)

Figure 2-4. **NYC PV Market Growth Scenarios**



Source: Center for Sustainable Energy at Bronx Community College 2006

This leads to a total installed PV capacity of at least 4 MW by 2010 and at least 12 MW by 2015. Under the High Growth scenario, the market size would be twice this, or 24MW, by 2015 and under the Aggressive Policy scenario, the market size would be more than twice this again (over 50 MW) by 2015.

Factors Effecting PV Market Growth in NYC

The PV market in NYC is young and heavily dependent on subsidies for survival. The good news is that these subsidies come from a number of sources and are not likely to go away anytime soon. However, in order to continue to grow, the fledgling industry will need continued public support for certainly at least the next five years. There are numerous factors that will affect market growth, as shown in Table 2-1.

Table 2-1. Factors Affecting PV Market Growth in NYC

Factors Supporting PV Growth	Factors Inhibiting PV Growth
▪ High Energy Prices (Con Ed up 36% in Jan 2006) ▪ Need for In-city generation ▪ Rising Demand for Electricity ▪ NYSERDA and other Subsidies (especially NYC-specific subsidies) ▪ Increasing Public Interest ▪ Technology Improvements (and reduced cost) ▪ Tax credits/Incentives ▪ Peak/Time-of-Use rates ▪ Need for Peak Demand Reduction (and the creation of programs to support it) ▪ On-site renewable energy mandates such as those in Battery Park City Green Guidelines	▪ No commercial net-metering ▪ Grid interconnection limitations (Con Ed network grid, reverse power relay) ▪ High PV prices ▪ Approvals Process and Building code ▪ Unknowledgeable/untrained building community ▪ Lack of public awareness/ understanding of the technology ▪ Constantly shifting subsidy programs ▪ Lack of political leadership ▪ Product availability (potentially a problem if explosive market growth)

Richard Klein, Quixotic Systems, speaking of the current PV market in NYC: "An installer couldn't survive if just working in NYC." However, a small change in any of the above factors could drastically change the market overnight. In particular, the introduction of a NYC-specific subsidy program that accounts for the relatively higher cost of doing business in this city, could tip PV economics enough to make installations more mainstream.

Subsidies for PV in NYC have been derived from a number of sources, including:

- State Systems Benefits Charge funds administered by NYSERDA
- Various funds administered by NYPA
- Power Plant Pollution Settlement Funds administered by NYSERDA
- Power Plant Expansion Settlement Funds administered by NYC EDC
- State tax credits
- Federal tax credits

The odds are low that all of these incentives will disappear in the near future – in fact, there are many forces working to ensure that the incentives for PV only increase. However, to date, many incentive programs have been fairly small and of limited duration. The most consistent source of PV subsidy has been from the PONs offered by NYSERDA using funds from the Systems Benefits Charge (SBC).

If the NYC market is shifting towards larger installations, then future market growth may be stunted by the lack of incentives for commercial installations in New York State. The solar energy tax credit, sales tax exemption and net metering laws are only available to residential customers and NYSERDA's PON 716 is available for systems up to 50 kW in size. (CSEBCC, 2006)

However, these limitations are largely legislative, and there are already movements in place working to change them. For example, if NYSERDA PON 716 was adjusted to include systems up to 500 kW or 1 MW in size, numerous larger PV installations would likely start to appear in NYC relatively quickly.

The Main Entities that Provide Financial Support for PV Installations in NYC

NYSERDA. As of January 2006, about 23.5% of the total NYSERDA PON 716 PV installations were in Con Edison territory (including Westchester). Total number of installations: 246 completed, 133 in process, 1721 kW residential 440 kW commercial.[3] In addition to PON 716, NYSERDA has offered numerous other incentives for PV installation in New Construction, Energy Star Homes, Schools and other buildings – the vast majority of these have been 2 kW installations and have not been within the bounds of NYC. In 2004, NYSERDA eligible installers completed 87 PV systems totaling 336 kW, with average system size of 4.2 kW. Total number of systems installed: 332 utilizing $14.2 million in NYSERDA incentives. [4]

With the new Renewable Portfolio Standard (RPS), which states that 25% of New York State's power shall be generated from renewable sources by the year 2013,[5] and the renewal of the Systems Benefits Charge (SBC), there is no reason to believe that NYSERDA support for PV will wane in the near future.

New York Power Authority (NYPA). NYPA has been involved in over 700 kW of PV installations, many of those in NYC. NYPA performs PV installations on NYC municipal buildings, which buy power from NYPA, not Con Ed. They put out solicitations for competitive bids from installers when money is available

---

[3] http://www.clean-power.com/PowerNaturally/

[4] "Become One in a Million: Million Solar Roofs Partnership Updates." U.S. Department of Energy, Energy Efficiency and Renewable Energy. Million Solar Roofs and Interstate Renewable Energy Council Annual Meeting, October 2005, pp. 105-106.

[5] http://www.dps.state.ny.us/03e0188.htm

to subsidize projects. The RFPs are typically for turnkey installations that include the entirety of design, permitting and installing the system.

In 2005, NYPA installed about 50 kW of PV in NYC at sites including Bronx High School of Science, NY Hall of Science, and PS 13 on Staten Island. They have about the same amount of installations planned for 2006. As of now, they have no PV installations planned for 2007, but it is reasonable to estimate that they will continue to install 30-50 kW at 3-5 sites each year for the foreseeable future, assuming funding continues to be available.

Metropolitan Transportation Authority (MTA)/New York City Transit (NYCT). The largest NYC PV installations have been on MTA/NYCT property. On many of these installations, the MTA works in cooperation with NYPA. Stanley Karoly, Chief Electrical Engineer for NYC Transit, has stated that, while he can't talk specifically about any future projects, MTA is considering PV systems, both large and small, for a number of projects. These include the Fulton Street Transit Center in Brooklyn, as well as the numerous outdoor canopies on above-ground subway stations. They are always looking for cost effective energy solutions for their construction projects. Furthermore, Gabriel Reves, also an Engineer for NYC Transit, expressed a need for trained maintainers of the large PV systems that already exist in the MTA system.

NYC Economic Development Corporation (NYCEDC). The EDC has been involved in several PV installations, and has several more planned in the coming years. One notable recently completed installation is 50 kW building-integrated PV (or "BiPV") installation at Whitehall Ferry Terminal. Through their administration of a settlement fund with Keyspan over the Ravenswood power plant expansion, NYCEDC will be involved in several PV installations during the coming years, including:

- Noguchi Museum – 15 kW
- LaGuardia Community College, CUNY – 100 kW
- Mount Sinai Queens – 14 kW

In situations such as the Keyspan-Ravenswood Project Settlement Fund, which provides $1million in funding for renewable energy projects, NYCEDC is the direct administrator of the funds for the PV installations. However, NYCEDC can play an even more important role as an advocate for the city and advisor to the state agencies and programs that fund renewable energy projects. Additionally, while budget constraints are always an obstacle, NYCEDC is standardizing green language into all of RFP's for private development on City land, which may lead to greater deployment of renewable energy. NYCEDC is partnering with Dr. Stephen Hammer at Columbia, who will be performing a detailed analysis of renewable energy potential in NYC in the spring of 2006. This project will include matching resource potential with load pockets to help determine where PV and other renewable energy resources can add the most value to the Con Edison electric grid. This research may help to drive new policies that further encourage the deployment of PV in NYC.

PV Potential of NYC

NYC buildings have an aggregate footprint of over five billion square feet. Even if only 10% of the building rooftop area is suitable for photovoltaics, it would be enough to house 5,000 megawatts of PV modules,[6] or over one-third of the peak electrical demand of the city. The total amount of sunlight falling on the area of NYC could produce 125 thousand gigawatt-hours, or more than 2.5 times the city's total demand (Perez, 2001). The market potential is huge, and as conventional electricity becomes more expensive, PV will look increasingly attractive to potential customers.

The potential for PV is greatest in areas where buildings are all of similar height and not shaded by trees or taller structures. Manhattan is, typically, a very difficult place for PV installations except on the tallest buildings in a neighborhood, because shorter buildings have shadows cast upon their rooftops. Only a small percentage of total NYC land area is contained by the island of Manhattan so despite the difficulties of installing PV amongst skyscrapers, the opportunities in NYC are still vast. Table 2-2 shows land-use in the city.

Table 2-2. 2005 Land Use in NYC by Borough (land area in millions of sq ft)

	Residential	Commercial	Manufacturing	Vacant	Total
Bronx	505.8	57.4	92.3	32.1	687.6
Brooklyn	915.6	44.2	187.8	59.6	1207.2
Manhattan	218	89.4	48.5	8	363.9
Queens	1620.5	40.6	157.9	68.8	1887.8
Staten Island	805.7	29.8	224.4	175.6	1235.5
Total	4065.5	261.3	711	344.1	5381.9

Source: New York City Housing and Neighborhood Information System (http://www.nychanis.com)

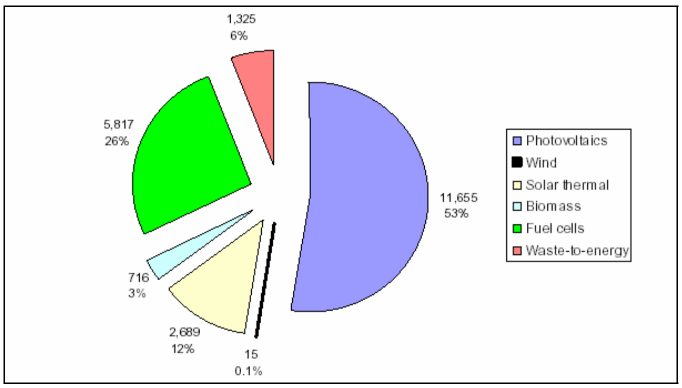
As the Table 2-2 shows, the vast majority of land-use in NYC is residential. Manufacturing takes up a much smaller segment of land-use, but is a notoriously high energy consumer. Manufacturing buildings tend to have large flat roofs that are good candidates for big PV installations. Aesthetic concerns are also not a big driver for manufacturing facilities, so installing PV modules on roofs is not likely to receive any opposition on these grounds.

[6] 10% of 5 billion is 500 million square feet. Assuming 10 W per square foot (average for crystalline silicon modules) this yields total PV capacity of 5 billion watts = 5 million kilowatts = 5,000 MW = 5 GW.

NYC has been a leader in the building-integrated PV (BiPV) into the facades of large buildings such as the Conde Nast Building in Times Square and the Solaire in Battery Park City. The technical potential for exterior wall installations is limited to facades that face South, Southeast or Southwest and are taller than any other objects or structures to the South. The best opportunities for façade PV integration are along waterways, facing parks and on the tallest buildings in a neighborhood.

Furthermore, of all renewable technologies, PV holds the greatest potential for New York City, as shown in Figure 2-5.

Figure 2-5. Alternative Energy Potential in NYC (GWh by 2022)

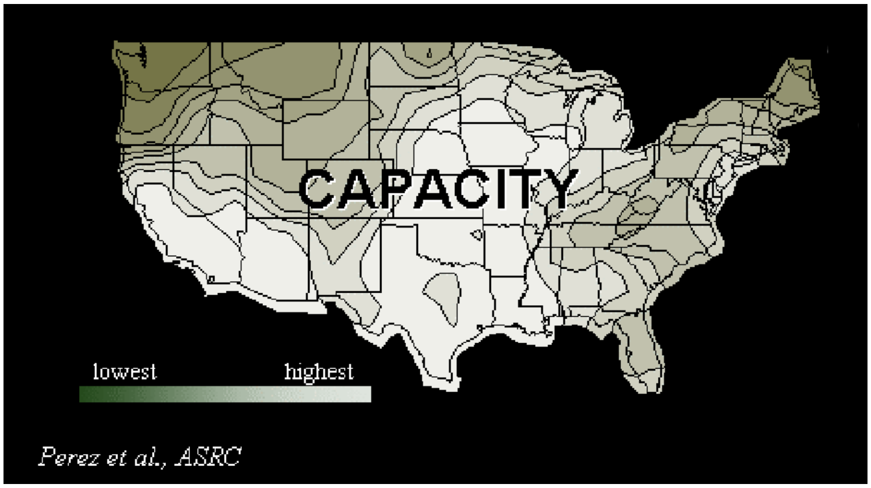


Source: Center for Sustainable Energy at Bronx Community College, 2006, based on Plunkett et al, 2003

Work by University of Albany Professor Richard Perez and others has shown that PV has great potential to strengthen the NYC electrical grid and to mitigate the causes of blackouts. PV system output and Con Ed system-wide peak loads tend to be coincident (both occurring on sunny summer afternoons).[7] Effective Load Carrying Capacity (ELCC) is a measure that takes into account the value of PV generating power when needed most. Although NYC does not get as much sunlight as Southwestern regions of the country, the ELCC for PV installations in NYC is actually among the highest, as shown in the following Figure 2-6.

