# New York State Photovoltaic Market Trends

Final Report 10-16
June 2010

New York State
Energy Research and
Development Authority

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# NEW YORK STATE PHOTOVOLTAIC MARKET TRENDS

Final Report

Prepared for the

**NEW YORK STATE**
**ENERGY RESEARCH AND**
**DEVELOPMENT AUTHORITY**

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# EXECUTIVE SUMMARY

Photovoltaic (PV) technology uses light from the Sun, in the form of photons, to generate electrical energy. Having no moving components, this technology is unique from any other form of electrical energy generation in that it converts solar energy directly into usable electrical energy. Currently, the world's electrical energy usage is estimated at approximately 17,000 terra-watt-hours (or 17 trillion kWh). This energy consumption is continuing to grow due to an increasing population along with rising energy consumption per capita. While this is a substantial amount of power, it is only approximately one-ten-thousandth ($^{1}/_{10,000}{}^{th}$) of the solar radiation captured by the Earth. Still less than 1% of the world's electrical energy demand is currently generated by PV technology. The United States is the largest energy user in the world, consuming 24% of the world's energy for only 4.6% of the world's population. While the current PV energy generation makes up just over 0.1% of the total U.S. electrical energy generation market, government funded financial incentives are helping to make this technology economically viable, thereby increasing its overall market share.

In 2008, New York residents consumed over 280 terra-watt hours of electrical energy, ranking it 11$^{th}$ in the nation for energy usage. Currently, New York does not have any utility-scale PV installations; however, the residential and commercial PV installations make up approximately 0.2% of the overall electrical energy consumption. To support PV installations in New York, many programs and incentives are in place throughout the state. These include a renewable portfolio standard, installation incentives, net metering, and tax breaks aimed at increasing the economic viability, and thereby the installation rate, of PV technology. To analyze the statewide PV market trends for New York, 2003-2008 PV installation data from the New York State Energy Research and Development Authority (NYSERDA) and the Long Island Power Authority (LIPA) was evaluated. PV installations in New York are increasing more rapidly than the rest of the U.S., climbing from just over 1 MW of installed capacity in 2003 to 23 MW in 2008. Additional observed trends indicate that Long Island residents were quicker to embrace photovoltaic technology and that commercial arrays are getting larger, but still represent only a small portion of the entire PV market in the state.

## Section 1
## INTRODUCTION

### PHOTOVOLTAIC TECHNOLOGY OVERVIEW

Photovoltaic technology, also referred to as solar electric technology, photoelectric, or PV, is an energy technology that uses semiconductor materials fabricated into cells that absorb energy from the Sun's radiation. Photons emitted from the Sun can be used to excite electrons and create direct-current (DC) electricity. Having no moving components, this technology is unique from any other form of electrical energy generation. Photovoltaic technology exploits the atomic behavior of semiconductor materials, such as silicon doped with boron or phosphorus, which have diverse electrical characteristics. Arranged in adjacent layers, electrons in the semiconductor materials are vaulted into higher energy levels when struck by the Sun's radiation. The energy difference between the opposing material surfaces generates power through the cell's conductive contacts.[1] Silicon, usually crystalline silicon, constitutes more than 90% of PV modules that are sold worldwide. A cutaway view of a PV cell is shown in Figure 1.[2] The most appealing benefit of PV technology is that it only requires sunlight, which is free, and releases no harmful emissions when generating electricity.

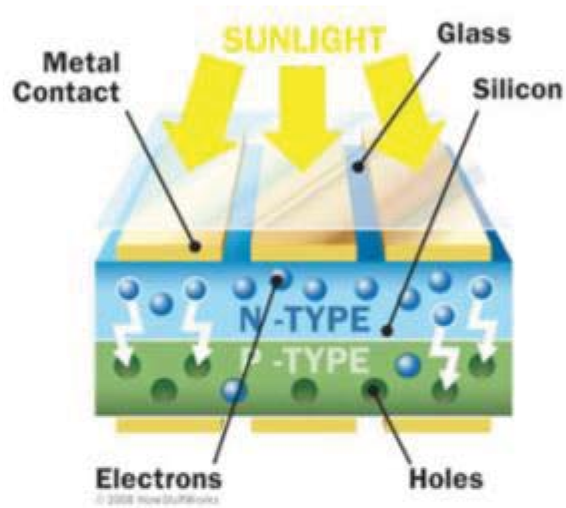


**Figure 1: PV Cell Components**

Since PV cells generate very little power individually (1-2 watts), several are electrically connected in modules for electrical generation. These are tightly sealed to protect the internal components from all types of weather conditions. Modules are then integrated into PV arrays, which are arranged in series (to increase voltage) or parallel (to increase amperage), depending upon the application. Systems must also have an inverter to convert the electricity from DC to alternating-current (AC), which is usable in household appliances. The addition of energy storage may be particularly beneficial for non-grid tied systems or in the event of a grid-power outage.[3]

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[1] U.S. Energy Information Administration (2010). *Solar Explained*. Retrieved April 7, 2010, from http://tonto.eia.doe.gov/energyexplained/index.cfm?page=solar_photovoltaics

[2] HowStuffWorks. *Power of Light: Photovoltaic Cells*. Retrieved April 7, 2010, from http://express.howstuffworks.com/exp-solar-power1.htm

[3] U.S. Department of Energy, Energy Efficiency and Renewable Energy. *Get Your Power From the Sun*. Retrieved April 7, 2010, from www.nrel.gov/docs/fy04osti/35297.pdf

The method of PV power utilization can vary depending on the particular needs of the application. Configurations are designed to economically manage power from the array for the specific end-use needs. Systems accomplish this by selling unused power back to the utilities or storing it in batteries for later use. The most common configurations are;[4]

> **Off-grid domestic systems** are generally used to supply low power loads to residences that are not located near existing power lines, although some people choose this method to permit them to live independent of the power grid. Electricity usage must be minimized to avoid the need for a large PV array, which typically means only the essentials, such as lighting, water pumps, and refrigeration, are electric. Significant energy storage is required to provide power at night and in the event of cloudy weather for a number of days.
>
> **Off-grid non-domestic systems** are generally used to supply low power loads for telecommunication applications such as roadway signs or emergency phones where grid-tied electricity is not readily available. In third-world countries, these systems are used for vaccine refrigeration and other highly critical applications. Smaller amounts of higher power density energy storage are typically used since these are mobile applications.
>
> **Grid-connected distributed systems** supply a grid-connected PV customer an offset to their utility supply. The energy generated by the system is first used to fulfill the customer's electricity demand. Any excess electricity may be sold back to the grid if net metering is allowed.
>
> **Grid-connected centralized systems** are generally arranged in a large ground-mounted configuration and designed for the sole intention of generating bulk power for the utility grid to offset fossil fuel electricity generation.

A PV system must be sited in an area that has year-round, unobstructed sunlight for the majority of the day to be functionally efficient. Shading on just one cell of a module can reduce its entire electrical output, so roof-mounted systems are common. The directional orientation of the panels also plays a significant role in their efficiency. Fixed arrays are angled towards the equator to be perpendicular to the Sun's rays as often as possible throughout the year. Tracking arrays can increase electrical output by following the Sun during the day and throughout the year, but the cost and energy consumption of such a system can often negate the increased output. An emerging trend in photovoltaic technology is building integrated configurations. When the PV modules can act as the impermeable roof surface that protects

[4] International Energy Agency (2007). *Trends in Photovoltaic Applications*. Retrieved April 7, 2010, from www.iea-pvps.org/products/download/rep1_16.pdf

against the weather, costs are reduced and issues with the PV system impacting the roofing material are eliminated. Aesthetic concerns are also reduced. Some thin-film solar cells can be adhered to the channels in a metal seam roof. Most recently, companies have commercialized photovoltaic roofing shingles. It is claimed that these solar shingles can be treated as any traditional asphalt roofing shingle, including being walked over or even dropped from a roof top. The cost of installation can be drastically reduced if no specialized technique is involved.[5] The fabrication of PV technology has become considerably more cost-efficient since its introduction as a power generation method for space applications in the late fifties. Nevertheless, the design still requires some innovation before it is cost competitive with fossil fuel power generation for most commercial and residential applications.[6]

Because of the simplicity by which PV cells operate, their performance degrades only slightly overtime and manufacturers can offer a guarantee that the system will still run at 80% of the rated power output after 20 years. Figure 2 shows how PV is the only currently employed electricity generation technology that transforms energy from the Sun directly into usable electrical power without mechanical or thermal work.

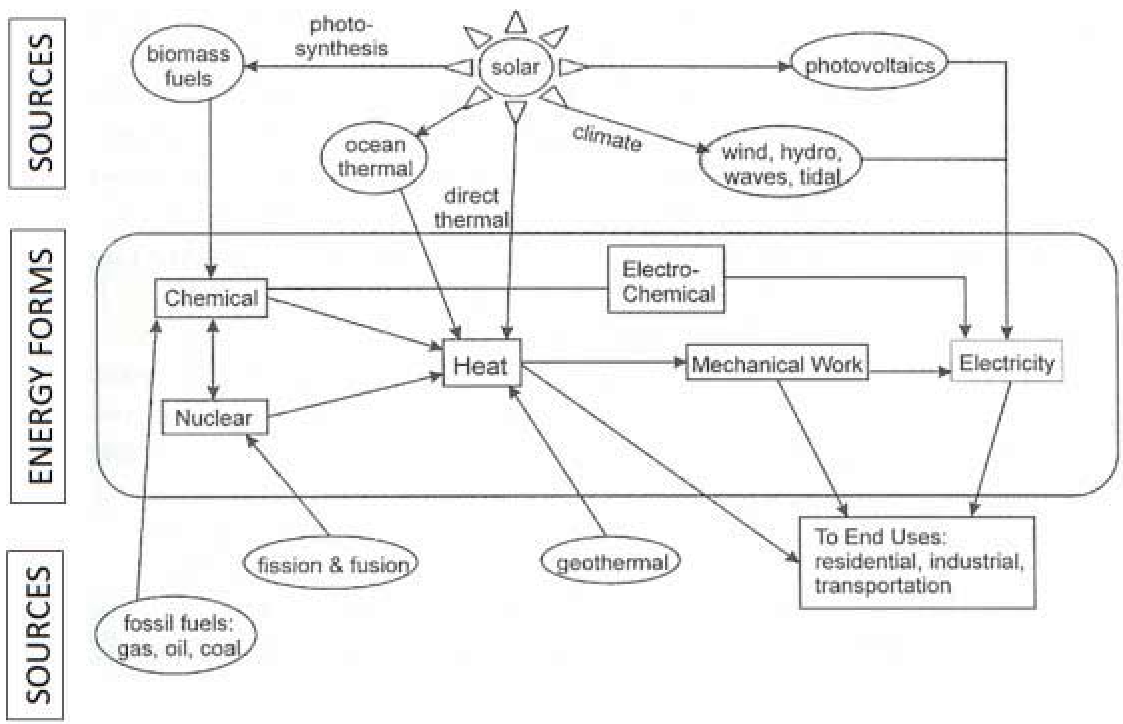


**Figure 2: Energy Sources and Conversion Processes**

[5] New York Times (2010). *Dow Unveils Solar Shingles*. Retrieved April 7, 2010, from http://greeninc.blogs.nytimes.com/2009/10/07/dow-unveils-solar-shingles/

[6] U.S. Energy Information Administration (2010). *Solar Explained*. Retrieved April 7, 2010, from http://tonto.eia.doe.gov/energyexplained/index.cfm?page=solar_photovoltaics

The cost of installing PV technology has decreased over the past 10 years. These trends are driven by the expansion of this technology that has been supported by state and federal incentives. Because of the global demand and the materials used, the cost per kilowatt of PV modules has not varied substantially in recent years.  Still, modules continue to increase their output per area, which decreases the number needed for an array, lowering installation costs and mounting hardware expenses. With more installations, the permitting and fee process is typically less intensive, while the higher volume of installations reduces overhead, labor, and profit expenses. These non-module costs, which also include the inverters and electrical infrastructure, have a significant effect on the overall installation cost and give insight into the market's direction.

