Solar Thermal in New York City: Opportunities + Challenges

FINAL REPORT OF THE NYCEDC SOLAR THERMAL PILOT PROGRAM

NEW YORK CITY ECONOMIC DEVELOPMENT CORPORATION | JUNE 2013

EXECUTIVE SUMMARY

In New York City, over 30% of a building's energy consumption is used to provide space heating and hot water. This demand is largely met by fuel oil- and natural gas-powered boilers; nearly 96% of New York City buildings use these fuels for heating, but at a significant economic and environmental cost. New Yorkers spend more than $15 billion on energy each year, paying among the highest energy prices in the nation. Building energy use accounts for approximately 75% of New York City's greenhouse gas emissions.[1] Solar thermal technology provides a renewable, emissions-free and cost-efficient alternative to fossil fuel-based space and water heating.

In spite of the opportunity, the industry has seen slow growth with few solar thermal systems installed in New York City. A few key barriers limiting growth include a lack of financial incentives and financing options and limited awareness of the technology, its reliability, performance and value. The New York City Economic Development Corporation (NYCEDC) sought to address these barriers and explore the potential for solar thermal technology as a driver of economic growth in New York City's clean technology and energy sector. In 2009, NYCEDC launched the Solar Thermal Pilot Program to study the performance, determine the potential and identify key next steps to scale deployment of solar thermal technologies in New York City.

Through this program, NYCEDC provided financial assistance to New York City-based building owners installing solar hot water (SHW) systems. Each system installed was equipped with performance monitoring equipment. Following installation of the four pilot program demonstration projects, system owners monitored performance and collected data over the course of one year. In addition, program participants joined NYCEDC and other key industry stakeholders for a Solar Thermal Roundtable to share their experiences with the technology. NYCEDC collected and analyzed the quantitative and qualitative data to develop recommendations to facilitate growth, namely by focusing deployment at preferable sites, increasing the availability and applicability of incentive programs and promoting awareness of solar thermal technologies through robust metering.

By encouraging local deployment of solar thermal technologies, New York City will develop a cost-effective solution that transforms the nature of energy use for water and space heating. Successful growth of this nascent industry will yield significant greenhouse gas emission reductions, improve air quality and create local, skilled jobs for New York City residents.

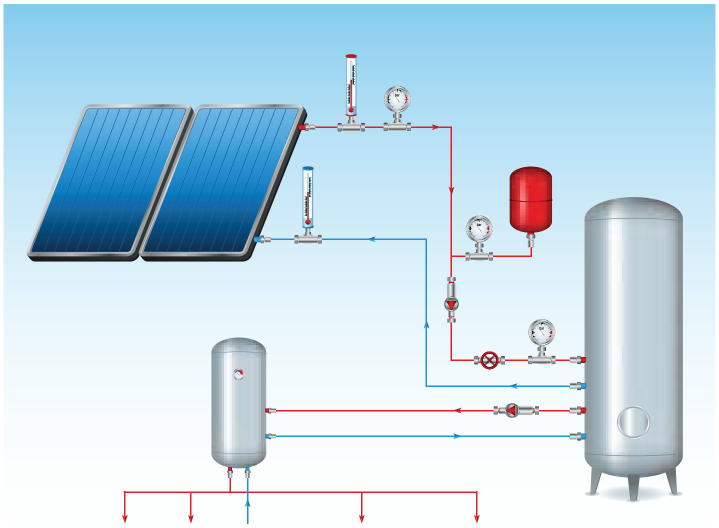
[1] PlaNYC - A Greener, Greater New York, 2011, http://www.nyc.gov/planyc

SOLAR THERMAL TECHNOLOGY AND THE POTENTIAL FOR NEW YORK CITY

Developing the solar thermal market has the potential to drive economic growth in New York City's clean technology and energy sector by offering a clean and cost-efficient alternative to fossil fuels.

Solar thermal systems capture incoming solar radiation and store it in the form of thermal energy. The most common application of solar thermal technology, and the focus of the Solar Thermal Pilot Program, is to provide domestic hot water. In its most basic form, a solar hot water system consists of rooftop mounted solar collectors which capture incoming solar radiation and heat water in a storage tank. The water reaches temperatures ranging from 120 to 170 degrees Fahrenheit and is then transported to consumers for domestic use. While solar photovoltaic (PV) systems generate electricity from solar energy, solar thermal systems convert solar energy directly to heat. In general, solar thermal systems are more efficient, converting over 50% of solar energy into heat in comparison to PV which typically converts less than 15% into electricity.