[7] Currently there are a number of programs through NYSERDA, Con Ed, NYPA and the NYISO that reward building owners for peak load reductions, however these programs typically do not include PV in the list of eligible measures. Given the peak-shaving capabilities of PV, it would be prudent and beneficial to encourage policies that count PV as a peak load reducing measure.

Figure 2-6. **Effective Load Carrying Capacity (ELCC) of PV across the U.S.**

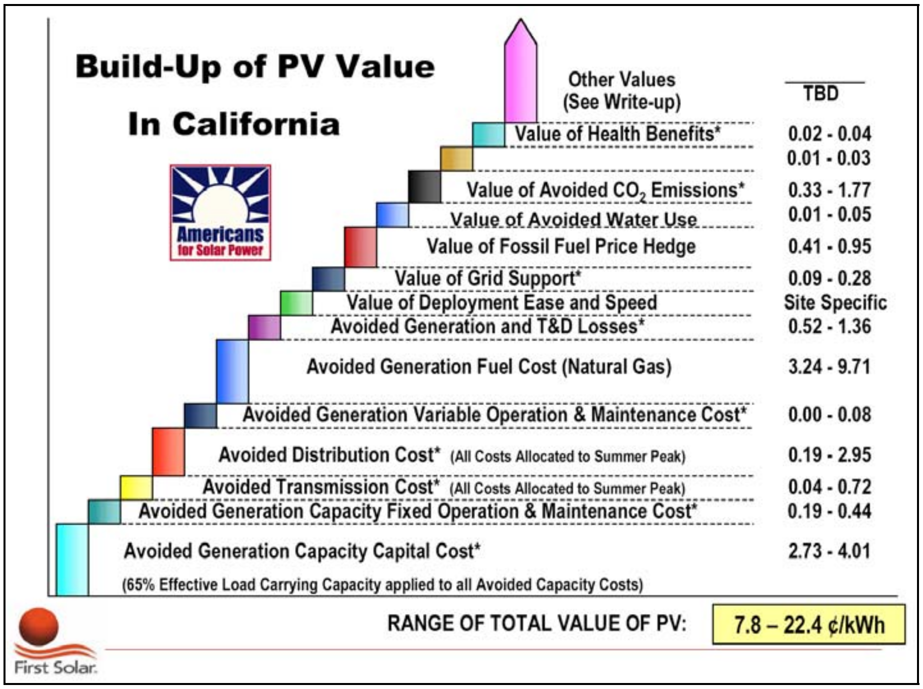


Source: Perez, 2001.

Furthermore, PV is a distributed resource that can help to strengthen the utility transmission and distribution (T&D) network by supplying power when and where it is needed most. For this application, PV works in combination with a battery-backup to insure that the power is available when the T&D system is constrained. As Con Ed runs into capacity constraints, the utility itself may begin to deploy, or encourage the deployment of, PV in the parts of the grid that need it most. On the west coast, several efforts have been made to quantify the full value of PV, including externalities and other benefits – including T&D and fuel cost savings as well as avoided emissions and health benefits – that are often not factored into PV economic calculations.

Figure 2-7 demonstrates the full value of PV in California – in NYC it is reasonable to expect that PV's full value is at the high end of this range, if not even greater. It is important to understand that the reason why these benefits are often not monetized is that they accrue to different entities than the purchaser of the PV system. For example, reduced strain on the T&D infrastructure is a benefit to the utility and emissions reductions and associated health benefits effect health insurers and the society at large.

Figure 2-7. Full Value of PV in CA, including T&D benefits



Source: Hamer, 2005

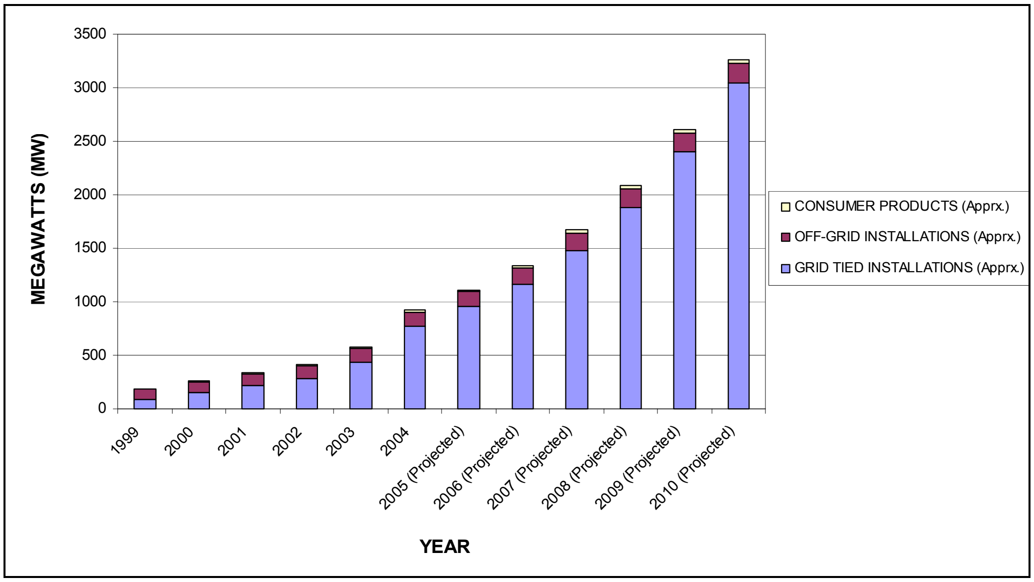
NATIONWIDE AND WORLDWIDE PV MARKET GROWTH

Annual worldwide growth of the solar PV has averaged over 30% since 1999 and was 60% in 2004. Figure 2-8 is an estimate of the future market growth of PV. Best industry projections for 2005 and 2006 suggest a slower growth rate of 20% due to a temporary supply shortage of raw silicon. For 2007 and beyond, best guess growth estimates are 25%, as reflected in the chart below. A higher future growth rate of up to 40%, especially with greater and more sustained subsidies, less expensive PV technology or more expensive conventional energy prices, is not unreasonable.[8] However, even if the growth rate is 25% annually, the market will see a doubling in three years, a tripling in five and growth to $100 billion in a decade.

---

[8] For example, the "Hypergrowth" scenario from the Solar Opportunity Assessment Report suggests a 38% man-on-the-moon type goal compared to a 24% growth business-as-usual case. *Solar Opportunity Assessment Report*, Solar Catalyst Group, 2003. www.solarcatalyst.com

Figure 2-8. Annual Worldwide PV Installations



Source: Bright Power, based on data from SolarBuzz, Rogol

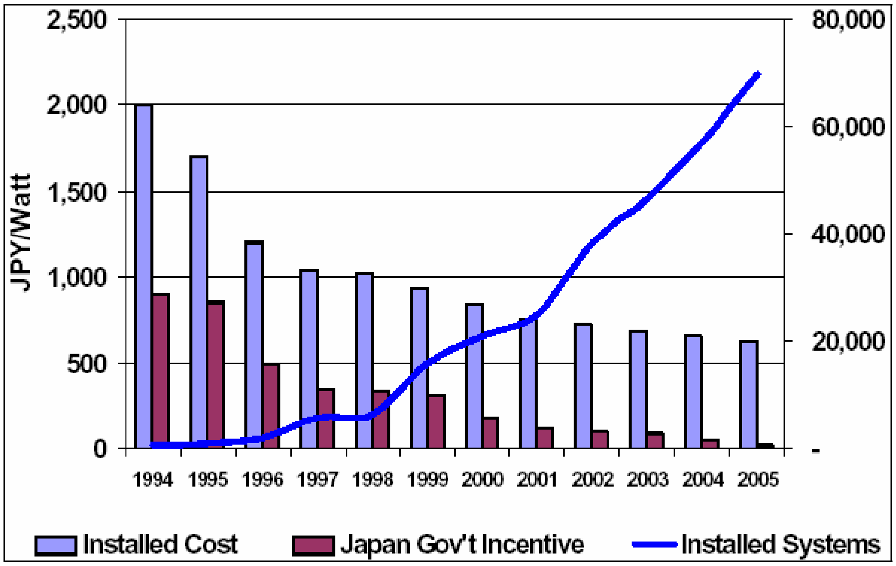
There are two different types of rooftop solar technology; *grid connected PV* and *off-grid PV*. The main difference between the two is that *off-grid PV* does not depend on the utility infrastructure and uses batteries to store energy, whereas *grid connected PV* is wired directly into the utility service through an inverter and energy does not need to be stored in batteries. Grid-connected solar PV is the fastest growing energy technology in the world at 60% average annual growth rate over the last five years, while off-grid PV has been growing at 17%.[9]

There are about 2,000 megawatts (200 million square feet) each of grid-connected and off-grid PV installed globally. This is a small fraction (~0.1%) of total world-wide primary energy demand. Grid-connected PV installations are concentrated in three countries – Japan, Germany and the US.

Of 400,000 homes that had grid-connected PV systems on their roofs as of 2003, 200,000 of these are in Japan.[10] The solar market in Japan is a result of good, sustained government policy, high cost of retail electricity, and decreased cost of installation. Financing and integration with new home builders have also helped to drive the Japanese market. Japan's national solar power program reduced solar prices by more than 50% and increased the number of installations from 500 to over 60,000 in a decade, while phasing out rebates. This trend is expressed in Figure 2-9 below.

[9] Martinot, Eric. Global Revolution: A Status Report on Renewable Energy Worldwide. Renewable Energy World, November-December 2005. pp28-43. www.renewable-energy-world.com
[10] Martinot, 2005.

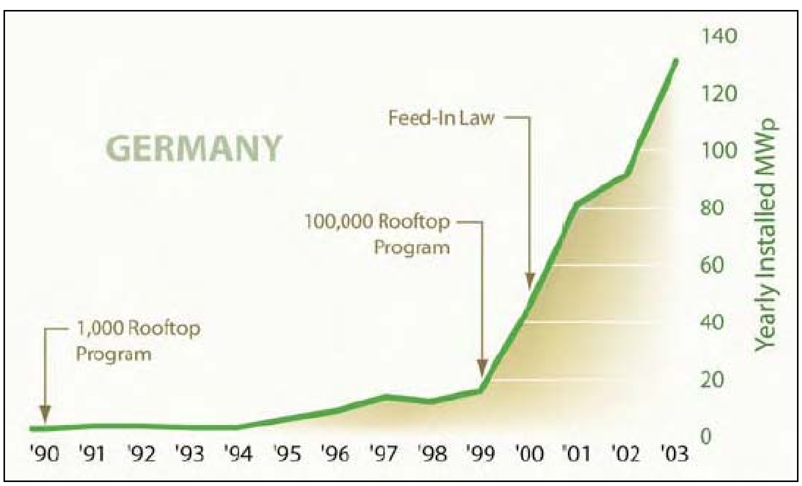
Figure 2-9. Japanese PV Installed Cost & Number of Systems Compared to Incentive Level



Source: O'Brien, 2005

Germany is the solar leader of Europe. This country has accomplished PV growth through a very aggressive subsidy program, and through encouragement of large utility-scale solar farms in addition to rooftop installations. Figure 2-10 shows the effect of the German feed-in law on increasing annual solar installations.[11] Under this law, grid-connected PV systems receive a substantial bonus for the energy that they generate over their lifetimes.