## GLOBAL ENERGY USAGE, ELECTRICITY GENERATION, AND SOLAR RESOURCE

The current estimation for the cumulative global energy usage is 17,000 terra-watt-hours (TWh) or 17,000,000,000 MWh of electricity.[7] Usage is not evenly distributed thought the world and is highly concentrated in certain parts of the globe. Developed countries with active and healthy economies use substantially more energy than un-industrialized, developing nations. Because the economy of a nation is so reliant on the abundance of energy, energy-use will undoubted rise as developing countries strive for better quality of life. In addition, energy consumption per capita has significantly increased in previous years as shown in Figure 3.[8] These two trends will amplify the demand for electrical consumption as the world increases both its population and its energy use per person.

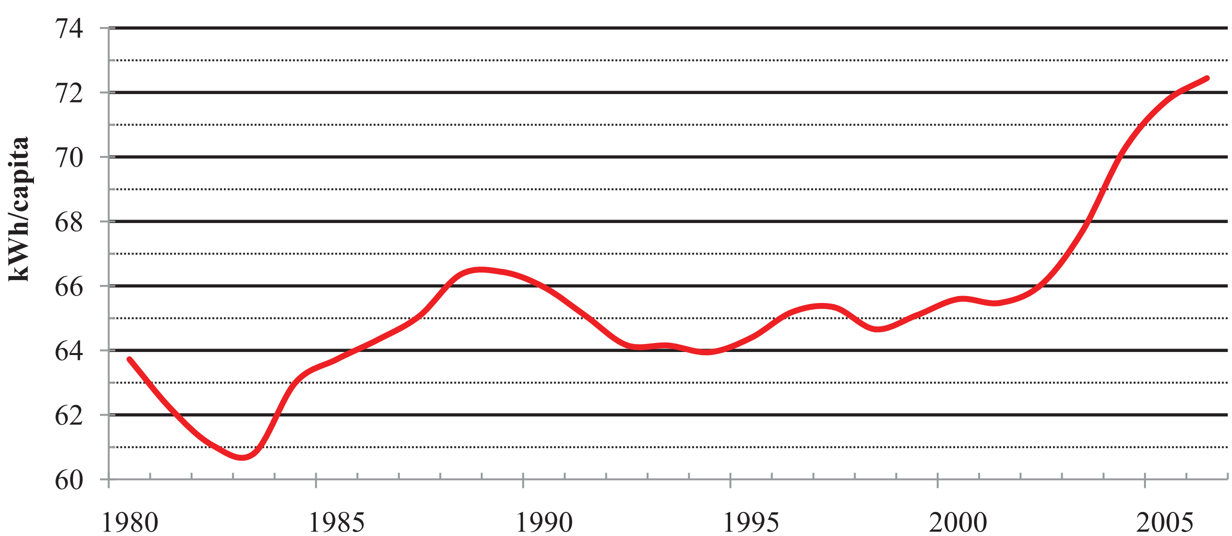


**Figure 3: Global Electricity per Capita Consumption**

[7] Energy Information Administration (2008). *International Energy Statistics*. Retrieved May 14, 2010, from http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=2

[8] Tester, J., Drake, E., Driscoll, M., Golay, M., Peters, W. (2004). *Sustainable Energy: Choosing Among the Options*. Cambridge, Massachusetts: The MIT Press

Only a small portion of this growing electricity need is currently being generated with renewable technology and an even smaller percentage is sourced from PV technology. As is shown in Figure 4, direct solar energy makes up a very small fraction of the world's overall energy needs at less than 0.07%.[9]

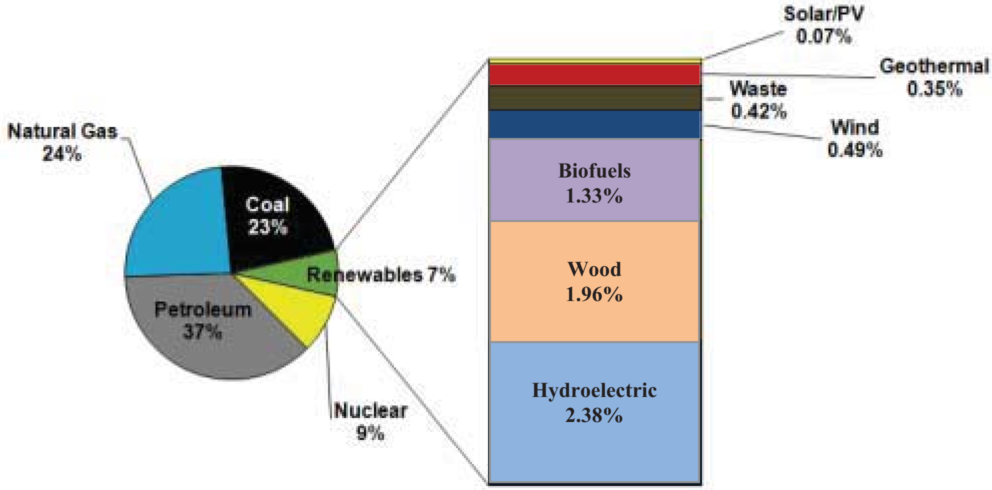


**Figure 4: Renewable Energy as Share of the World's Total Primary Energy Consumption**

The amount of solar energy intercepted by the Earth can meet the global demand and is available in all areas of the world. Figure 5 indicates that there is sufficient solar resource to fulfill the cumulative global power demand.[10] The current estimation for the cumulative global energy consumption of roughly 17,000 TWh of energy is approximately one-ten-thousandth ($^{1}/_{10,000}{}^{th}$) of the solar radiation on the Earth.[11]

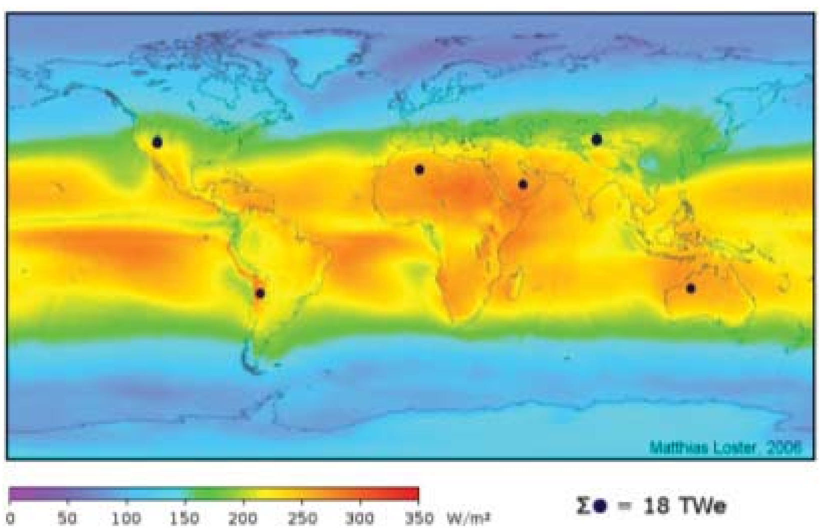


**Figure 5: Global Solar Energy Potential**

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[9] Energy Information Administration (2008). *Renewable Energy Consumption by Major Source*. Retrieved May 12, 2010, from www.eia.doe.gov/emeu/aer/pdf/pages/sec10_2.pdf

[10] Matthias Loster. *Total Primary Energy Supply: Required Land Area*. Retrieved May 14, 2010, from www.ez2c.de/ml/solar_land_area

[11] Global Energy Network Institute (2010). *GLOBAL Renewable Energy Resources*. Retrieved May 14, 2010, from www.geni.org/globalenergy/library/renewable-energy-resources/solar.shtml

**GLOBAL PHOTOVOLTAIC PROGRAMS AND INCENTIVES**

The demand for renewable energy continues to escalate as global authorities recognize the significance of offsetting grid-power demand and decreasing dependence on imported non-renewable fuels for the benefit of the environment, as well as national security. More regions of the globe have begun instituting financial incentives and training programs that promote the use of and advancement of renewable energy technologies such as PV. Historically, leaders in this effort have been Japan, China, Germany, Taiwan, and the United States.[12]

In recent years, Germany has made its mark on the global PV movement, generating over half of the world's solar power. As shown in Figure 5, the solar resource in Germany is not as good as other parts of the world, but solar electric technology is still viable. This is mostly due to extremely high feed-in tariffs, which has driven PV to account for 0.83% of Germany's electricity generation. Germany's leadership role in photovoltaic technology is also due to incentives aimed at stimulating research and development in this field. Currently, 13% of solar cells manufactured in Germany are thin-cell panels, using 1/100$^{th}$ the amount of silicon as conventional photovoltaic technology.[13]

Taiwan also initiated feed-in tariffs to boost PV installations. Nevertheless, the tariffs announced in 2009 were much lower than expected at roughly $0.080-$0.095 per kWh, so this might not encourage photovoltaic technology expansion as much as was initially anticipated.[14] Still, PV production in Taiwan is increasing rapidly and is expected to exceed 1 GW per year after 2010, which may help drive costs lower.[15]