New York City is the most favorable market for solar thermal technologies in the state. With high energy costs and an abundance of sunlight, New York City is ideal for cost-competitive, renewable energy solutions. For an average New York City family, solar thermal systems have the potential to provide up to 75% of the hot water needs, providing direct economic benefits of cost savings and indirect environmental benefits by displacing carbon-emitting fossil fuels with sunlight to heat hot water.[2]



Solar Hot Water System Components

NYCEDC SOLAR THERMAL PILOT PROGRAM

Solar thermal technologies are mature and provide high energy production with relatively low capital costs. However, despite a strong opportunity, solar thermal has seen slow growth in New York City, with relatively few systems installed. The Solar Thermal Pilot Program provides a framework to identify and analyze market constraints and to develop standards and best practices for a robust and sustainable marketplace in New York City.

Preliminary research revealed several barriers for wide-scale deployment, including:

- **Lack of incentives**
  A variety of federal, state and local incentives are offered for solar PV systems that generate electricity, but comparatively few incentives are available for solar thermal. Further, the incentives that are available are largely misaligned, limiting eligibility to systems that displace electric water heating, thereby eliminating 96% of the New York City building stock that uses fuel oil or natural gas.
- **Lack of financing**
  High upfront costs deter potential investment in SHW systems. The initial "sticker shock" is only further compounded by the lack of financing options available for solar thermal systems.
- **Lack of awareness**
  Potential customers are unfamiliar with the technology, its reliability, performance and economic benefits. This is partially attributable to a lack of performance data as solar thermal systems are not commonly metered. Potential customers are unwilling to shoulder the upfront costs of installation if the long-term benefits are unclear or appear uncertain.

The Solar Thermal Pilot Program addresses these barriers. The program provides financial assistance, offering grants of 30% of installation costs, up to $50,000 per solar thermal system and increases transparency of solar thermal technologies, requiring all systems installed under the program to be equipped with performance monitoring equipment.

Through a competitive application process, NYCEDC selected four projects across a diverse spectrum of building types and locations: a five-story mixed-use residential and commercial building in the Bronx (Site #1); a mixed-use residential and community center in Manhattan (Site #2); a six-story mixed-use residential and commercial building in Queens (Site #3); and a community center with recreational facilities in Staten Island (Site #4).

Monthly performance and financial data was collected at each of the four sites for one year. Program participants were also asked to attend a roundtable discussion with key industry stakeholders. Using quantitative and qualitative data, NYCEDC will determine the potential for solar thermal in New York City and identify the financial, technical and regulatory barriers limiting growth.

[2] Solar Domestic Hot Water Technologies Assessment, NYSERDA, 2008.

SOLAR THERMAL PILOT PROGRAM DEMONSTRATION PROJECTS

Program participants monitored system performance and collected monthly data for one year following installation. The results are promising; the average payback period for the four pilot projects is 6.5 years, with three of the four systems reporting a payback period of 5 years or less. On average, participating building owners saved over 20%, nearly $2,000, on their annual energy costs, and more than 35% on their summer energy costs.

SITE #1

Site #1 is a five-story mixed-use residential and commercial building located in the Bronx. Built in 2007, the 30-unit, 29,000 square foot building uses approximately 4,000 gallons of hot water per day produced by natural gas powered boilers. Based on the hot water demand and the available roof space, 20 flat plate solar panels were installed. The solar system occupies 800 square feet of the building's rooftop.

The system installation costs totaled $129,337, including:

- **Engineering design: $10,000**
- **Management and permits: $11,000**
- **Materials: $71,368**
- **Installation labor: $36,969**

Site #1 received a $38,801 grant under the Solar Thermal Pilot Program. In addition to the NYCEDC grant, Site #1 received a Federal Tax Credit of $27,160 and five-year accelerated depreciation of $26,164. Financial incentives accounted for $92,125, or 71% of the system cost. The system was installed in November 2010, with data collected from January through December 2011.

In 2011, the system produced 1,967 therms, which accounted for 45% of the 4,364 total therms used for hot water that year. From 2010 to 2011, the building's overall energy usage decreased by 3%. However, because overall energy usage includes both space and water heating, analyzing the summer months provides a more accurate gauge of the performance of the SHW system. From 2010 to 2011, the building's energy usage during the summer months, May through September, decreased by 28%, a significant savings.

Reduced energy consumption translates into cost savings for building owners. During the data monitoring period, the building owner saved $718, or 6% on their gas bill compared to the prior year. In the summer months, the cost savings compared to 2010 were $438, a savings of 18%. Assuming a 10% increase in natural gas fuel prices annually and accounting for depreciation, the expected payback period for the SHW system deployed at Site #1 is five years.