Figure 2-10. German PV Market Growth

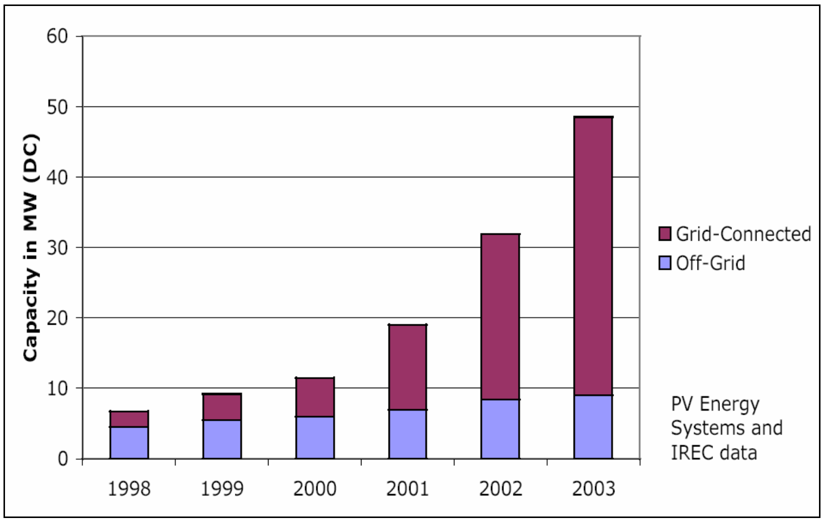


Source: SEIA & SEPA, 2004

[11] The Feed-In Law fixes preferential tariffs for approved renewable energy projects for a 20-year period from the plant commissioning. Tariffs were initially set at 48.1 euro cents/kWh for PV, compared to about 7 euro cents/kWh for hydropower. http://www.solarbuzz.com/FastFactsGermany.htm

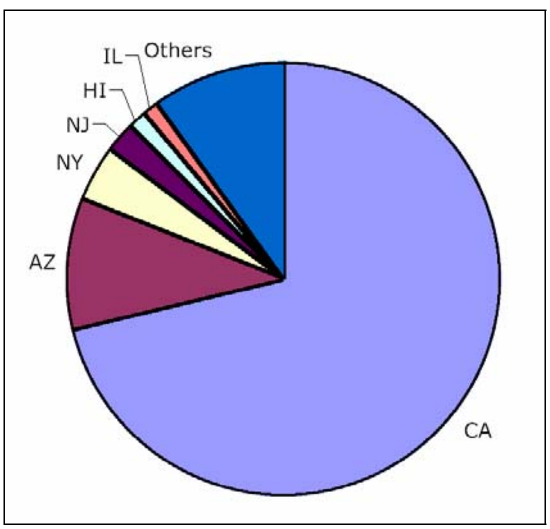
The United States has stronger support for solar energy on a state by state level than on the national level. By October 2005, 21 States, including New York, and the District of Columbia had enacted Renewable Portfolio Standards (RPS), which set targets for renewable energy production as a percentage of total energy production.[12] In some states, such as New Jersey, the RPS rules set a carve-out, or minimum percentage, specifically for PV.

Figure 2-11. Annual Installed U.S. PV Capacity



Source: Sherwood, 2005

Figure 2-12. Installed Grid Connected PV Capacity by State (1997-2003)



Source: Sherwood, 2005

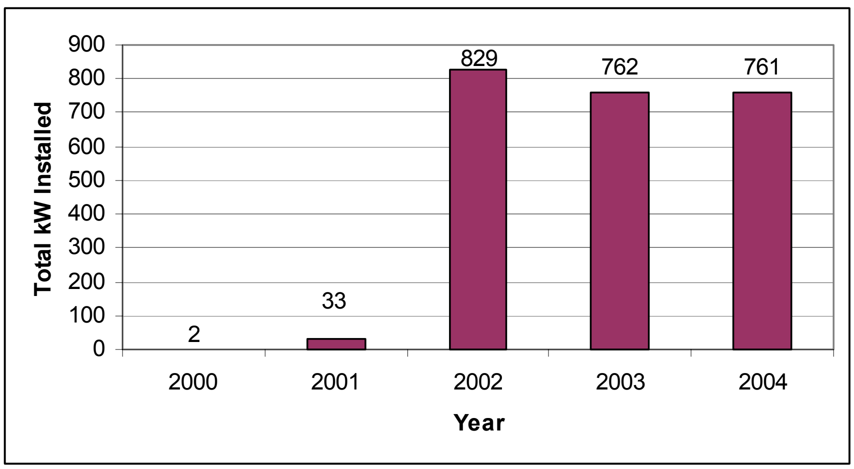
[12] Union of Concerned Scientists http://www.ucsusa.org/clean_energy/clean_energy_policies/res-at-work-in-the-states.html accessed 12/28/05

On a national level, Congress passed an energy bill in mid-2005 that contains enhanced tax credits for solar energy through the year 2007. These tax credits are granted based on the customer's net cost after any rebates from a utility or state. The Solar Energy Industries Association (SEIA) is working to make these credits a more permanent part of the federal tax landscape. If SEIA succeeds, this will positively impact the solar market nationally and locally.

Neighboring Markets

Long Island. Many NYC-based installers perform work on Long Island. As of August 31, 2005, there were 618 PV installations on Long Island totaling 2,922 kW. The Long Island Power Authority (LIPA) has its own PV incentive program, which had incentive levels that were higher than those of NYSERDA for some time. This, along with LIPA's ability to concentrate all PV proliferation efforts on two counties, has led an installed PV capacity on Long Island that is almost three times that of NYC.

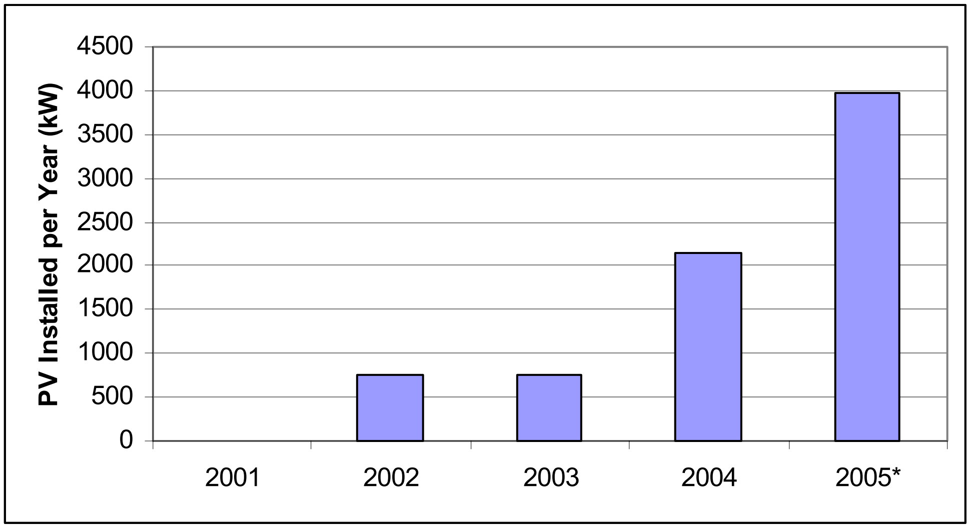
Figure 2-13. Annual Installed PV under the LIPA Solar Pioneer Program



Source: LIPA, 2005

New Jersey. Many NYC-based installers perform work in NJ, where the PV market has experienced explosive growth. The incentive program for PV in NJ is at a higher level per Watt than the one for NY, the net-metering cap is higher and it additionally has a market for SRECs, or the renewable energy attribute of electricity generated by solar. These three factors have been significant drivers of the NJ solar market.

Figure 2-14. Annual Installed PV in NJ



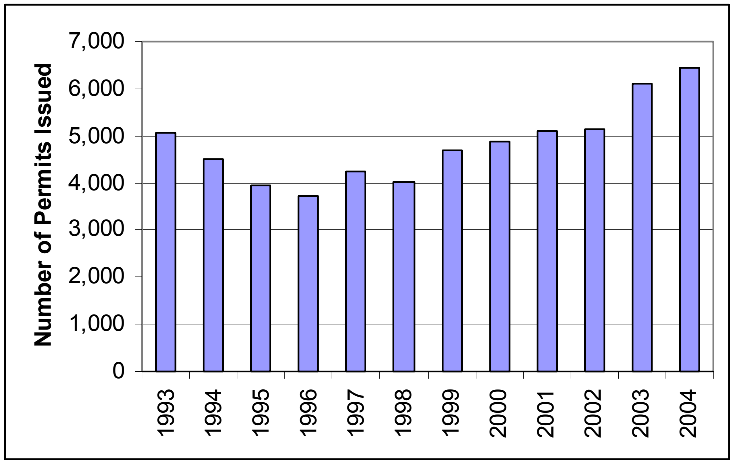
Source: New Jersey's Clean Energy Program, 2005.
* - 2005 value is for first three quarters only.

NYC BUILDING CONSTRUCTION

New construction is booming in New York City. However, only a tiny fraction of this new construction currently includes PV. While not all buildings are suitable for a PV rooftop or curtain-wall installation, many could incorporate the technology.

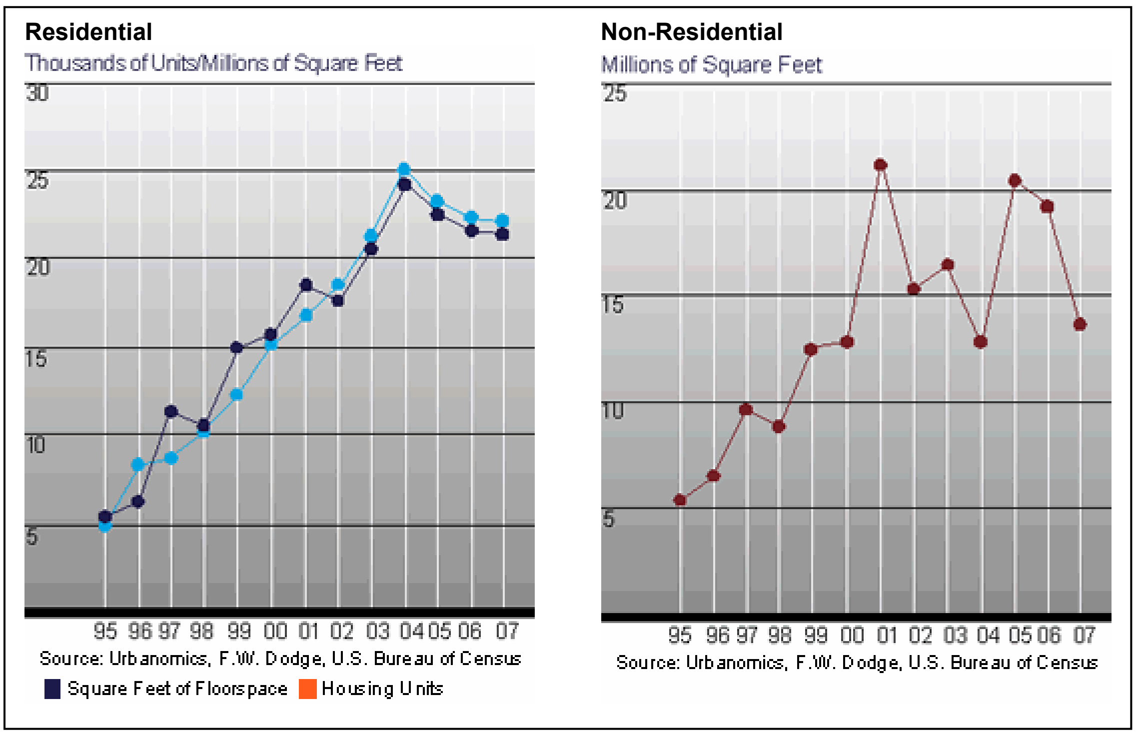
The following figures demonstrate the growing construction sector. In total in 2004, over 6,400 permits were issued for new buildings in NYC. Figure 2-15 shows the growth in the number of new construction permits through the first half of this decade. Figure 2-16 shows that this growth is projected to slow but nonetheless that there will be substantial construction in the coming years. While not all of these buildings are suitable for PV systems, many of them are potential sites for PV. Finally, Figure 2-17 shows that significant sums are being spent on NYC construction, of which PV is currently a very small part.