China launched an incentive program in 2009 that covers half the total cost of installing utility-scale PV generation if the maximum output is at least 500MW. This incentive will cover up to 70% of the costs if the locations are in areas that were not previously connected to the utility. The Chinese government also launched an incentive plan to assist with smaller installations as well. These funding opportunities, which are part of China's "Golden Sun" initiative, will likely increase the number of PV installations in the next two or three years.[16]

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[12] Earth Policy Institute (2007). *Eco-Economy Indicators*. Retrieved March 9, 2010, from www.earth-policy.org/index.php?/indicators/C47/

[13] Renewable Energy World (2008). *What's Next for the German Photovoltaic Industry?* Retrieved March 9, 2010, from www.renewableenergyworld.com/rea/news/article/2008/09/whats-next-for-the-german-photovoltaic-industry-53518

[14] DIGITIMES (2009). *Taiwan government sets tentative PV feed-in tariffs*. Retrieved March 9, 2010, from www.digitimes.com/news/a20090921PD209.html

[15] PRLog (2008). *Thin-film technology - new solar PV trend in Taiwan*. Retrieved March 9, 2010, from www.prlog.org/10049058-thin-film-technology-new-solar-pv-trend-in-taiwan.html

[16] Yvonne Chan (2009). *China unveils subsidies of 50 percent on large solar power projects.* Retrieved March 9, 2010, from www.businessgreen.com/business-green/news/2246509/china-unveils-subsidies-per%20

## GLOBAL PHOTOVOLTAIC MARKET TRENDS

Concerns regarding global warming and the limited availability of non-renewable resources have fueled interest in photovoltaic technology and a return to solar research and development. Moreover, the cost of manufacturing PV has started to decline with the perpetual development of new optimization techniques and the volume of production. This trend, along with the emergence of long-term renewable electricity purchasing policies and contracts, has fueled investment in this industry. Over the course of the past twenty years, it has become one of the most rapidly progressive markets in the world.[17]

As shown in Figure 6, if solar energy can maintain the same growth rate it has for the past decade, solar power can supply all projected electricity demands in 26 years.[18] In 2006, Germany alone had 1,000 MW of PV installations, accounting for more than half of the added capacity of photovoltaic technology that year for the entire world market. Japan is still a leader in the global PV market at almost 20% of all solar electric generation. Both Spain and the United States have recently increased their share of the overall annual PV generation.

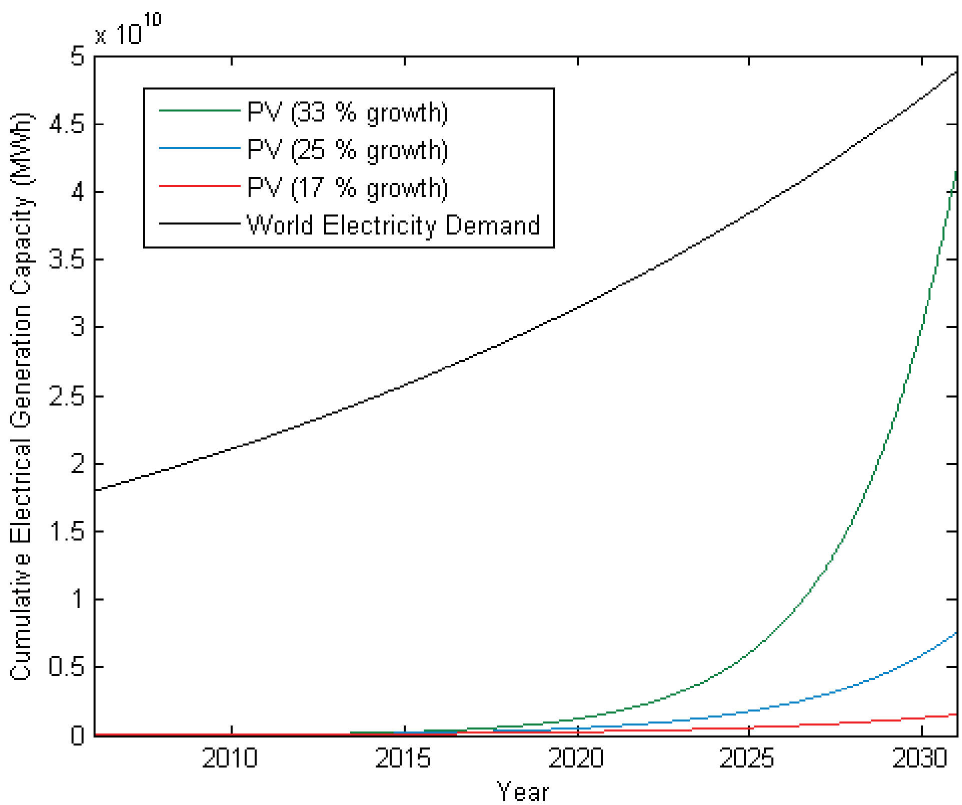


**Figure 6: Projected PV Cumulative Installed Capacity**

[17] Solar Initiative of New York (2007). *New York's Solar Roadmap*. Retrieved April 7, 2010, from www.hv-pv.com/wp-content/uploads/2008/06/nys_solar_roadmap_4-07.pdf

[18] Entropy Production (2007). *The Glittering Future of Solar Power*. Retrieved April 7, 2010, from http://entropyproduction.blogspot.com/2007/05/glittering-future-of-solar-power.html

**U.S. ENERGY DEMAND, ELECTRICITY GENERATION, AND SOLAR RESOURCE**

The United States is the largest consumer of electricity in the world. With only 4.6% of the world's population, the U.S. accounts for over 24% of the world's energy consumption.[19] Despite some efforts to reduce this demand, our energy consumption continues to grow, as seen in Figure 7.[20]

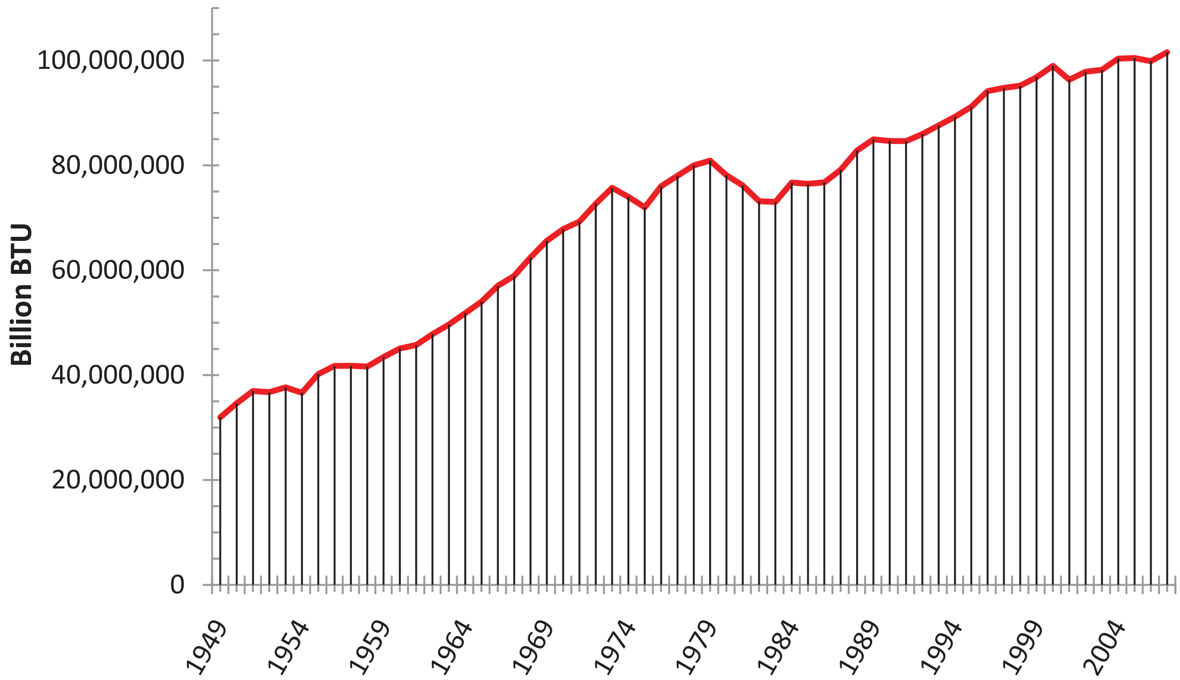


**Figure 7: Total Energy Consumed in the U.S. Over the Past 50+ Years**

While the increasing rate of energy consumption in the U.S. has slowed compared to the late 50s and 60s, the current rate will necessitate an expansion or significant improvement to the energy generation and distribution system. Since energy consumption and a healthy economy often go hand-in-hand, more efficient methods of obtaining the required energy are necessary.

The primary non-renewable sources of energy for electricity generation in the U.S are coal, crude oil, natural gas, and nuclear. The use of crude oil has decreased in recent years due to price fluctuations and because this fuel source is so critical to the transportation industry. While energy from renewable sources, such as hydro, wind, and solar, is on the rise in the U.S., they account for less than 5% of the total annual energy consumption. The electricity generation from these various sources over the past 50 years is shown in Figure 8.[20]

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[19] Tester, J., Drake, E., Driscoll, M., Golay, M., Peters, W. (2004). *Sustainable Energy: Choosing Among the Options*. Cambridge, Massachusetts: The MIT Press

[20] Energy Information Administration (2008). *Annual Energy Overview*. Retrieved March 10, 2010, from www.eia.doe.gov/emeu/aer/overview.html

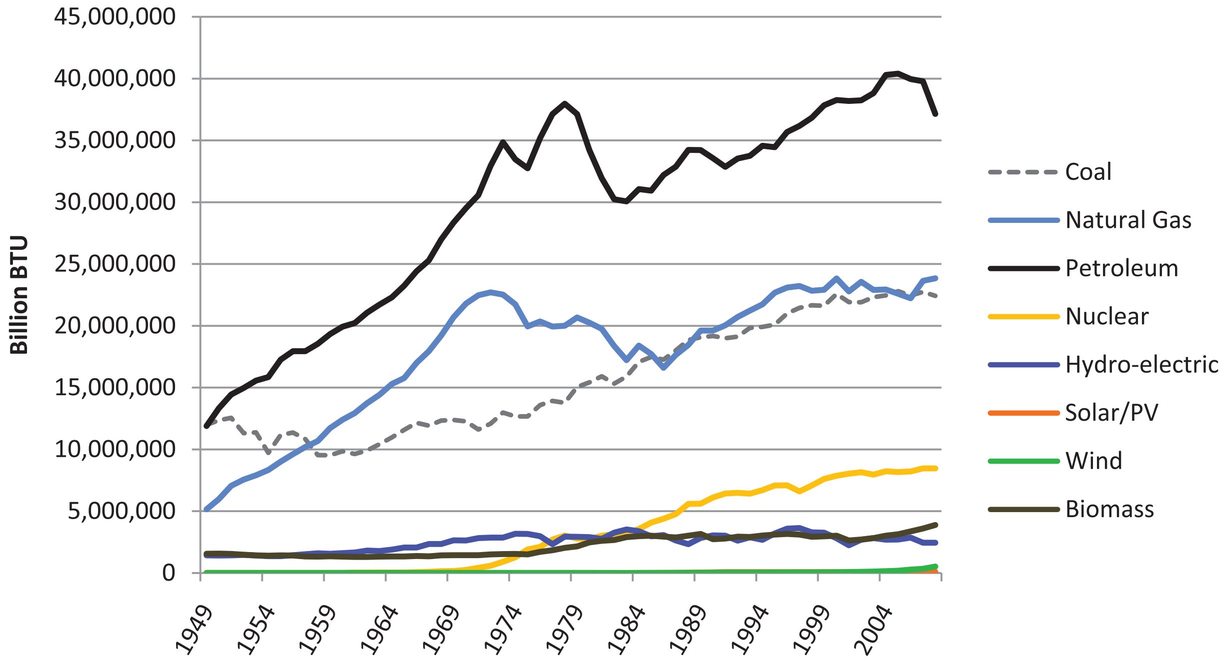


**Figure 8: Electricity Sources in the U.S.**

The U.S. receives enough sunlight for 100% PV generated electricity to meet and exceed the current energy demand. As shown in Figure 9, the areas with highest potential energy are the southern and south-western states. [21] Currently, the states producing the most solar energy are California, New Jersey, and Colorado.