Figure 2-15. Number of Construction Permits Issued for New Buildings in NYC



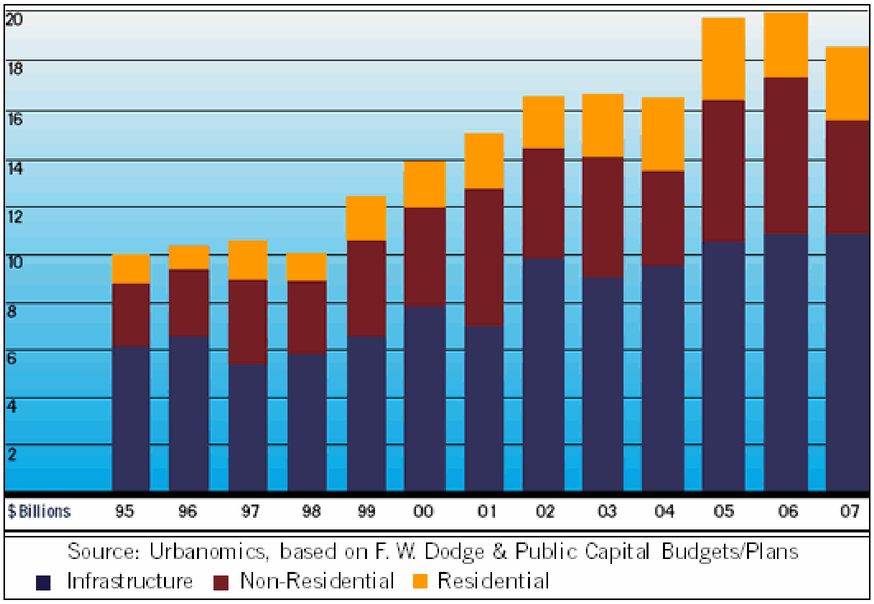
Source: NYC Department of Buildings, BIS mainframe

Figure 2-16. New Construction in NYC (1995-2007)



Source: http://www.buildingcongress.com/code/outlook/2007-charts.htm

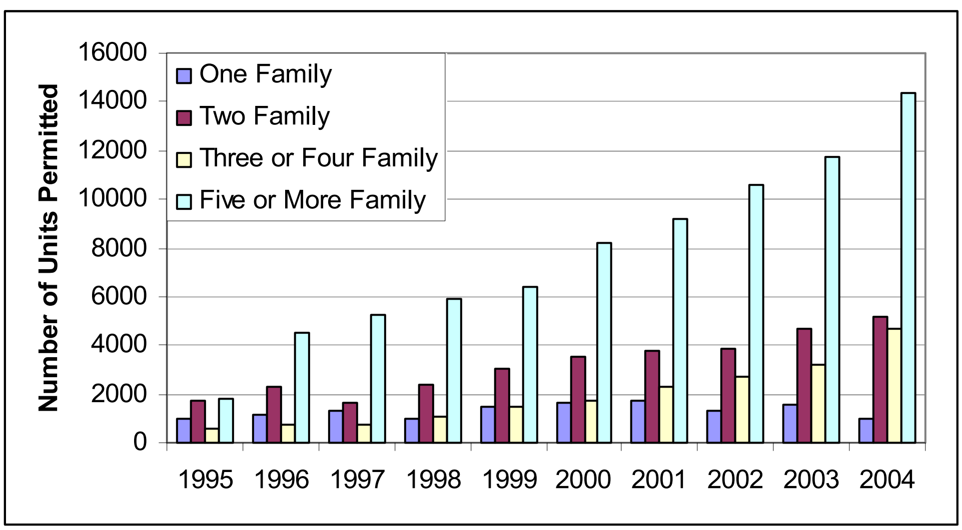
Figure 2-17. NYC Construction Spending 1995-2007



Source: http://www.buildingcongress.com/code/outlook/2007-charts.htm

As shown in Figure 2-17, large investments are being made in all sectors. As Figure 2-18 shows, the greatest number of units are being constructed as part of larger multifamily buildings. However, there are also a substantial number of two-family units, primarily in Queens, Staten Island and Brooklyn, and three and four-family units, primarily in Queens, Brooklyn and the Bronx. (For full breakout see Appendix.)

Figure 2-18. Permits Issued for Privately-Owned New Residential Units by Building Type



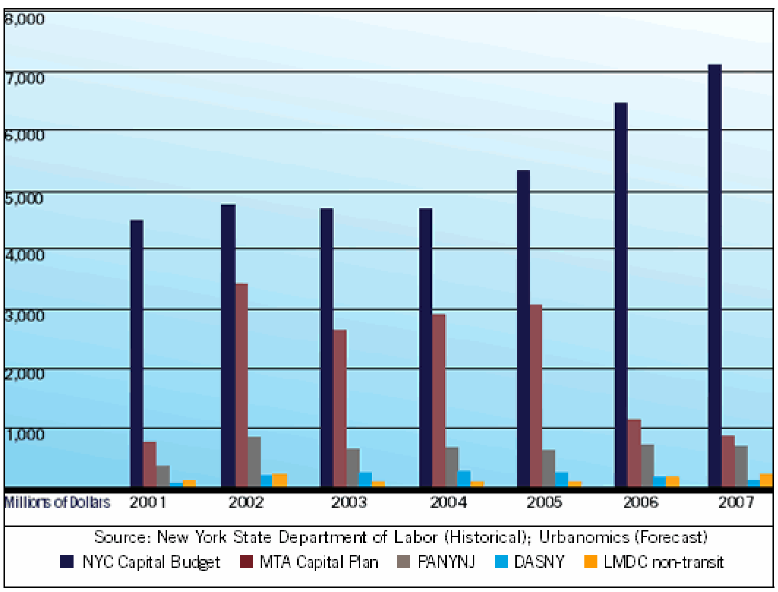
Source: NYCHANIS

Each residential building ownership structure – single-family owner-occupied, multi-family owner-occupied, investor owned, co-op, condo, mixed use building – has different hurdles towards implementing PV.

Public Sector Construction

The public sector is currently a major client of PV systems, thus the projected increase of NYC capital spending on construction indicates potential increased PV demand in the public sector. Recently passed Green Buildings legislation (Intro 324-A/Local Law 86) mandates that all new public construction be conducted up to LEED Green Building standards. On-site renewable energy is one facet of green building, but it is not specifically mandated within the legislation. Without additional legislation specifically directing the installation of PV, it is doubtful that much will be installed on buildings covered under this law. Such legislation could take the form of the Battery Park City Green Guidelines, which mandate that a percentage of a building's base-load electricity comes from on-site renewable energy generation.

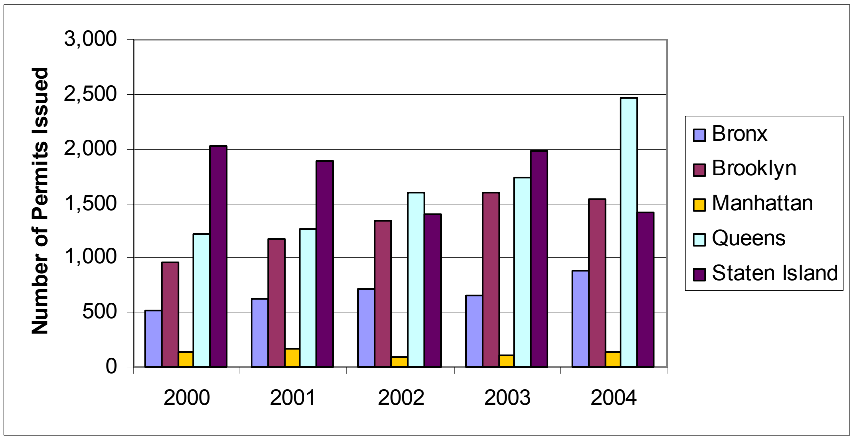
Figure 2-19. Public Construction Spending 2001-2007



Source: http://www.buildingcongress.com/code/outlook/2007-charts.htm

New Construction by Borough

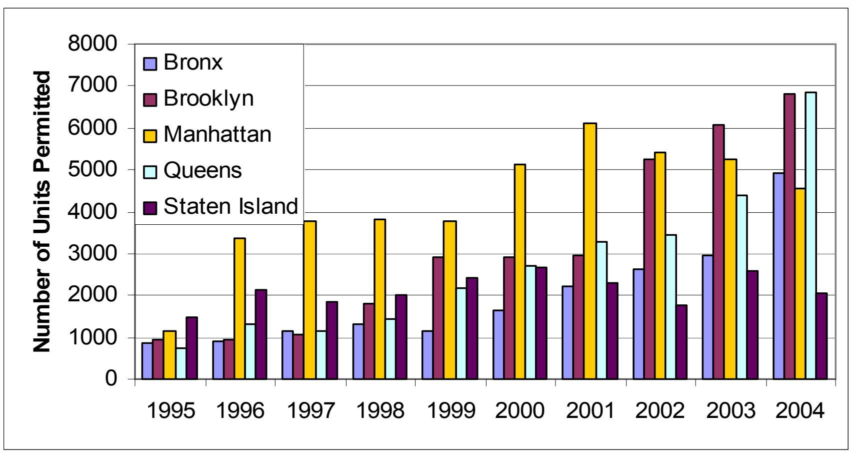
Figure 2-20. Number of Construction Permits Issued for New Buildings in NYC by Borough



Source: NYC Department of Buildings, BIS mainframe

It is clear from Figure 2-20 that the greatest volume of new projects is in Queens, Brooklyn and Staten Island. Figure 2-21 shows that while Manhattan and the Bronx have fewer projects, they still have a substantial number of housing units being constructed – this implies that the buildings in these boroughs tend to be larger.

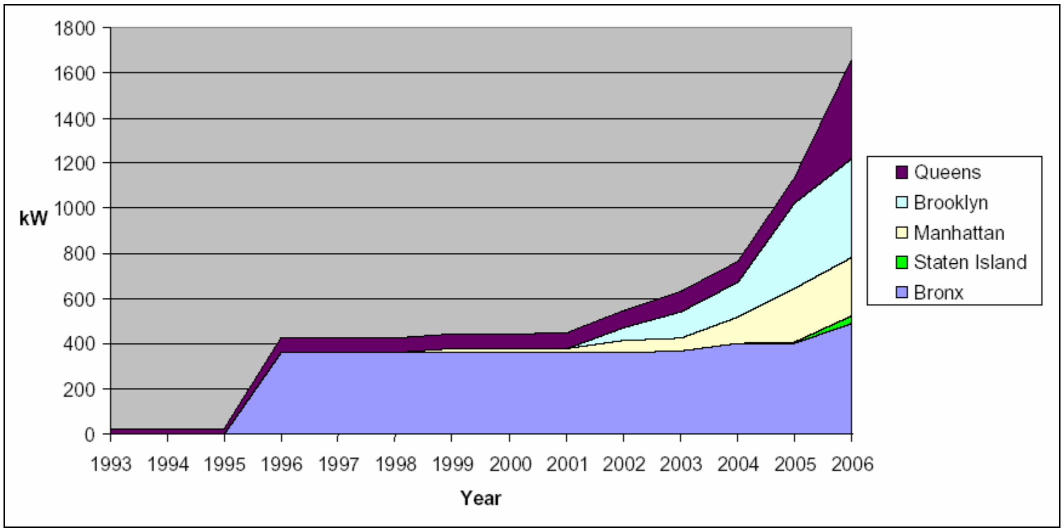
Figure 2-21. Permits Issued for Privately-Owned New Residential Units by Borough



Source: NYC Department of Buildings

Compare these new construction charts to Figure 2-22 - PV installed by borough over the same period.

Figure 2-22. **PV Installed in NYC by Borough kW, projected thru 2006**



Source: Center for Sustainable Energy at Bronx Community College, 2006

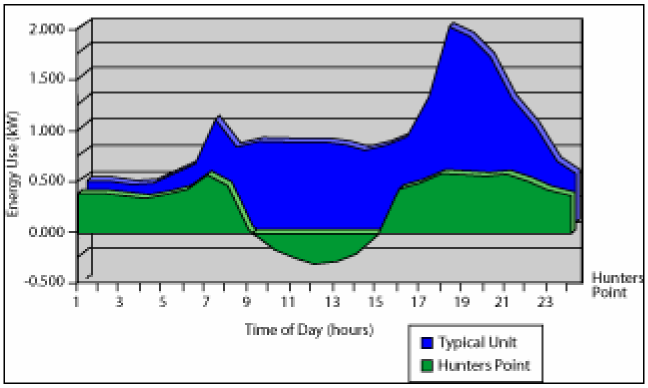
Both new construction and PV installations are growing. The boroughs that have demonstrated the greatest recent growth in PV are Queens and Brooklyn. The one borough in which new construction and PV market growth have not coincided is Staten Island, where there is currently very little installed PV capacity.