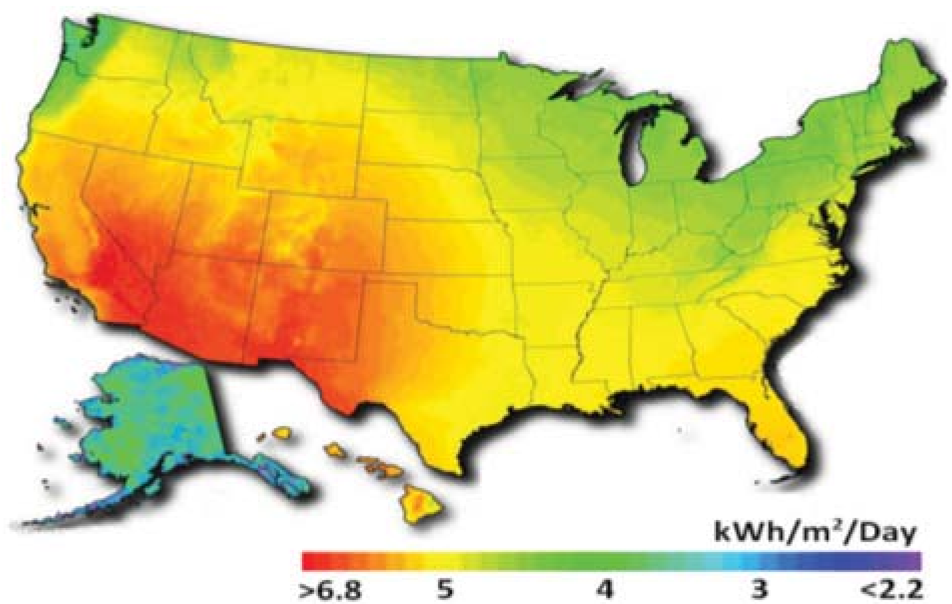


**Figure 9: U.S. Solar Resource Map**

[21] National Renewable Energy Laboratory (2010). *Solar Maps*. Retrieved March 10, 2010, from www.nrel.gov/gis/solar.html

## NATIONAL PHOTOVOLTAIC PROGRAMS AND INCENTIVES

The PV market has been primarily driven by incentives. While most electricity generation technologies benefit from some government incentives, these are especially important to PV because of the relatively high cost-per-watt to purchase and install this technology. Therefore, incentives are generally more influential to the success of a local PV market than its amount of solar resources. For example, New Jersey has extremely low solar insolation, but due to generous incentives it is second in the U.S. for PV capacity. It should then come as no surprise that the three states with the most PV generated electricity have substantial solar energy incentives.

California's current 10-year, $3 billion Go Solar California campaign, offers performance-based incentives, depending on system output, to private and commercial applications. Payment amounts are decreased through the duration of the program. This campaign resulted in over 125 MW of PV installed in 2008. In addition, some other current incentives include tax credits that are based on 100% of the system value, feed-in-tariffs that are based on time-of-use factors, and San Francisco specific grants provide $1,000 to $7,500 per installation dependant on eligibility. The California Energy Commission also administers the New Solar Home Partnership program. This program supplies assistive funding for new homes to include solar energy in their design.[22]

A significant rebate program and progressive renewable portfolio standard (RPS) has boosted the success of PV energy in New Jersey in the recent years through the use of Solar Renewable Energy Certificates (SREC). The rebate system has recently switched from a capacity based program (size of the array) to a performance based program (actual energy output). The solar trading cost of the SRECs has recently averaged $560 per MWh generated; however, trades of up to $700 per SREC have been recorded.[23]

In Colorado, 90% of the PV installations were partially funded by Xcel Energy, the largest utility in the state, in exchange for rights to the renewable energy credits created by the array. Colorado also recently doubled the RPS solar requirement to 0.8%, which will promote the application of solar energy over the next few years.[22]

## NATIONAL PHOTOVOLTAIC MARKET TRENDS

The PV market is growing exponentially in the U.S., with a 63% capacity increase from 2007 to 2008. The most influential state in the solar energy industry is California, which reported a 95% increased output in 2008. While the number of the PV installations in the U.S. has been steadily growing over the

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[22] North Carolina Solar Center and the Interstate Renewable Energy Council. *Database for State Incentives for Renewables and Efficiency*. Retrieved April 23, 2010, from www.dsireusa.org

[23] DSIRE. *New Jersey Board of Public Utilities - Solar Renewable Energy Certificates (SRECs)*. Retrieved May 12, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NJ07F&re=1&ee=0

last decade, the growth rate doubled in 2006 when the Federal Investment Tax Credit was increased. The growth of the installed capacity of PV power in the U.S. is shown in Figure 10.[24]

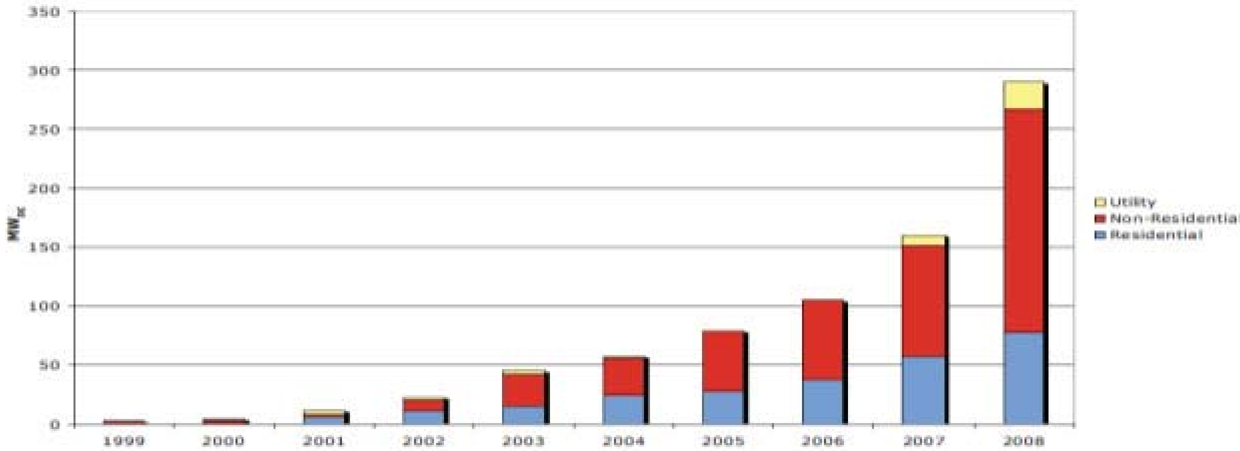


**Figure 10: Annual Installed PV Capacity in the U.S.**

Utility PV applications are expected to significantly increase in the coming years due to state RPS programs. With many states setting goals of 20% renewable energy capacity or more within the next decade, residential installations alone will not be able to account for this large portion of the statewide energy requirements. Currently, the largest PV farm is the 25MW Desoto Next Generation Solar Energy Center located in Arcadia, Florida. Nevertheless, several plans and preliminary designs are underway to construct much larger installations, such as the proposed 550MW Topaz Solar Farm in California. Figure 11 shows the projected U.S. PV installation trends for the next several years, which indicates a much larger contribution by utility-scale applications. [25]

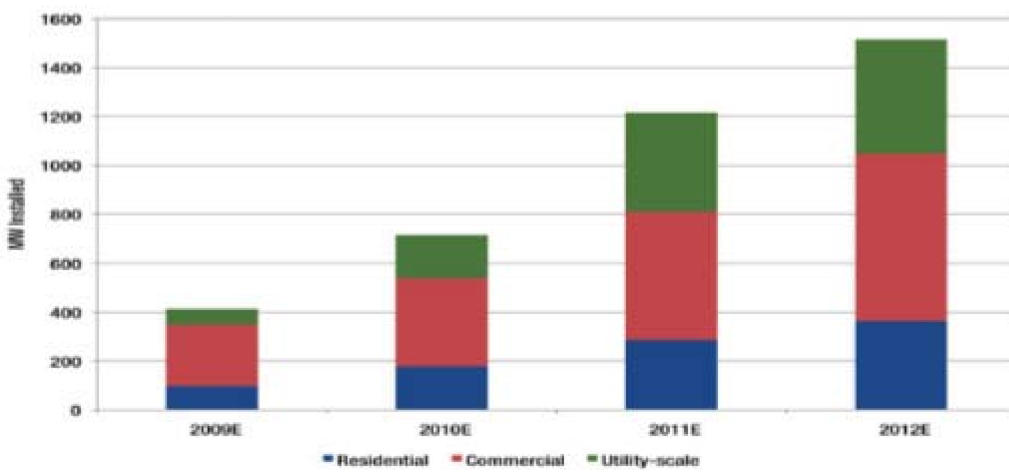


**Figure 11: Projected U.S. PV Installations**

[24] Interstate Renewable Energy Counsel; Larry Sherwood (2009). *U.S. Solar Market Trends 2008*. Retrieved May 12, 2010, from www.irecusa.org/fileadmin/user_upload/NationalOutreachDocs/SolarTrendsReports/IREC_Solar_Market_Trends_Report_2008.pdf

[25] GTM Research (2009). *Emerging Trends in the U.S. Solar Market.* Retrieved April 9, 2010, from www.areadevelopment.com/article_pdf/id10088_Emerging%20Trends%20in%20the%20U.S.%20Solar%20Market.pdf

## Section 2

## NEW YORK STATE PHOTOVOLTAIC MARKET

### CUMULATIVE ENERGY DEMAND AND ELECTRICITY GENERATION

New York has a substantial electrical energy demand and ranks 11th in the United States for total net generation. As can be seen in Figure 12, the overall energy requirements in 2008 were approximately 280 TWh.[26] As of 2009, New York is one of the highest producers of electrical energy in the nation but is the second lowest user of electricity per capita.[27] With a large population living in New York City where apartments have lower energy demands but incomes are still high, the energy requirements per capita are half of the U.S. average.[28] This lower energy per capita can also be credited to alternative forms of heat for the winter, mostly biomass (wood) fuels, in rural communities, and mild summers that reduce the air-conditioning requirements statewide.

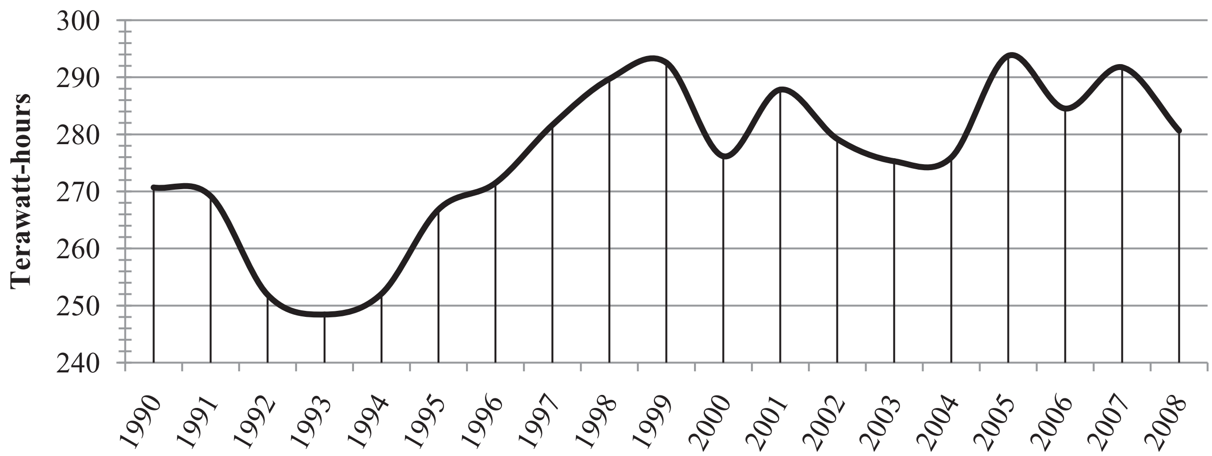


**Figure 12: Total Electricity Generation in New York State**

New York has a highly variable source of electricity generation. While most states rely primarily on a single fuel source to provide the bulk of their electricity needs, New York has almost equal production from natural gas, nuclear, and hydro-electric, along with some coal and minimal petroleum electricity generation. This not only creates an extremely redundant energy system that is impervious to short term fuel shortages, but also makes it adaptable for flexible integration of alternative energy sources in the future.

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[26] U.S. Energy Information Administration . *Electric Power Annual 2008*. Retrieved April 2, 2010, from www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html

[27] U.S. Energy Information Administration. *State Ranking 5. December 2009*. Retrieved April 2, 2010, from http://tonto.eia.doe.gov/state/state_energy_rankings.cfm?keyid=33&orderid=1 and http://tonto.eia.doe.gov/state/state_energy_rankings.cfm?keyid=60&orderid=1

[28] U.S. Energy Information Administration. *New York State Energy Profiles*. Retrieved April 2, 2010, from http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=NY

The primary source of renewable energy in the state is hydroelectric. The largest hydroelectric plant in New York is the Robert Moses Niagara plant that produces 2,353 MW without any carbon emissions. Other forms of renewable energy generation have also increased in recent years. The installed wind capacity in New York doubled between 2006 and 2008, but only contributes to only about 1% of the energy usage in the state. The increase in cumulative PV installed capacity pushed it into the top 10 states in the nation for solar technology, but it is still insignificant compared with other electricity sources. Figure 12 shows the historic utility electricity generation for NYS by energy source.[29]

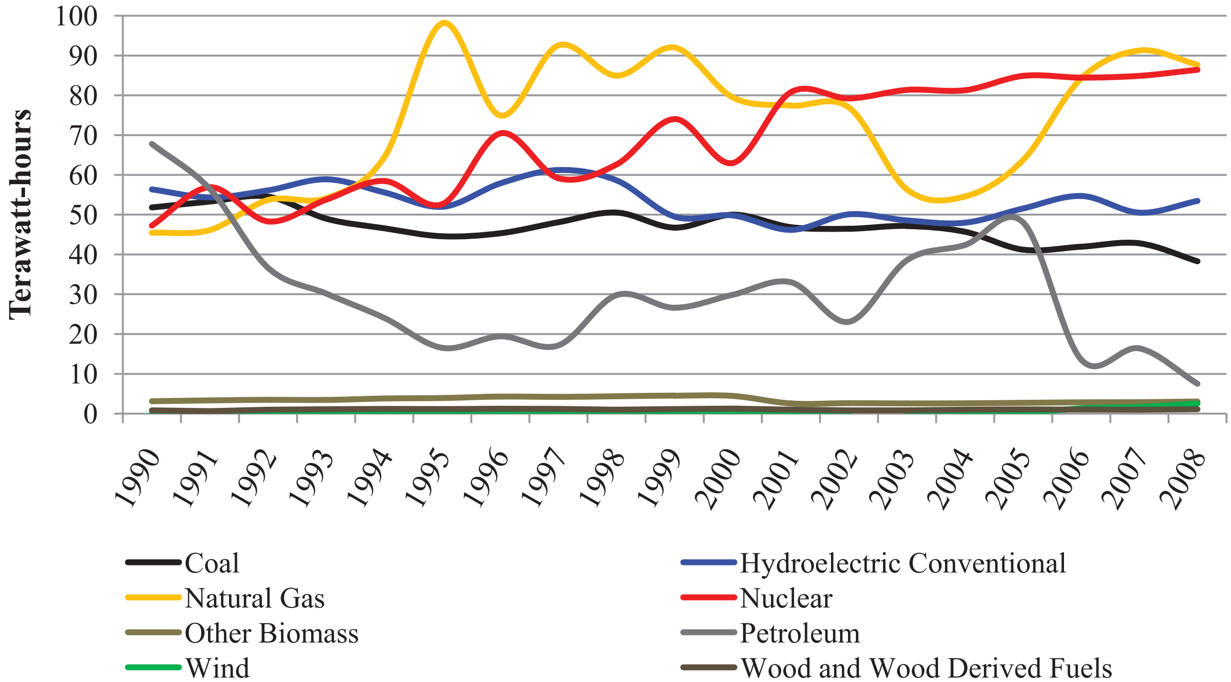


**Figure 13: New York State Electricity Generation by Source**

## PHOTOVOLTAIC POWER POTENTIAL

Currently, there is no utility solar electricity generating plant in the State of New York. The primary application for this technology is residential or commercial energy offsets. In general, these systems are grid connected so the facility's energy demand can be met at all times without a back-up energy storage system for when the Sun is not shining. This approach also allows the owner to sell excess energy back to the grid in the event that the system is generating more energy than needed. While the solar energy potential for New York is somewhat limited compared to other U.S. states, there still is ample amount to

[29] U.S. Energy Information Administration. *Electric Power Annual 2008 - State Data Tables*. Retrieved May 12, 2010, from www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html

meet a significant portion of the energy needs. A map of the solar energy potential in New York is shown in Figure 14.[30]

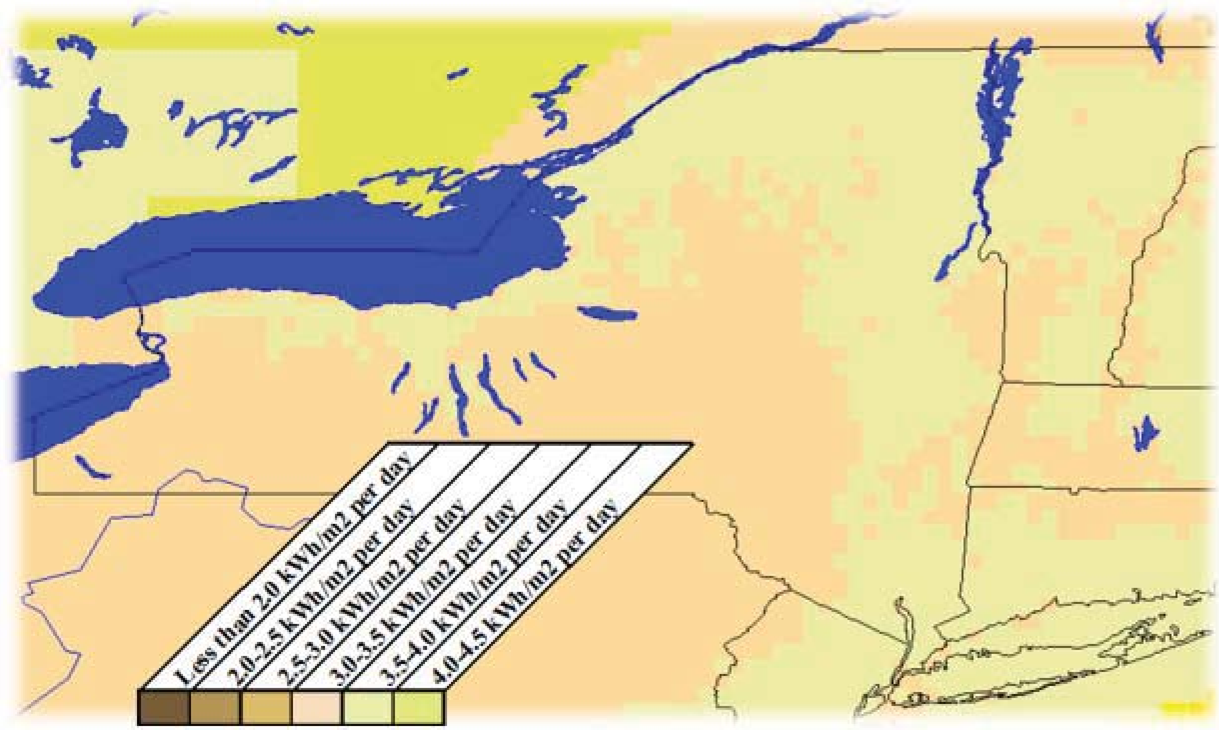


**Figure 14: New York State Solar Energy Resource**

New York has more solar potential than Germany, which is the world's leader for solar energy (based on installed capacity versus population). Germany has installed nearly 3,000 MW of PV capacity to date, even though its geological location is not optimal for solar energy as shown in Figure 15.[29] New York's power demand schedule is also ideally suited to PV energy because peak power typically occurs in the mid afternoon, which coincides with the maximum power output of a PV array. When compared with New York, Germany has only four times the population, but over 300 times the installed PV capacity.