<u>Power Demands of New Construction</u>

New buildings can put added strain onto NYC's already constrained power grid, especially when they are larger than what previously existed on the site. A lot can be done in the building design, construction and appliance specification phases that can help to reduce the energy demands of a building. However, the addition of PV can also help to reduce demands of new construction on the electrical grid.

Redevelopment of the Hunters Point Naval Shipyard in San Francisco is an example that demonstrates the ability to reduce new construction impacts on a strained electric grid. Instead of increasing transmission line capacity to this peninsula, the project includes 1600 homes that are built to ENERGY STAR efficiency standards and include PV on their roofs. As shown in Figure 2-23, these homes are net exporters of electricity at certain times of the day.

Figure 2-23. Electricity Consumption of a Hunters Point (ENERGY STAR) Home with 1.2 kW PV System versus a Typical Home



Source: Building Energy Research Alliance as cited at http://www.eere.energy.gov/buildings/building_america/rh_0504_hunters_point.html, 1/15/06.

Ed Smeloff, Former Assistant General Manager of the San Francisco Public Utilities Commission, noted: "The combination of energy efficiency and solar electric generation on the new homes will mean that the Hunters' Point Shipyard community will be able to produce locally all of the electricity it needs during periods of peak demand for the city's electric system."

CONCLUSIONS ON FUTURE DEMAND FOR PV IN NYC

The PV industry in NYC is relatively small, consisting of only a few full-time firms that do not survive on business in NYC alone. All of the NYC-based solar installers interviewed for this study, including David Buckner of Solar Energy Systems, Anthony Pereira of altPower, and Richard Klein of Quixotic Systems, were clear that they rely on business outside of NYC because at present they could not support themselves purely on work within the city. Any number of factors – a special incentive either from NYSERDA or the City, a new development with guidelines akin to those in Battery Park City, an incentive from Con Ed to install PV in certain load pocket areas, a city mandate to put PV on public buildings, or a substantial reduction in PV costs, to name a few – could result in a substantial growth of the PV industry in NYC. With a statewide, nationwide, and global trend towards encouraging PV deployment, it is reasonable to expect that one or more factors will transpire to increase PV demand in NYC. The next section contains an assessment of what skills are need for PV installers in NYC and estimates for what the future demand for PV workforce in the city will be.

Section 3
SPECIFIC TRAINING NEEDS IN NYC

New York City presents unique market challenges for PV training. The city has a large construction industry with many professionals who could potentially be involved in the installation of PV into NYC's buildings. But NYC is also a leader in finance and business. These industries employ a large number of people in the city and have the potential to transform the PV markets in the city and state, as well as in the nation and in the world.

According to Anthony Pereira, President of the New York Solar Energy Industries Association (NYSEIA) and one of NYC's best-known solar installers, the PV industry is moving away from mom & pop design/build installers. Increasingly, the industry will consist of companies that market, design and sell PV systems, with the systems themselves installed by experienced electrical and construction crews that do not necessarily specialize in PV. In some parts of the country, there are home builders who are beginning to integrate PV into their new constructions. In these cases it is not uncommon for their regular construction crews to install the PV systems. As PV becomes more common in NYC, we may begin to see this trend as well.

SKILLS NEEDED FOR PV INSTALLERS

The North American Board of Certified Energy Practitioners (NABCEP) Task Analysis for the Photovoltaic System Installer provides an excellent and comprehensive framework for a PV installation course. The NABCEP Task Analysis defines the primary objective for the PV installer as follows:

> Given basic instructions, major components, schematics and drawings, the PV installer is required to specify, configure, install, inspect and maintain a grid-connected PV system that meets the performance and reliability needs of the customer, incorporates quality craftsmanship, and complies with all applicable safety codes and standards by:
>
> 1. Working Safely with Photovoltaic Systems
> 2. Conducting a Site Assessment
> 3. Selecting a System Design
> 4. Adapting the Mechanical Design
> 5. Adapting the Electrical Design
> 6. Installing Subsystems and Components at the Site
> 7. Performing a System Checkout and Inspection
> 8. Maintaining and Troubleshooting a System

For full NABCEP Objectives and Task Analysis for Solar Photovoltaic Installer, see Appendix B.

It may be helpful at this point to consider the various entities and certifying bodies that exist in the NY PV industry and review their different programs. Table 3-1 contains an attempt at doing so.

Table 3-1. Various Important Entities and Certifying Programs Involved in PV

Entity	Program/Certificate	Description
North American Board of Certified Energy Practitioners (NABCEP)	Entry Level PV Certificate	Requires passing an exam that tests understanding of the basic terms and operational aspects of PV systems.
	PV Installer Certification	Requires passing a more rigorous exam and demonstrating field experience installing PV systems.
NYSEIA/NYSERDA	PV Internship	Students are eligible to take an internship with a practicing installer after completing an Entry Level Certificate.
NYSERDA	Eligible Installer	Eligible to receive the NYSERDA incentives for PV installations performed. Listed on NYSERDA website, with preferred listings given to NABCEP certified installers

The end goal of the PV training program is the development of a qualified workforce of NABCEP certified, NYSERDA eligible installers. These installers will be trained in all eight NABCEP Objectives for a PV Installer as outlined above. They will be given the opportunity to participate in internships with working PV installers to ensure that they receive adequate field experience. And they will perform PV installations that meet the highest standards of workmanship and quality.

Of course, PV installers should have core competencies in science, math and language in order to grasp the basis of the technology, proceed with calculations that are required on the job, and to effectively describe it all to their clients. Those lacking these critical foundations would strongly benefit from refresher seminars aimed specifically at these areas.

Different Roles in a NYC PV Installation

In the course of a PV installation, the eight NABCEP objectives outlined above are not necessarily performed by the same person. In fact, objectives 3-5 contain purely cognitive tasks that are generally not performed at the site of the installation. In designing PV training for a city such as New York, program developers should be mindful of the various needs of the different types of workers who may be involved in PV projects.

Salesperson. This person is the first and primary point of contact with the potential customer. S/he needs to present a credible face to the customer, and must have a thorough understanding of PV technology and the installation process. Strong skills in Objectives 2-3 are recommended. Familiarity with Objective 8 would be helpful as well, since this is the person the customer is likely to call if there is a problem. However, this person does not need to know the minutia of proper electrical hook-up, wire sizing, conforming to electrical code, etc. (although professional installers usually serve this function)

Site Surveyor. This person, who may or may not be the same as the salesperson, must be well-versed in factors effecting PV system performance, namely shading and module orientation. S/he must be proficient with the Solar Pathfinder or a similar shading analysis tool and the other tasks of Objective 2. However this person does not need to know how to perform a code-compliant PV installation.

Architect. Particularly if the PV project is part of a new construction or substantial renovation, an architect will often be involved in Objective 3.

Electrical Engineer/System Designer. A licensed electrical engineer is typically required to perform Objective 5, and their counsel is often sought on Objective 3. Without stamped engineer's drawings, the project cannot receive the necessary permits.

Construction/Project Manager. This person is responsible for ensuring that all parts of the project happen in the order that they need to. This includes strength in Objectives 1, 6 and 7 and a familiarity with at least Objectives 4 and 5. This may also be the person responsible for handling the paperwork – filings for permits, incentives, etc.

Roofers/Laborers. These workers must have a thorough understanding of Objectives 1 and 6, and a familiarity with at least Objective 7. It is not necessary for these workers to understand how to perform a site survey or how to design a PV system.

Electrician. This person must have a thorough understanding of Objectives 1, 6 and 7. It would be helpful for this person to have a good working knowledge of Objectives 5 and 8 as well. However, it is not necessary for the electrician to know how to do a site survey or design a PV system.

Maintenance Person. This person may be someone independent of all the other people involved in the installation. In fact, as the industry grows, one can imagine an entire company dedicated solely to the maintenance of PV systems. For large systems, in particular, there is demand for personnel who are trained in the maintenance of PV systems. This person must have deep understanding of Objectives 1 and 8. Of course, in order to more accurately troubleshoot and perform a repair, familiarity with all other Objectives is necessary as well.

Each of these roles will not necessarily be performed by a different person. However, it is important to understand that the skills needed to perform each role are not the same and that the people who will fill these roles may possess very different knowledge bases and skill sets. This is particularly true of licensed electricians, necessary for the wiring of systems, who generally are not solely employed for PV installations.

PV Installation Skills

General PV Skills based on available course curricula

- Basic knowledge of sunlight, sun angle, and how PV works
- Components of a PV system – modules, inverters, junction boxes, batteries
- Selection of a good site for a PV system – using a solar Pathfinder
- Setup configuration, sizing, wiring and controls
- Relevant sections of NEC codes pertaining to PV systems
- Interconnection agreements
- Specific parameters of concern to utilities in grid connected systems
- Maintenance and trouble shooting
- Hands-on experience setting up of a grid connected system

Specific NYC PV skills

- NYC Permitting Process
- Con Edison Interconnection
- Division of Labor (between different types of laborers)
- Building-integrated PV glazing
- Installing PV on flat roofs

Most trainings and training materials to date have focused on PV for homes, often in suburban and/or rural environments. The uniqueness of performing PV installations in NYC's dense urban environment should not be underestimated. In PV training courses at the SUNY Farmingdale Solar Energy Center, half of a day is spent covering the specifics of permitting jobs and interconnecting with the utility on Long Island. Naturally, attention to the specific challenges of completing PV installations in New York City must be given attention where New York City PV installers are being trained.

Training for PV "Support" Jobs

Historically, the PV industry has suffered from relatively unsophisticated marketing and financing. The industry has not yet reached the standard mass marketing approach. In New York City, it is important that contractors, engineers and laborers learn the mechanics of designing and installing PV systems. But it is also important that training is open to policy-makers, salespeople, accountants, consultants and bankers, who can help to broaden the market.

There is an increasing need for marketing, financial, and political players educated in the specifics of PV. Their roles can include expanding the PV marketplace, making the sales financially attractive, and ensuring that building codes and permitting processes are supportive of solar technology.

The need to build the "business side" of solar is echoed by Gordian Raacke, Executive Director of Renewable Energy Long Island (RELI). In a message that he sent in Fall 2005 regarding training for installers, he wrote:

> We are looking at topics such as
>
> - Business Planning and Growth Strategies in a Changing Solar Market Place (no, those PV rebates won't be around forever)
> - Effective Marketing, Public Relations and Networking for Small Businesses
> - Sales and Customer Service and other stuff for which you don't have the time
>
> The seminars should be hands-on and geared towards the small and in many cases very small (1 to 5 employees) firm.

The full PV Installation Process can be thought of as 10 steps, only a few of which involved the physical installation of a PV system.

1) *Marketing*. Introducing the concept of PV to potentially interested customers. Many people are still misinformed about solar technology – its costs, its functionality, its abilities and its limitations. Marketing can be performed by media and government as well as by companies involved in the PV business.
2) *Qualification of Site/Customer*. Learning about the potential customer's site – location, roof characteristics, electricity consumption, financial situation (e.g. ability to pay for a PV system, eligibility for tax credits, etc.)
3) *Site Visit/Survey*. A visit to the building site to measure roof space, assess potential shading, survey electrical service, and meet the potential customer.
4) *System Design*. Using information from the site survey to design a system that meets the customer's needs. This includes both mechanical and electrical aspects of the design.

5) *Sales*. Convincing the customer to actually purchase the system.
6) *Incentive Program Administration/Financing Procurement*. All paperwork necessary to receive the state rebate and, if necessary, financing for the customer.
7) *Permitting & Approvals*. Obtaining permits as necessary from the Department of Buildings and Con Edison (or the local utility).
8) *Installation – Mechanical*. Includes installation of racking and modules.
9) *Installation – Electrical*. Includes installation of inverter, wiring.
10) *Inspection*. Receiving sign-off from Con Ed, NYSERDA the Department of Buildings. The completion of this step allows the system to become operational, and the final portion of NYSERDA incentive money to be received.

The core of PV Installation trainings focus on steps 3, 4, 8 and 9 – what might be considered the "technical" aspects of a PV Installation. However, the other listed steps are no less important for the PV installation process, and the people performing these roles can benefit from PV training as well. A PV marketing/salesperson should have a thorough understanding of the technology and installation process. The individuals handling the permits and approvals need to have an understanding of PV in order to accurately decide if the project should receive approval. The inspector needs to understand the technology in order to assess whether or not the installation has been performed properly. (Florida Solar Energy Center, for example, offers training specifically designed for Inspectors of PV systems.)

TRAINING DEMAND/NEED FOR WORKFORCE

Based on conversations with the active solar installers in NYC, there is a need for:

- *System designers/Engineers* – individuals with the ability and credentials to produce CAD computer-generated PV system designs.
- *Project managers* – technically capable individuals who are able to interface between engineers and electricians, comfortable both in the office and in the field.
- *Office workers* – individuals who are familiar enough with system design and installation to handle the volumes of paperwork involved in the PV installation process.

Additionally, the MTA has expressed a need for:

- *Training for PV System Maintainers.*

Both labor representatives and NYC-based PV installers that were interviewed report that the PV industry is not currently constrained by a lack of capable labor. In general, construction crews and electricians are capable of learning what they need to know to install PV "on the job" (as long as they are working under a construction/project manager who more thoroughly understands PV technology). It is prudent for these crews to receive training just before working on a PV job. This training, covering the basics of handling, mounting and connecting PV arrays, needs to be only 1-2 days.

This suggests several high-value PV training applications:

Course for Engineers. This course would focus primarily on the design aspects of PV, site assessment, and the variety of inverters, modules, mounting techniques and system designs. This could be integrated into the engineering curriculum at a technical college. It could also be offered as continuing education for licensed engineers. (40 hours)

General Course targeted for Contractors/Construction Managers. This would focus primarily on site assessment, mechanics of mounting and wiring a system and hands-on system installation. PV system design would be covered, but not to an engineer's level of detail. (24-40 hours)

Short Course for Electricians/Laborers. This would cover basic PV handling, safety and the unique aspects of connecting DC wiring. (5-15 hours)

New York City Transit (NYCT) engineers have suggested a need for PV system maintenance training. For example, Gabriel Reves, Principal Engineer at NYCT, indicated a need for about ten maintenance workers trained in PV for the nearly 500 kW of installed PV capacity in the NYCT system. A general course in PV installation can suffice for this, although one targeted specifically at maintenance and maintenance issues may be prudent.

With the growing number of BiPV opportunities, a course targeted at architects would appear warranted. It would cover the design parameters of a PV system (best orientation of modules, etc.) so that the systems are properly configured, but would focus on the variety of ways to integrate PV into a building design. BiPV systems also pose particular maintenance challenges.

Lastly, while training for installers is important, there are a number of additional high value training applications in business development, financing and marketing that should be considered in working to build the core of qualified people of all disciplines necessary to grow NYC's PV industry.

PV Employment Potential

It has been estimated that for every megawatt of solar PV, 35.5 jobs are created in manufacturing, installation, servicing, sales and marketing.[13] While it is unlikely that the majority of the manufacturing jobs will be located in NYC, there are several electronics companies discussing the manufacture of inverters and other power electronics for PV.

According to the Renewable Energy Policy Project, sustained 30% PV industry growth over the next 20 years would have the following effects on New York State's Manufacturing and Construction & Installation sectors:

Table 3-2. New York Economic Impacts of 30% PV Industry Growth over 20 years

Manufacturing		Construction & Installation	
Jobs	$Millions	Jobs	$Millions
1607	1289	428	364

Source: Sterzinger and Svrcek, 2005

Table 3-2 implies that more than one-fourth of PV jobs created in New York are in Construction & Installation. Taking the 35.5 jobs per megawatt figure cited above, we arrive at nearly 9 construction and installation jobs per megawatt of installed PV.

A 2001 report by Singh and Fehrs contains a derivation of this 35.5 jobs per megawatt figure.[14] Nearly 45% of the labor hours are in the types of work that a PV installation company often performs: systems integration, distributor/contractor, installer and servicing for ten years of operation. This implies a total of 16 PV installer-type jobs per megawatt of PV installed.

Conversations with NYC installers suggest that the industry can support employment on the order of one job per 100 kW installed annually, or 10 jobs per megawatt. It is important to note that these are full-time equivalent jobs, and many electricians, roofers, glazers and other laborers will not be spending all of their time installing PV systems. Furthermore, full-time NYC-based PV installers do not perform all of their work within the city (and some non-NYC-based installers do perform installations in the city).

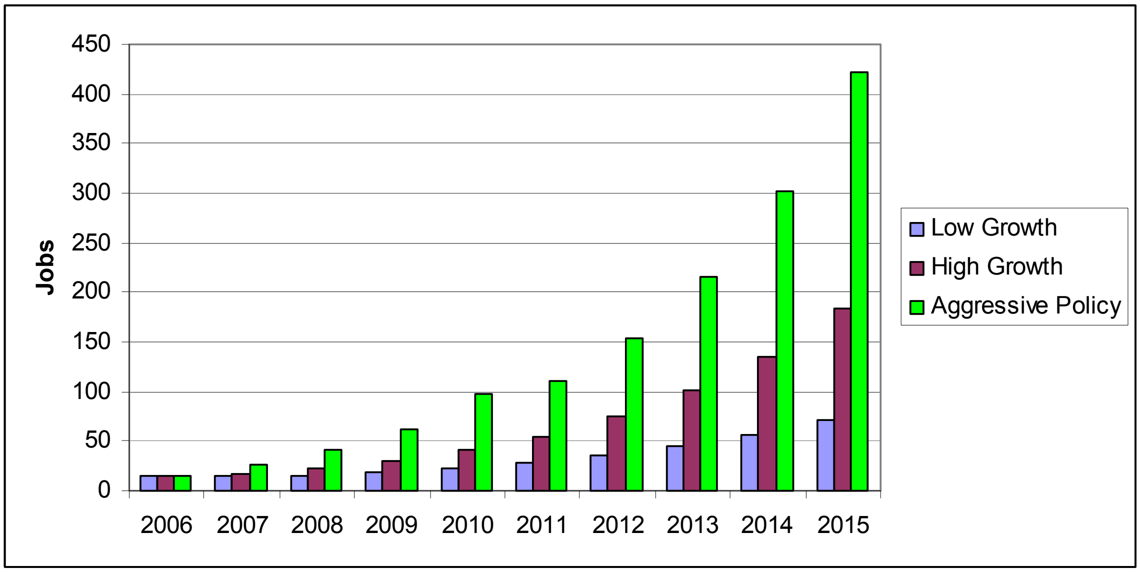
There are currently about 15-20 full-time equivalent jobs in PV installation in NYC. Assuming the low-end of employment (15) and annual installations of 519 kW (projected for 2006 - see Section 2), this shows that there is about 1 NYC job for every 35 kW installed within the city. This works out to nearly 30 jobs per megawatt – the reason being that these positions do not spend all of their time on NYC installations, but

---

[13] Solar Opportunity Assessment Report, Solar Catalyst Group, 2003. p. 11. www.solarcatalyst.com
[14] Singh, V., & Fehrs, J. (2001). The work that goes into renewable energy (Research Report No. 13). Washington, DC: Renewable Energy Policy Project, p. 13.

also on installations in neighboring locales. By 2010 the low growth scenario projects that there will be at least 800 kW installed in NYC annually, with a possibility of over 3 MW under the aggressive growth scenario. This would suggest at least twenty-three full time jobs (eight more than current), with a possibility of eighty or more additional jobs within the next five years, as shown in Figure 3-1.

Figure 3-1. Projected Number of Full Time Equivalent Jobs in PV in NYC



Source: Bright Power, Inc. based on CSEBCC Growth Scenarios

A training program cannot assume that all its students who successfully complete their course work will enter the field or remain within the geographic area where they received their training. Furthermore, it has been the experience of other training programs that the majority of electricians and other technical people who receive PV training do not spend the primary amount of their time installing PV systems. This implies that the demand for well-trained PV installers may easily be at least twice as great as the total number of jobs available, and highlights the need for more specialized trainings that target specific installation tasks.

SURVEY OF CURRENT TRAINING PROGRAMS IN NYC REGION

There is only one PV training program currently offered in NYC, at the Bronx Community College, which is part of the CUNY system. Three courses are currently offered in suburban locales relatively close to NYC. An overview of the current course offerings can be found in Table 3-3.

Table 3-3. PV Training Courses in the NYC Vicinity

Institution	Course Title	Course Details	Summary	Type of program	Text used
Farmingdale State University of New York Solar Energy Center	Residential Photovoltaic System Installation and Maintenance Workshop	4 days 20-25 Students per course 3-4 times per year	Overview of photovoltaic (PV) systems including general PV skills, NYC laws, codes, and site visits. Hands on set up.	Certificate Program: Offers both Entry Level Knowledge and Full Certification	"The New Solar Electric Home; The Photovoltaics how-to handbook" - Davidson "Photovoltaics: Design & Installation Manual" - SEI, 2004
Bronx Community College - Center for Sustainable Energy	Photovoltaic (sunlight to electricity) Installation Training Workshop	5 days or 20 hours Once per semester ~ 10 Students per course Total: 100+ students trained over 5 years	General PV skills. Financing. North American Board of Certified Energy Practitioners (NABCEP) Photovoltaic (PV) Entry Level Certificate of Knowledge Exam.	Certificate program for Entry Level Knowledge Exam.	"Photovoltaics: Design & Installation Manual" - SEI, 2004 "The Solar Electric House" - Strong, 2003
State University of New York at Delhi	Photovoltaics (PV): Design and Installation	4 days Once per semester	General PV skills. Pre-requisite for NABCEP. Accredited through Instate Renewable Energy Council.	Extension of the Electrical Construction and Maintenance Curriculum	
Hudson Valley Community College	Photovoltaic (PV) Entry Level Certificate of Knowledge	Length: 35 hours March - April 22 Tues, Thurs, Sat 9 students per course Once per semester	General PV skills. North American Board of Certified Energy Practitioners (NABCEP) Photovoltaic (PV) Entry Level Certificate of Knowledge Exam. Have PV laboratory on-site.	Certificate program. Within Electrical Construction and Maintenance Program Curriculum in Workforce Development Institute	

Other courses are offered in Western NY and other states, such as California, Colorado and Florida. Courses are sometimes offered in various New Jersey locations. There are also courses offered online by Solar On-Line (www.solenergy.org) and others. However, due to the advantages of hands-on training in this field, on-line courses should not be thought of as a substitute for classroom courses.

The Farmingdale Solar Energy Center is the fourth institute to receive ISP accreditation in the nation. Prof. Yelleshpur Dathatri had established a viable program with significant enrollments. Offered four times per year, the course size has been raised to 25 from 15 because of high demand. In each course there are 3-4 people from NYC. The only course currently offered is a workshop that takes place on four consecutive days. However, there are plans to start offering a new four credit course that is part of the Graduate Program in Advanced Technologies.

AVAILABILITY AND APPLICABILITY OF TRAINING MATERIALS

A number of well-regarded texts exist for PV Installation Training. Many were designed originally as a how-to guide for a self-taught individual. The training manual that generally seems to receive the best reviews (and the one that both the Farmingdale and Bronx programs recently switched to) is:

Photovoltaics : Design and Installation Manual by Solar Energy International

However, this text focuses primarily on smaller systems for residential and more rural applications. It does not, for example, address the design of the large high-voltage systems that can be installed on large urban roofs.

Other available texts include:

Adi, Pieper The Easy Guide to Solar Electric, Part I: Introduction and Part II: Installation Manual

Andreev V.M., V. A. Grilikhes, Vyacheslav M. Andreev, V. D. Rumyantsev Photovoltaic Conversion of Concentrated Sunlight 1997

Friedlander, Anna Faye Handbook of Photovoltaic Applications Released: 1986

Hamakawa, Yoshihiro Thin-Film Solar Cells : Next Generation Photovoltaics and Its Applications (Springer Series in Photonics)

IEA Photovoltaic Power Systems Programme Photovoltaics in Cold Climates Released: 1998

Komp, Richard J. Practical Photovoltaics: Electricity from Solar Cells Paperback Guide on materials, procedures, and applications. Appendix with assembly instructions.

Luque, Antonio, Steven Hegedus (Editors) Handbook of Photovoltaic Science and Engineering Hardcover - June 23, 2003 Describes the technology according to a review: bridges articles from Popular Science and 'other' scientific papers. Text book

Markvart, Tomas Solar Electricity, 2nd Edition "Solar Electricity was written for the UNESCO Energy Engineering Series distance learning package, and was intended to be self-contained and accessible to upper level energy engineering students everywhere."