**Figure 15: Germany Irradiance Resource Potential (uses same color legend as previous figure)**

[30] Solar and Wind Energy Resource Assessment (SWERA). *SWERA Renewable energy Resource Explorer*. Retrieved April 2, 2010, from http://na.unep.net/swera_ims/map2/#

**PHOTOVOLTAIC RELATED POLICIES AND PROGRAMS**

The primary program in New York State aimed at increasing renewable energy installations is the RPS, which has an overall target of increasing the percentage of renewable generated energy to 30% by 2015. To accomplish this goal, the concept of Renewable Energy Credits (REC) was established. This plan requires non-renewable electricity generating plants to buy a certain number of these RECs, which are divided into 1-MWh blocks and traded between energy producers at many times the cost of non-renewable electrical energy. The plan has allocations for both residential applications, such as PV, solar heating, and small wind, as well as utility applications, such as large PV, wind farms, and hydroelectric plants. To assist in moving forward with this plan, the State will provide funds to assist with the initial deployment of these technologies. Under the RPS, 1,340 MW of renewable electric energy was expected by late 2009, producing over 3.8 million MWh of clean energy for New York residents. [31]

**Installation Incentives**

Funds from the New York State Energy Research and Development Authority (NYSERDA) are available to homeowners in New York to cover a portion of the actual cost of installing PV technology on their properties. These incentives are available only to approved installers. The funds must then be passed on to the customer to assist with the total cost of equipment and installation. NYSERDA currently has over 80 approved PV installers for this program throughout the state. The incentive amounts are limited to 50% of the system costs. PV system sizes are also limited as noted below, and may also not exceed 110% of the site's previously demonstrated power demand. Incentive amounts may also be reduced if the system design significantly reduces output due to limited sunlight or poor positioning. This NYSERDA incentive is available throughout the state, except for Long Island, which is covered by incentives from the Long Island Power Authority (LIPA). The current program incentives include: [32]

Residential incentives
- $1.75 per installed watt
- Maximum system size of 5kW per site

Non-residential incentives
- $1.75 per installed watt
- Maximum system size of 50kW per site

Schools, nonprofit organizations, municipalities
- $1.75 per installed watt
- Maximum system size of 25kW per site

[31] New York State Energy Research and Development Authority. *New York State Renewable Portfolio Standard*. Retrieved April 2, 2010, from www.nyserda.org/rps/RPS%20Performance%20Report%20WEB.pdf
[32] Database of State Incentives for Renewable Energy (DSIRE). *NYSERDA - PV Incentive Program.* Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY10F&re=1&ee=0

LIPA manages grants and incentives for PV technology in Long Island. LIPA provides rebates on the first 10kW of installed residential PV power, which is double that of NYSERDA. Non-residential PV installations can receive incentives for arrays as large as 2 MW, however the incentive amount decreases for installations greater than 50 kW. The system total size is limited to only 105% of average on-site power consumption during the previous year. The incentive may also not exceed 50% of the systems cost (except for municipal and nonprofit applications). Funding levels available from LIPA are as follows: [33]

Residential
- $2.50 per watt for the first 10 kW

Commercial
- $2.50 per watt for the first 50 kW
- $1.00 per watt the remaining cost, 50 kW to 2MW

Government, Schools, Nonprofit
- $3.50 per watt for the first 50 kW
- $2.00 per watt the remaining cost, 50 kW to 2MW

**Net Metering**

New York mandates that net metering is available for customers of major investor-owned utilities. While publicly owned utilities are not required to participate, LIPA does offer net metering and is the primary purchaser of excess renewable energy from nonutility sources in Long Island. The property owner is responsible for the cost of purchasing and installing all upgraded meters and hardware required for a grid connected system. Energy, purchased from a residential application, is crediting to the following month's bill at the retail price from the utility. Maximum eligible technology scaling for NYSERDA and LIPA jurisdictions are shown separately below.

NYSERDA (All of New York state, except Long Island) [34]

Residential
- 25 kW for solar installations
- 25 kW for wind energy installations
- 10 kW for micro-CHP and fuel cell installations

Non-residential
- The lesser of 2 MW or peak load for solar or wind energy installations

Farm Based
- 500 kW maximum wind energy installation
- 500 kw maximum biogas installation

[33] DSIRE. *Long Island Power Authority - PV Rebate Program*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY04F&re=1&ee=0

[34] DSIRE. *New York – Net Metering*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY05R&re=1&ee=0

LIPA (Long Island) [35]

Residential

- 27.5 kW for solar, wind, or hybrid energy system installations

Non-residential

- Solar, wind, and hybrid systems are eligible.
- Customers with a peak demand of 25 kW or less during the preceding 12 months may net meter systems up to 110% of their peak billing demand.
- Customers with a peak demand of 25 kW to 27.5 kW during the preceding 12 months may net meter systems up to 27.5 kW.
- Customers with a peak billing demand of greater than 27.5 kW during the preceding 12 months are limited to systems sized at 100% of their peak demand, not to exceed 2 MW

Farm Based

- 27.5 kW for solar installations
- 500 kW maximum wind energy installation
- 500 kW maximum hybrid system installation (solar may not exceed 27.5 kW)

**Tax Credits**

Cost incurred from the purchase and installation of PV technology is also eligible in New York for personal income tax credit. Enacted in 1997, the program will offset 25% of the total cost of the PV system up to $5,000. Nevertheless, tax credits that exceed the $5,000 cap disperse a larger credit over five years. The program was expanded in 2006 to provide tax credits for solar-thermal applications. To be eligible for this credit, solar systems must comply with certain standards set forth by the state, [36] which include:

- System must be less than 10 kW for residential applications and less than 50 kW for housing associations.
- Eligible equipment is defined as "an arrangement or combination of components utilizing solar radiation, which, when installed in a residence, produces energy designed to provide heating, cooling, hot water or electricity."
- Tax credits are not available for pool heating systems.
- Only the portion of system cost provided by property owner is eligible for a tax credit, equipment or installation costs covered by a grant from any source do not qualify.

[35] DSIRE. *Long Island Power Authority – Net Metering*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY14R&re=1&ee=0

[36] DSIRE. *Solar and Fuel Cell Tax Credit*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY03F&re=1&ee=0

New York residents are also exempted from any state sales tax on the purchase or installation of any solar energy system (includes solar-thermal and PV applications). This legislation also gives local governments the option to exempt these technologies from local sales tax.[37]

The New York State Real Property Tax Law stipulates a 15 year property tax exemption for renewable energy technology systems installed on the property owner's land. Under the initial enactment, this law was mandatory in all parts of the state. Nevertheless, in 1990, a clause was added that allowed local governments to opt out if desired. The amount of the property tax exemption is equal to the increase of property value accredited to the installation of the technology. Eligible technologies include passive solar heating, active solar thermal, PV, wind energy systems, and waste energy systems.[38]

New York enacted legislation in 2008, which provides property tax abatement for PV system equipment and installation costs on buildings within New York City. This property tax abatement is in addition to the property tax exemptions explained above. While the tax exemption excludes property owners from paying tax on their increased property value due to a PV installation, this abatement deducts a portion of their expenditures, associated with the installation of a PV system, from their total property taxes. Under this legislation, 5.0-8.75% (depending on date of installation) of the eligible expenditures due to the PV system installation are deducted annually from the owner's property tax for four years. This results in 20-35% of the total cost of the system. The annual abatement cap is set at $62,500 or the amount of property taxes owed that year. Abatements cannot be carried over to subsequent years.[39]

**PHOTOVOLTAIC MARKET TRENDS**

Residential and commercial installation data were obtained from NYSERDA and LIPA for a detailed analysis of New York's PV installation trends. The data were compiled through grant applications received from home owners and businesses throughout New York State. LIPA and NYSERDA operate in different territories; LIPA works in Long Island and NYSERDA operates throughout the remainder of the state. This provided two distinct data sets that could be analyzed separately or jointly depending on the desired objective. Complete yearly data from both sources were available only between 2003 and 2008. Tables, including annual data from NYSERDA and LIPA are available in Appendix A.

[37] DSIRE. *Residential Solar Sales Tax Exemption*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY24F&re=1&ee=0
[38] DSIRE. *Energy Conservation Improvements Property Tax Exemption*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY27F&re=1&ee=0
[39] DSIRE. *New York City Property Tax Abatement for Photovoltaic Equipment Expenditures*. Retrieved April 28, 2010, from www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY52F&re=1&ee=0

**Total Installed Photovoltaic Capacity in New York**

Despite the limited potential solar energy available in New York, the number of privately owned PV installations has grown significantly in recent years. As can be seen in Figure 16, the energy produced from PV generation in the state totaled over 18 GWh in 2008. This resulted from a continued rate of increase since 2003, which has escalated to 16 MW of capacity installed in 2008.

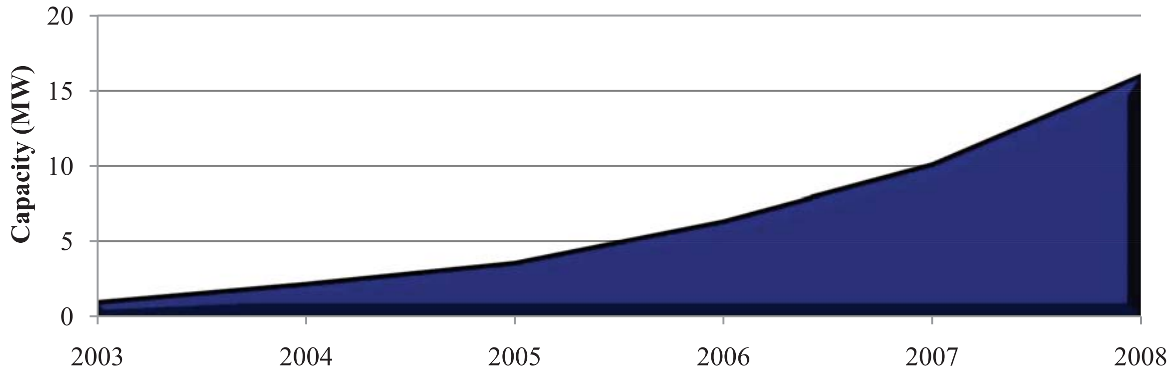


Figure 16: Cumulative Installed Capacity

**New York vs. National Photovoltaic Installation Trends**

In order to compare New York installation data to data for the entire U.S. which is a much larger scale, the percentage of total installations can be calculated on a yearly basis. This method was used to compare the New York installation trend with the United States' trend as a whole. In this comparison, the percentages were calculated by dividing the capacity installed for a particular year by the total capacity installed between 2003 and 2008. This was also done with national PV installation data to allow for a meaningful comparison between these widely varied data sets as shown in Figure 17. The trends indicate that a much larger percentage of installations occurred more recently in New York, whereas the U.S. as a whole has been fairly constant up until 2008.