Markvart, T., L. Castaner Practical Handbook of Photovoltaics: Fundamentals and Applications

Hardcover - October 30, 2003 "Everything you need to know about PV"

Prasad, Deo Designing With Solar Power: A Source Book For Building Integrated Photovoltaics (BiPV) Book with case studies. Author is Director of the SOLARCH Group, University of New South Wales Centre for a Sustainable Environment, Australia.

Randall, Julian Designing Indoor Solar Products: Photovoltaic Technologies For AES Released: 2005

Strong, Steven J. The Solar Electric House: Energy for the Environmentally-Responsive, Energy-Independent Home Used in Arizona State University PV courses

There are, however, no known texts that deal specifically with the challenges and pitfalls of installing PV in NYC. Such information might include:

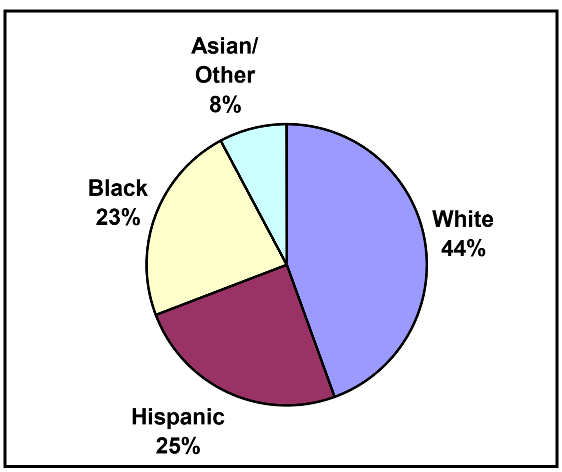
- Filing with the Department of Buildings and the BEC.
- Interconnecting with Con Ed.
- The NYC Building Code and Impacts on Solar Installations
- Handling NYSERDA Paperwork.

Thus, there are specific implications for curriculum development in NYC. There are only a few books that discuss BiPV design. While this type of training is most appropriate for architects, with increasing interest in green buildings, there is certainly a demand for it in NYC. Furthermore, different books suit different training needs, and materials should be carefully matched to the intended audience.

NEED FOR MULTILINGUAL EDUCATION

One quarter of the NYC construction workforce is Hispanic, as shown in Figure 3-2.

Figure 3-2. Demographics of NYC Construction Laborers



Source: *NYC Construction Labor Market Trends and Issues: A Labor Market Profile Prepared for the NYC Employment & Training Coalition*. The Fiscal Policy Institute, April 21, 2003.

With one-quarter of all construction workers Hispanic, this implies a need for some PV education conducted in Spanish. For laborers not involved in system design, a one-day course in the basics of handling and installing PV modules is desirable and prudent.

There is a Spanish language version of PV Design Pro software, and several agencies, including Solar Energy International, offer Spanish-language trainings in other countries. The availability of Spanish-language PV training manuals should be further explored – a preliminary survey has not proved fruitful.

RECOMMENDATIONS ON CLASS SIZE, NUMBER AND LOCATION

At Farmingdale, for example, the ideal class size is regarded as 10-15 students, although this is presently exceeded. This allows students to receive the personal attention required of a hands-on training.

For continuing education-type courses it may be valuable to offer at least one class at night. However, Prof. Dathatri cautions that it is difficult to demonstrate a PV system at night. So, it will be necessary to have at least one day of hands on training and demonstration. For marketing purposes, courses offered in the evenings should be considered in order to accommodate people who hold day-time jobs they are unable to leave. Bronx Community College, for example, offers a series of night classes and a full-day hands-on workshop that concludes the course on a Saturday.

With the largest construction booms happening in Brooklyn and Queens (as shown in Section 2), and a healthy training program already set-up in the Bronx, it seems that there is a great opportunity to supply training in the Southern boroughs.

Section 4
MARKETING PLAN TO ATTRACT STUDENTS

SELECTED RENEWABLE ENERGY EVENTS IN NYC

In addition to CUNY's marketing efforts, which include mass mailings, email broadcasts, and advertising, there are selected activities in the New York City area which offer addition promotional opportunity.

The events listed below suggest opportunities where PV training can be further marketed. They are co-sponsored, co-operative activities and only the primary producing entity is attributed here.

Table 4-1. Organizations That Hold Renewable Energy Related Events in NYC

Organization	Event	Frequency
American Institute of Architects (AIA)	Ecological Footprint Training: To Help People Make Sustainability Happen: this is a training program designed to address sustainable building.	Multipart training
Association of Energy Engineers New York Chapter	Meeting to discuss topics related to energy efficiency and renewable resource use.	Monthly
Bronx Community College Center for Sustainable Energy	Various Events	Specific Dates
Center for Economic and Environmental. (CEEP) Partnership, Inc	New York City Green Buildings Salon: conference (salon) on "greening of materials, interior designs, engineering considerations and impact on building occupants".	Monthly
	Energy & Environmental Funders: Meetings that touch on energy issues that relate to many sectors, including building.	Monthly
CUNY Graduate Center Continuing Education & Public Programs	Various classes and events.	Specific Dates
Environmental Business Assoc. of New York State (EBA/NYS)	Green Buildings Task Force Meeting: Discusses aspects that surround Green Building.	Quarterly

Green Drinks	Green Drinks: Monthly informal meeting of people who work in the environmental field to meet, network, and share information.	Monthly
Green Ground Zero	Built Green Television / Webcast Series: Airs a roundtable discussion by green industry leaders once a month. Talking Green: A group of series or lectures that target different green sectors including design and architecture. The schedules depend on the program.	Monthly Ongoing
GreenHomeNYC	Monthly Green Building Forum: 3rd Wednesday of every month @ 6:30 PM. Presentation and project discussion.	Monthly
Municipal Arts Society	Geography of New York: Four lectures and two walking tours. Covers topography and shoreline limitations on development.	Specific dates
Neighborhood Energy Network	Various Community Events	Specific Dates
NYC Apollo	Various Events	Specific Dates
NYSERDA	Various Events	Specific Dates
Sallan Foundation	Various Events	Specific Dates
Solar1	Green Renters Series. CitySol: Outdoor environmentally-friendly product fair and music event.	Weekday Evenings Summer
US Green Building Council New York Chapter	Breakfast technical seminars Evening Events	Monthly Specific Dates

SURVEY OF OTHER MARKETING CHANNELS

NYSERDA Energy $mart Communities Partners Dean Zias and Ben Abrams can help to spread the word to their email and publicity lists. Additionally, NYSERDA may be able to help with outreach to the current list of Home Performance contractors on GetEnergySmart.org. While these contractors are experts in energy efficient systems for buildings, they generally are not experts in renewables. They are likely among the most interested to learn about PV of those in the local contracting community.

Direct mailings to targeted contractors may also be a good way to achieve high numbers of students from technical professions. For example, Farmingdale has done successful targeted mailings to electricians. Bronx Community College has done similar mailings to selected trades groups in the Bronx and surrounding areas. Other contractors to consider sending direct mail to include:

- Roofers
- Home performance contractors

For a more design-oriented course, it may be useful to consider mailings to:

- Architects
- Engineering Firms
- Developers/Builders
- Contractors Associations.

The NYC website (NYC.gov) does offer announcements of building-related courses. There may be a way to include these courses in their announcements.

Section 5
CONCLUSIONS

Increasing interest in solar energy, combined with rising electricity prices and increasing constraints on the city's ageing electric system, are driving growth in the NYC solar market that mimics global PV industry growth. In order to ensure that the PV systems installed will work as intended, it is vital that the installers of these systems are adequately trained.

CUNY is in the early stages of implementing a comprehensive, ISP-accredited training program for PV installers in NYC. CUNY offers a wide variety of academic and vocational degrees, credit and non-credit courses and certificates, job training and worker re-training to meet New Yorker's changing workforce needs, and thus is in a good position to offer PV training to the city.

The NYC market is unique for solar in many respects, in the types of buildings, the configuration of the electrical grid, the building code and the types of systems that are installed. The CUNY program will specifically address these needs.

There are a number of organizations producing a variety of programs and events in NYC around sustainability, renewable energy and energy efficiency. These organizations and events provide very attractive and inexpensive marketing channels for the CUNY PV training program.

APPENDIX A

Table A-1. Number of New Privately-Owned Residential Building Permits Issued in New York City by Borough and Type of Building: 1995-2004

		Total	One Family	Two Family	Three or Four Family	Five or More Family
1995	**New York City**	**5,135**	**1,017**	**1,714**	**589**	**1,815**
	Bronx	853	95	542	196	20
	Brooklyn	943	44	326	293	280
	Manhattan	1,129	2	0	0	1,127
	Queens	738	150	292	94	202
	Staten Island	1,472	726	554	6	186
1996	**New York City**	**8,632**	**1,133**	**2,332**	**702**	**4,485**
	Bronx	885	5	350	201	329
	Brooklyn	942	94	328	369	151
	Manhattan	3,369	2	0	3	3,364
	Queens	1,301	84	468	108	641
	Staten Island	2,135	948	1,186	21	0
1997	**New York City**	**8,987**	**1,292**	**1,656**	**761**	**5,278**
	Bronx	1,161	24	234	241	662
	Brooklyn	1,063	144	168	249	502
	Manhattan	3,762	0	0	7	3,755
	Queens	1,144	61	540	264	279
	Staten Island	1,857	1,063	714	0	80
1998	**New York City**	**10,387**	**991**	**2,420**	**1,072**	**5,904**
	Bronx	1,309	28	392	308	581
	Brooklyn	1,787	112	370	403	902
	Manhattan	3,823	1	4	0	3,818
	Queens	1,446	89	548	291	518
	Staten Island	2,022	761	1,106	70	85
1999	**New York City**	**12,421**	**1,466**	**3,048**	**1,490**	**6,417**
	Bronx	1,153	25	350	567	211
	Brooklyn	2,894	248	580	514	1,552
	Manhattan	3,791	0	4	8	3,779
	Queens	2,169	91	850	401	827
	Staten Island	2,414	1,102	1,264	0	48
2000	**New York City**	**15,050**	**1,617**	**3,502**	**1,689**	**8,242**
	Bronx	1,646	36	632	317	661
	Brooklyn	2,904	133	848	609	1,314
	Manhattan	5,110	0	30	143	4,937
	Queens	2,723	87	936	620	1,080
	Staten Island	2,667	1,361	1,056	0	250

2001	**New York City**	**16,856**	**1,701**	**3,742**	**2,262**	**9,151**
	Bronx	2,216	20	648	520	1,028
	Brooklyn	2,973	229	916	771	1,057
	Manhattan	6,109	4	10	241	5,854
	Queens	3,264	142	1,184	726	1,212
	Staten Island	2,294	1,306	984	4	0
2002	**New York City**	**18,500**	**1,337**	**3,862**	**2,713**	**10,588**
	Bronx	2,626	18	776	719	1,113
	Brooklyn	5,247	189	1,004	1,011	3,043
	Manhattan	5,407	3	6	54	5,344
	Queens	3,464	214	1,302	884	1,064
	Staten Island	1,756	913	774	45	24
2003	**New York City**	**21,218**	**1,557**	**4,700**	**3,190**	**11,771**
	Bronx	2,935	55	600	565	1,715
	Brooklyn	6,054	118	1,334	1,392	3,210
	Manhattan	5,232	1	14	7	5,210
	Queens	4,399	161	1,446	1,194	1,598
	Staten Island	2,598	1,222	1,306	32	38
2004	**New York City**	**25,208**	**1,016**	**5,140**	**4,716**	**14,336**
	Bronx	4,924	33	654	1,145	3,092
	Brooklyn	6,825	113	880	1,882	3,950
	Manhattan	4,555	1	6	51	4,497
	Queens	6,853	265	2,206	1,627	2,755
	Staten Island	2,051	604	1,394	11	42

Appendix B

NABCEP Objectives and Task Analysis for the Solar Photovoltaic System Installer

1. Working Safely with Photovoltaic Systems		
Task/Skill:	***Skill Type:***	***Priority/ Importance:***
As part of safety considerations associated with installing and maintaining PV systems, any PV installer must be able to:		
1.1 Maintain safe work habits and clean, orderly work area	Cognitive, Psychomotor	Critical
1.2 Demonstrate safe and proper use of required tools and equipment	Cognitive, Psychomotor	Critical
1.3 Demonstrate safe and accepted practices for personnel protection	Cognitive, Psychomotor	Critical
1.4 Demonstrate awareness of safety hazards and how to avoid them	Cognitive, Psychomotor	Critical
1.5 Demonstrate proficiency in basic first aid and CPR	Cognitive, Psychomotor	Important
The installer must be able to identify electrical and non-electrical hazards associated with PV installations, and implement preventative and remedial measures to ensure personnel safety:		
1.6 Identify and implement appropriate codes and standards concerning installation, operation and maintenance of PV systems and equipment	Cognitive, Psychomotor	Critical
1.7 Identify and implement appropriate codes and standards concerning worker and public safety	Cognitive, Psychomotor	Critical
1.8 Identify personal safety hazards associated with PV installations	Cognitive, Psychomotor	Critical
1.9 Identify environmental hazards associated with PV installations	Cognitive, Psychomotor	Critical

2. Conducting a Site Assessment		
Task/Skill:	***Skill Type:***	***Priority/ Importance:***
In conducting site surveys for PV systems, the installer shall be able to:		
2.1 Identify typical tools and equipment required for conducting site surveys for PV installations, and demonstrate proficiency in their use	Cognitive	Very Important
2.2 Establish suitable location with proper orientation, sufficient area, adequate solar access and structural integrity for installing PV array	Cognitive	Very Important
2.3 Establish suitable locations for installing inverters, control, batteries and other balance-of-system components	Cognitive	Very Important
2.4 Diagram possible layouts and locations for array and equipment, including existing building or site features	Cognitive	Very Important
2.5 Identify and assess any site-specific safety hazards or other issues associated with installation of system	Cognitive	Very Important
2.6 Obtain and interpret solar radiation and temperature data for site for purposes of establishing performance expectations and use in electrical system calculations	Cognitive	Very Important
2.7 Quantify the customer electrical load and energy use through review of utility bills, meter readings, measurements and/or customer	Cognitive	Important

interview,		
2.8 Estimate and/or measure the peak load demand and average daily energy use for all loads directly connected to inverter-battery systems for purposes of sizing equipment, as applicable	Cognitive	Very Important
2.9 Determine requirements for installing additional subpanels and interfacing PV system with utility service, and/or other generation sources as applicable	Cognitive	Very Important
2.10 Identify opportunities for the use of energy efficient equipment/appliances, conservation and energy management practices, as applicable	Cognitive	Important

3. Selecting a System Design

Task/Skill:	***Skill Type:***	***Priority/ Importance:***
Based on results from a site survey, customer requirements and expectations, the installer shall be able to:		
3.1 Identify appropriate system designs/configurations based on customer needs, expectations and site conditions	Cognitive	Very Important
3.2 Estimate sizing requirements for major components based on customer load, desired energy or peak power production, autonomy requirement, size and costs as applicable	Cognitive	Very Important
3.3 Identify and select major components and balance of system equipment required for installation	Cognitive	Very Important
3.4 Estimate time, materials and equipment required for installation, determine installation sequence to optimize use of time and materials	Cognitive	Important

4. Adapting the Mechanical Design

Task/Skill:	***Skill Type:***	***Priority/ Importance:***
In adapting a PV system mechanical design, the practitioner shall be able to:		
4.1 Identify a mechanical design, equipment to be used and installation plan that is consistent with the environmental, architectural, structural, code requirements and other conditions of the site	Cognitive	Critical
4.2 Identify appropriate module/array layout, orientation and mounting method for ease of installation, electrical configuration and maintenance at the site	Cognitive	Critical

5. Adapting the Electrical Design

Task/Skill:	***Skill Type:***	***Priority/ Importance:***
In adapting a PV system electrical design, the practitioner shall be able to:		
5.1 Determine the design currents for any part of a PV system electrical circuit	Cognitive	Critical
5.2 Select appropriate conductor types and ratings for each electrical circuit in the system based on application	Cognitive	Critical
5.3 Determine the derated ampacity of system conductors, and select appropriate sizes based on design currents	Cognitive	Critical
5.4 Determine appropriate size, ratings and locations for all system	Cognitive	Critical

overcurrent and disconnect devices		
5.5 Determine appropriate size, ratings and locations for grounding, surge suppression and associated equipment	Cognitive	Critical
5.6 Determine voltage drop for any electrical circuit based on size and length of conductors	Cognitive	Critical
5.7 Verify that the array operating voltage range is within acceptable operating limits for power conditioning equipment, including inverters and controllers	Cognitive	Critical
5.8 Select an appropriate utility interconnection point, and determine the size, ratings and locations for overcurrent and disconnect devices.	Cognitive	Critical

6. Installing Subsystems and Components at the Site

Task/Skill:	***Skill Type:***	***Priority/ Importance:***
As part of the PV system installation process, the practitioner shall be able to:		
6.1 Utilize drawings, schematics, instructions and recommended procedures in installing equipment	Cognitive	Critical
6.2 Implement all applicable personnel safety and environmental protection measures	Cognitive	Critical
6.3 Visually inspect and quick test PV modules	Psychomotor	Important
6.4 Assemble modules, panels and support structures as specified by module manufacturer or design	Psychomotor	Very Important
6.5 Install module array interconnect wiring, implement measures to disable array during installation	Psychomotor	Very Important
6.6 Complete final assembly, structural attachment and weather sealing of array to building or other support mechanism	Psychomotor	Critical
6.7 Install and provide required labels on inverters, controls, disconnects and overcurrent devices, surge suppression and grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware	Psychomotor	Critical
6.8 Label, install and terminate electrical wiring; verify proper connections, voltages and phase/polarity relationships	Psychomotor	Critical
6.9 Verify continuity and measure impedance of grounding system	Cognitive, Psychomotor	Very Important
6.10 Program, adjust and/or configure inverters and controls for desired set points and operating modes	Cognitive	Critical

7. Performing a System Checkout and Inspection

Task/Skill:	***Skill Type:***	***Priority/ Importance:***
After completing the installation of a PV system, as part of system commissioning, inspections and handoff to the owner/operator, the practitioner shall be able to:		
7.1 Visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship	Cognitive, Psychomotor	Very Important
7.2 Check system mechanical installation for structural integrity and weather sealing	Cognitive, Psychomotor	Critical
7.3 Check electrical installation for proper wiring practice, polarity, grounding and integrity of terminations	Cognitive, Psychomotor	Critical
7.4 Activate system and verify overall system functionality and performance, compare with expectations	Cognitive, Psychomotor	Critical

7.5 Demonstrate procedures for connecting and disconnecting the system and equipment from all sources	Cognitive, Psychomotor	Critical
7.6 Identify and verify all required markings and labels for the system and equipment	Cognitive	Critical
7.7 Identify and explain all safety issues associated with operation and maintenance of system	Cognitive	Very Important
7.8 Identify what documentation is required to be provided to the PV system owner/operator by the installer	Cognitive	Very Important

8. Maintaining and Troubleshooting a System

Task/Skill:	***Skill Type:***	***Priority/ Importance:***
In maintaining and troubleshooting PV systems, the practitioner shall be able to:		
8.1 Identify tools and equipment required for maintaining and troubleshooting PV systems; demonstrate proficiency in their use	Cognitive, Psychomotor	Very Important
8.2 Identify maintenance needs and implement service procedures for modules, arrays, batteries, power conditioning equipment, safety systems, structural and weather sealing systems, and balance of systems equipment	Cognitive, Psychomotor	Very Important
8.3 Measure system performance and operating parameters, compare with specifications and expectations, and assess operating condition of system and equipment	Cognitive, Psychomotor	Very Important
8.4 Perform diagnostic procedures and interpret results	Cognitive, Psychomotor	Very Important
8.5 Identify performance and safety issues, and implement corrective measures	Cognitive, Psychomotor	Critical
8.6 Verify and demonstrate complete functionality and performance of system, including start-up, shut-down, normal operation and emergency/bypass operation	Cognitive, Psychomotor	Critical
8.7 Compile and maintain records of system operation, performance and maintenance	Cognitive	Very Important

Appendix C

REFERENCES

Building America (2004). *Hunters Point Shipyard in San Francisco Will Meet Building America Performance Levels*. http://www.eere.energy.gov/buildings/building_america/rh_0504_hunters_point.html.

The Center for Sustainable Energy at Bronx Community College (CSEBCC, 2006). *New York City's Solar Future – Part 1: The Market for Photovoltaic Systems in New York City*. New York, NY: The City University of New York's Million Solar Roofs Initiative.

Clean Power Estimator. http://www.clean-power.com/PowerNaturally/

The Fiscal Policy Institute (2003). *NYC Construction Labor Market Trends and Issues: A Labor Market Profile Prepared for the NYC Employment & Training Coalition.* http://www.fiscalpolicy.org/construction.pdf

Hamer, Glen (2005). *Aggregated Utility Markets For PV*. Slides from EMPower Meeting, Paris, France. First Solar, June 28, 2005. http://www.uneptie.org/energy/act/re/PV-Hydro/docs/meeting_june2005/Aggregated%20Utility%20Markets%20For%20PV.pdf

Long Island Power Authority (LIPA, 2005). *Request for Proposals for A Performance Evaluation Study of Photovoltaic Systems Installed through The Long Island Power Authority's Clean Energy Initiative Solar Pioneer Program*. LIPA/KeySpan, November 7, 2005.

Martinot, Eric (2005). Global Revolution: A Status Report on Renewable Energy Worldwide. Renewable Energy World, November-December 2005. pp28-43. www.renewable-energy-world.com

Million Solar Roofs Initiative (MSRI, 2005). "Become One in a Million: Million Solar Roofs Partnership Updates." U.S. Department of Energy, Energy Efficiency and Renewable Energy. Million Solar Roofs and Interstate Renewable Energy Council Annual Meeting, October 2005.

New Jersey's Clean Energy Program (2005). *New Jersey Solar Market Update*. http://njcep.com/media/NJ_Solar_Market_Update_Augu.pdf

New York Building Congress. Construction Outlook 2005-2007. http://www.buildingcongress.com/code/outlook/2007-charts.htm

New York City Department of Buildings, Building Information System mainframe. Supplied by Deborah F. Taylor, AIA, LEED AP, Executive Director, Special Projects and MEA New York City Department of Buildings, December 2005.

New York City Housing and Neighborhood Information System (NYCHANIS). http://www.nychanis.com

New York State Public Service Commission (2006). "Retail Renewable Portfolio Standard." Case 03-E-0188. http://www.dps.state.ny.us/03e0188.htm

North American Board of Certified Energy Practitioners (NABCEP, 2002). Objectives and Task Analysis for the Solar Photovoltaic System Installer. http://www.nabcep.org/pdf/resources/SolarPVTaskAnalysis.pdf

O'Brien, Christopher (2005). *Creating a Stable Investment Climate for Solar Creating a Stable Investment Climate for Solar (slides)*. SEIA & Sharp Solar. http://www.eesi.org/briefings/2005/Climate%20&%20Energy/10.6.05Solar/OBrien10.4.05.pdf

Perez, Richard (2001). Meeting Peak Demand With Photovoltaics. ASRC. http://www.asrc.cestm.albany.edu/perez/newpubs/LoadMatch.html

Plunkett, John et al (2003). *Energy efficiency and renewable energy resource development potential in New York State - Volume 4: Renewable supply technical report.* Albany, NY: New York State Energy Research and Development Authority.

Rogol, Michael et al (2004). *Sun Screen: Investment Opportunities in Solar Power*. CLSA.

Sherwood, Larry (2005). *U.S. Solar Market Trends*. Proceedings of the 2005 Solar World Congress, American Solar Energy Society.

Singh, Virinder and Jeffrey Fehrs. (2001). *The work that goes into renewable energy* (Research Report No. 13). Washington, DC: Renewable Energy Policy Project. http://www.crest.org/articles/static/1/binaries/LABOR_FINAL_REV.pdf

SolarBuzz. http://www.solarbuzz.com

Solar Catalyst Group (2003). *Solar Opportunity Assessment Report*. http://www.solarcatalyst.com

Solar Energy Industries Association and the Solar Electric Power Association (SEIA & SEPA, 2004). *Our Solar Power Future*. http://www.seia.org/roadmap.pdf

Sterzinger, George and Matt Svrcek (2005). *Solar PV Development: Location of Economic Activity*. Washington, DC: Renewable Energy Policy Project. http://www.crest.org/articles/static/1/binaries/SolarLocator.pdf