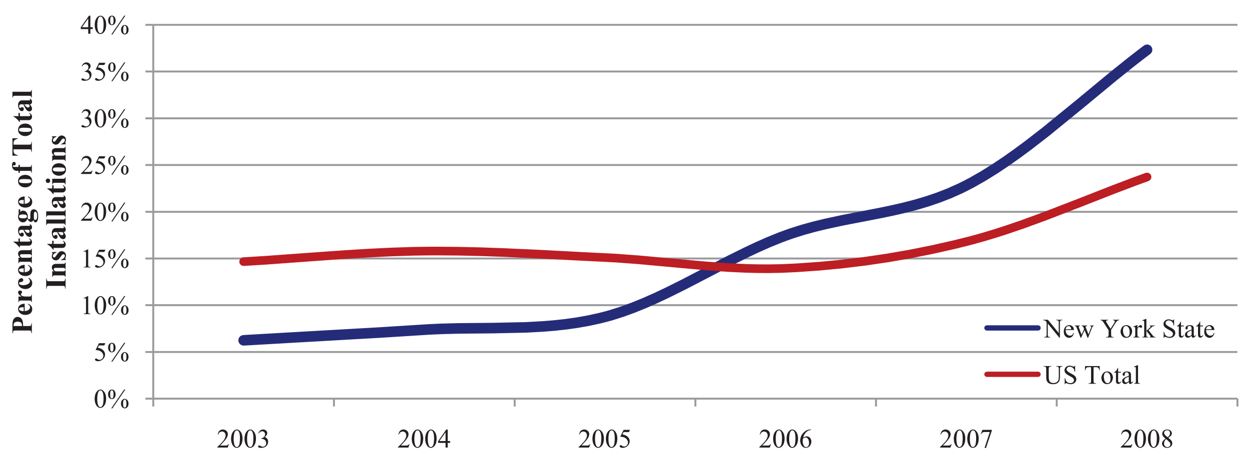


Figure 17: Installation Trends for New York and the United States

## Emissions Reduction in New York State from Photovoltaic Technology

Based on all PV installations since 2003, the cumulative energy generation from residential and commercial applications was over 45 GWh of electrical energy. This results in substantial emission reduction due to photovoltaic technology's zero emission electricity generation. The New York electricity generation emission factors as well as the total estimated emission reduction due to the PV installations is shown in Table 1. These emission factors were calculated by the U.S. Energy Information Administration for 2008 and based on the electricity generation mix for New York, which was 31% Natural Gas, 31% Nuclear, 19% hydroelectric, 14% coal, 3% petroleum, and 2% from other renewable. [40]

**Table 1: Emission Reduction from 26,199 MWh of yearly PV electrical generation in New York**

| | Sulfur Dioxide | Nitrogen Oxide | Carbon Dioxide |
|---|---|---|---|
| Emission Factors (lbs/MWh) | 1.3 | 0.8 | 740 |
| Cumulative Amount | 30 Tons | 18 Tons | 16,855 Tons |

## Regional Trends

The total PV installed capacity is similar between NYSERDA and LIPA jurisdictions before 2007, even though LIPA covers a much smaller geographic area. This can be seen in Figure 18, in which the bars show the percentage of installations funded by each organization and the lines represent the actual PV capacity that was installed. These two trends indicate that Long Island, which accounts for about 40% of the state's population, was initially more interested in PV than the rest of the state and only recently has the rest of the state been able to equal it in new PV installations. It is important to note that the median annual income of Long Island residents is $64,000 as compared to $50,600 for the rest of the state[41], which may have made the initial investment in this technology more feasible, and LIPA offers greater incentives to install PV. These factors may have encouraged more PV installations in Long Island when the program was initially started.

[40] U.S. Energy Information Administration. *New York Electricity Profile*. Received April 5, 2010, from www.eia.doe.gov/cneaf/electricity/st_profiles/new_york.html

[41] U.S. Census Bureau. *State & County QuickFacts*. Retrieved May 11, 2010 from http://quickfacts.census.gov/qfd/states/36000.html.

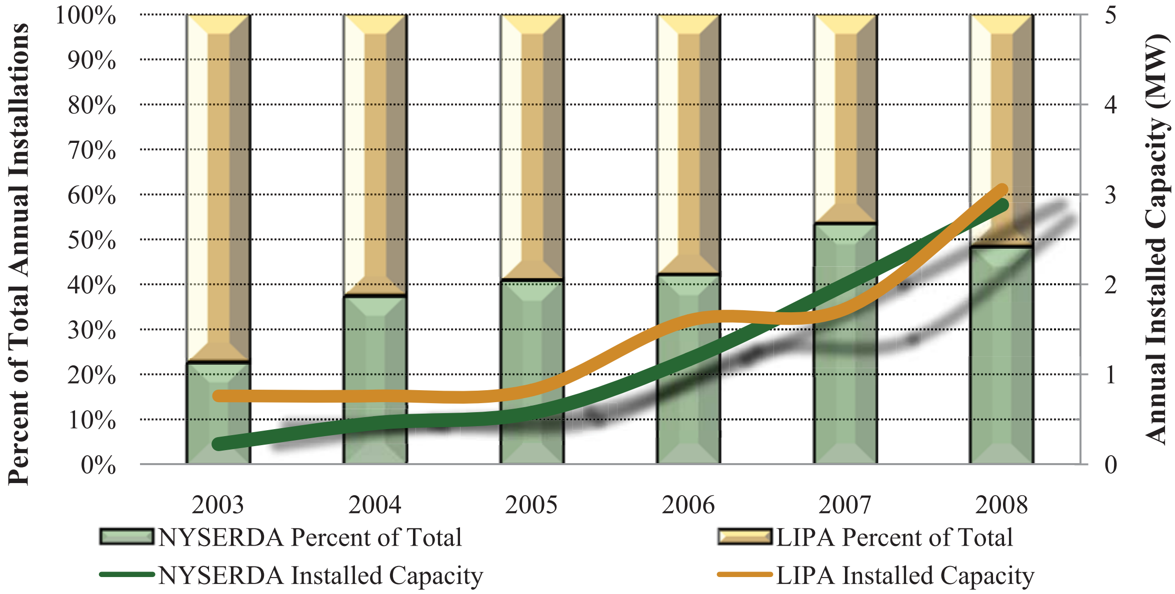


**Figure 18: PV Installation Variations between NYSERDA and LIPA**

PV Installations on Long Island have an advantage in the overall energy output per installed capacity. The capacity factor (estimated PV electrical production ÷ [PV Capacity*hours per year]) for Long Island was calculated at 15%, which is 30% higher than PV installations in other areas throughout New York (11%). This is most likely due to difference in the solar resource potential as previously shown in Figure 14.

**Array Size Trends**

The average size of residential PV installations in New York is approximately 5.4 kW with commercial arrays averaging over 11.8 kW (these figures include both NYSERDA and LIPA data). Still, the smaller and more plentiful residential arrays actually end up contributing more to the overall cumulative PV capacity. The average sizes of the installed arrays, measured in installed power (kW), are shown in Figure 19. There is a substantial commercial array size increase in 2005 (for LIPA) and 2006 (for NYSERDA); which could be the result of varied funding opportunities. Nevertheless, because the curve appears for both NYSERDA and LIPA data, the most probable cause is the RPS adopted by the state as a whole in late 2004. This program resulted in a significant Renewable Energy Credit market in New York, making energy generated from renewable resources much more valuable than equal amounts of electricity from other, non-renewable sources. Because of RECs, the economic viability of large PV systems that require a higher initial investment, but generate more power, can result in increased profits throughout the life of the array.

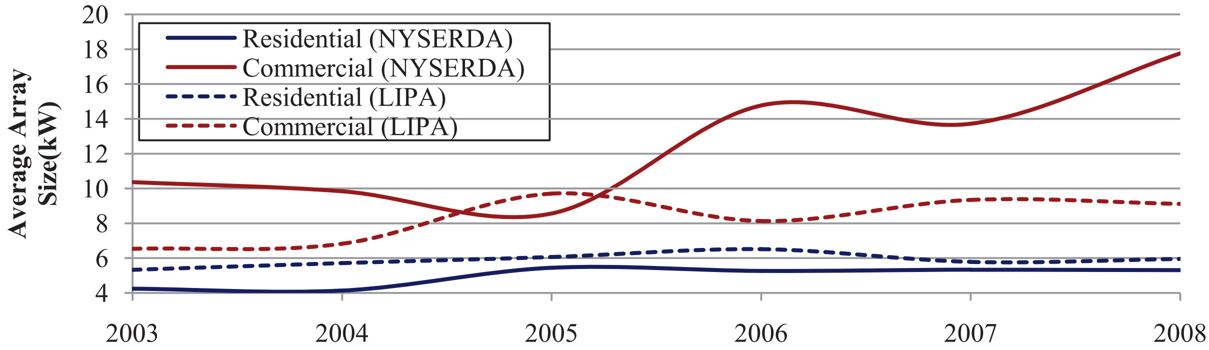


**Figure 19: Average PV Array Size**

## Residential vs. Commercial Trends

From 2003 to 2008, the majority of PV installations in New York have been for residential customers. During these six years, commercial PV installations have averaged only 13% of the total installed PV capacity. Notwithstanding, as shown in Figure 20, commercial installations are increasing their share of the New York market in more recent years. In fact, the annual percentage of total commercial installations shows strong growth, while the annual percentage of total residential installations is increasing at a much slower rate. This trend will likely continue as utility scale PV installations are driven by the state's RPS.

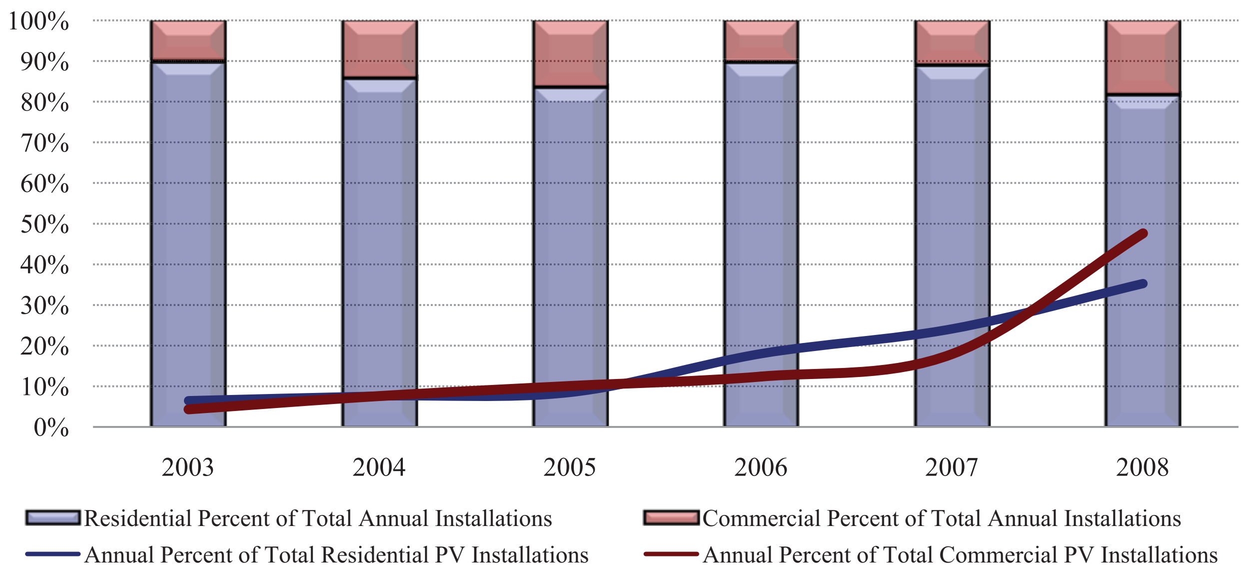


**Figure 20: Residential and Commercial PV Installation Trends Based on Capacity**

## Economic Trends and Considerations

The economic viability of residential or commercial installations is highly reliant on funding from government resources. After the NYSERDA incentive has been applied to the installation cost, the average simple payback period for residential PV arrays, installed between 2003 and 2008 in NYSERDA's jurisdiction, is 25 years, with a 32% return on investment over 30 years. Commercial systems average 24 years to pay off, but have a higher 30 year return on investment at 47%. This is most likely due to the fact that the average commercial system is much larger and generates significantly more power. If the NYSERDA funding is not included the average simple payback period increases to almost 47 years for residential applications and 50 years for commercial installations. These calculations are only based on the economic savings associated with offsetting grid power with power generated on-site. It also does not include other potential profits or savings from tax breaks, tax credits, or RECs because of the highly variant nature of each. Also, if grants are accepted for alleviating installation cost, REC rights generally belong to the sponsoring entity for a certain period of time, further reducing their impact on this simplistic economic analysis. The yearly economic data calculated is shown in Table 1.

**Table 2: Economic Results for NYSERDA Supported PV Installations**

| | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Mean |
|---|---|---|---|---|---|---|---|---|
| With NYSERDA Incentive | Simple Residential Payback Period (Yrs) | 24 | 25 | 26 | 24 | 26 | 26 | 25 |
| | Simple Commercial Payback Period (Yrs) | 19 | 20 | 21 | 24 | 31 | 29 | 24 |
| | 30yr Return on Investment (Residential) | 43% | 31% | 35% | 34% | 24% | 28% | 32% |
| | 30yr Return on Investment (Commercial) | 79% | 60% | 55% | 36% | 12% | 42% | 47% |
| Without Incentive | Simple Residential Payback Period (Yrs) | 48 | 49 | 49 | 45 | 47 | 46 | 47 |
| | Simple Commercial Payback Period (Yrs) | 50 | 50 | 48 | 46 | 55 | 55 | 50 |

Average Residential energy cost ~ $0.183^ Average Commercial energy cost ~ $0.168^

^NYSERDA *New York State Energy Fast Facts*. www.nyserda.org/energy_information/fastfacts.pdf

The cost associated with installing a PV system within NYSERDA jurisdiction has varied in recent years, as shown in Figure 21. These calculations include inflation factors to equalize the yearly costs from 2003 to 2008.[42] Since 2003, the portion of the residential installation costs covered by NYSERDA incentives has decreased. Still, because the residential installation costs have been decreasing more rapidly, the overall PV system is actually more economically viable. The percentage of received commercial incentives has also decreased, while the overall cost of installation has actually increased since 2003. Incentive amounts have remained relatively high with the average around 47% for residential and 53% for commercial PV installation costs from 2003 to 2008.

[42] InflationData.com. *Historical US Inflation Rate 1914-Present*. Retrieved May 14, 2010, from www.inflationdata.com/inflation/inflation_rate/historicalinflation.aspx

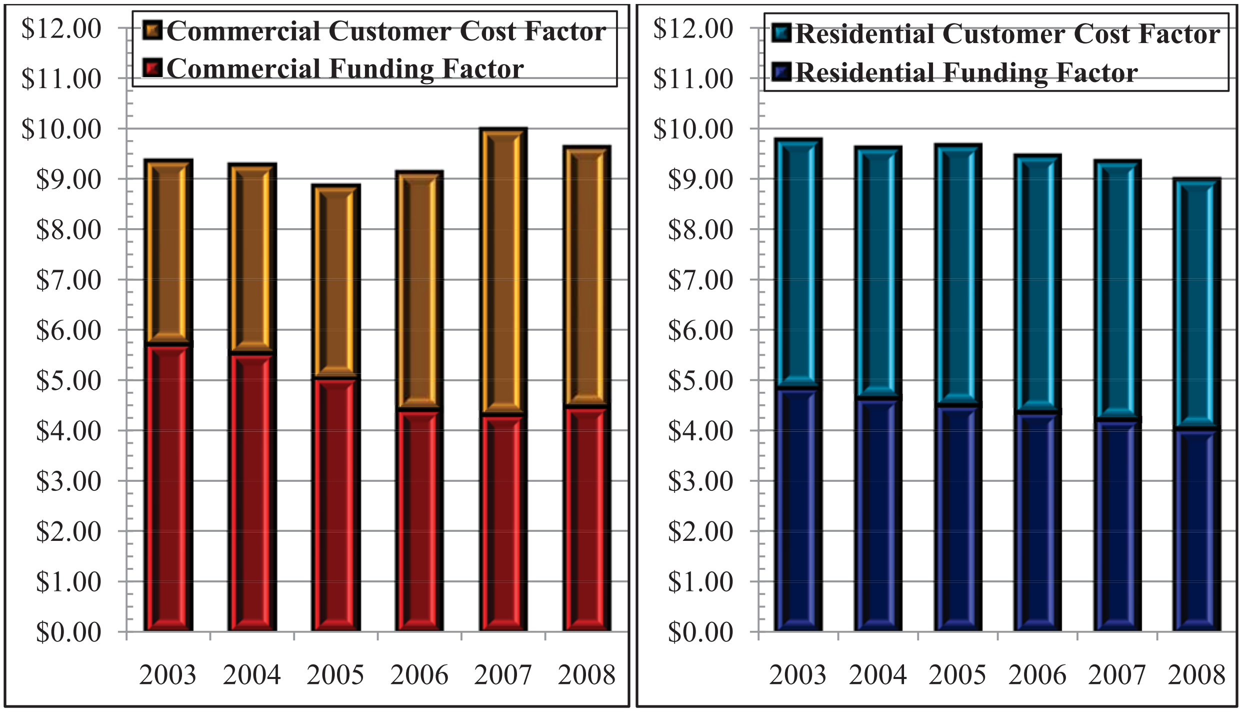


**Figure 21: The Cost Factors Associated with PV Installations and Previous Funding Amounts**

Another economic benefit from increased PV installations in New York is the economic stimulation for installers, retailers, and manufactures involved in the photovoltaic technology, along with its associated service components. Over 3,500 residential and commercial PV installations were completed between 2003 and 2008 in the state. PV modules for installations in New York were purchased from a variety of manufactures, as shown in Figure 22 with their respective market shares for residential and commercial installations. Unfortunately, most of the PV modules are produced in other states, but the distributers, wholesalers, and installers who are located within the state do benefit from the expanding activity associated with a growing PV market.

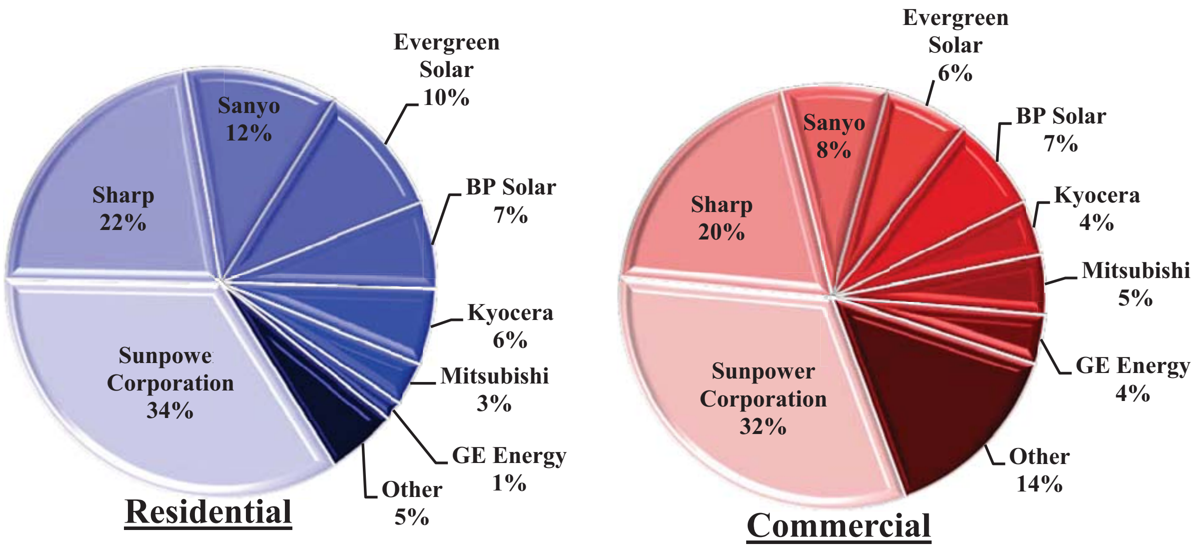


**Figure 22: Manufacturer's Share of the New York PV Market**

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# New York State Photovoltaic Market Trends

Final Report 10-16

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