Although the annual cost savings are significant, they were lower than the expected first-year savings of $3,885. The relatively modest cost savings were a factor of (1) colder weather conditions in 2011 than in the year prior, requiring higher energy consumption for space heating, (2) increased tenant occupancy resulting in increased demand for heat and hot water and (3) a new gas supply contract for the building that included a higher price per therm of energy. For these reasons, comparing actual versus expected energy production is a more accurate gauge of system performance than cost savings alone. During the reporting period, the SHW system produced 1,967 therms, just shy of the expected production of 2,072 therms.

Site #1: 12 of the 20 flat plate solar panels

Displacing natural gas with solar energy to produce hot water has associated environmental benefits as well. From 2010 through 2011, the SHW system resulted in avoided emissions of 23,104 pounds of carbon dioxide. With a system life expectancy of 20 years, the SHW system at Site #1 will result in avoided carbon dioxide emissions of 460,270 pounds, equivalent to forgoing 57 household-years' worth of natural gas emissions.[3]

SITE #2:

Site #2 is a five-story, new construction building located in Manhattan. Designed for residential and community outreach use, the building was expected to use approximately 300 gallons of hot water per day, the entirety of which would be supplied by the SHW system with natural gas boilers installed as auxiliary power. Given the relatively low hot water load for the building, Site #2 installed eight flat plate solar collectors, occupying 216 square feet of the building's rooftop.

The system installation costs totaled $28,600, including:

- **Engineering design: $2,500**
- **Management and permits: $4,000**
- **Materials: $16,600**
- **Installation labor: $5,500**

Based on the total project cost, Site #1 received an $8,580 grant from NYCEDC. Site #1 did not apply for additional grants or incentives from other sources. The system was installed in December of 2010, with data collected from January through December 2012.

Over the twelve month reporting period, the SHW system at Site #2 produced 353 therms, 20% less than the estimated production of 440 therms. In spite of the lower than expected output, the annual production met 80% of the building's hot water demand, resulting in a 10% annual energy savings and a 28% energy savings during the summer months. At $1.56 per therm, the SHW system saved building owners approximately $550 in the first year.

Although the SHW system provided a significant portion, 80%, of the building's hot water demand, the payback period for the system is 16 years – three times longer than the other pilot program systems. This may have been due to several factors:

- Site #2 did not pursue additional financial incentives to help offset the system costs, in comparison to the other sites which all received additional incentives
- The grant application for Site #2 was based on a system cost estimate of $28,600; however, the actual installed costs totaled $33,100, further reducing cost-coverage of the NYCEDC grant
- Limited available roof space at Site #2 required the installation of two smaller arrays. The four-panel arrays are positioned at a 90-degree angle relative to one another, reducing the proportion of the array facing the optimal direction. The result is an eight-panel system that produces the energy equivalent of six panels.

In terms of environmental benefits, the SHW system at Site #2 resulted in avoided emissions of 4,130 pounds of carbon dioxide during the reporting period. Assuming a system life expectancy of 20 years, the SHW system at Site #2 will displace 82,601 pounds of carbon dioxide, equivalent to forgoing 10 household-years' worth of natural gas emissions.

Site #2: Flat plate solar arrays

[3] Using the EPA's average annual per household emissions from natural gas use (8,049 pounds of carbon dioxide) http://www.epa.gov

Site #3: 24 of the 44 evacuated tube solar collectors

SITE #3:

Site #3 is a mixed-use residential and commercial building located in Queens. The six-story building comprises 88 units, which collectively use 3,000 gallons of hot water per day. Based on the high volume of hot water needed and available roof space, 44 evacuated tube solar collectors were installed. The rooftop solar system occupies 1,800 square feet of space. In addition to the solar thermal array, high-efficiency gas powered water heaters were installed on site.

The system installation costs totaled $249,000, including:

- **Engineering design: N/A**
- **Management and permits: $8,500**
- **Materials: $172,423**
- **Installation labor: $68,077**

Site #3 received a $50,000 grant from NYCEDC as well as $74,700 in financing incentives through a Federal Tax Credit and a five-year accelerated depreciation of $43,506. In total, financial incentives accounted for $168,206, or 68% of the system cost. The system was installed in May 2011, with data collected from the June 2011 through July 2012.

During the twelve month data monitoring period, the SHW system at Site #3 produced 16,674 therms, resulting in a 26% annual energy savings and a 52% saving during summer months. At less than a dollar per therm for natural gas, the building owners saved over $16,000 in the first year alone. Assuming a 10% increase in natural gas fuel prices annually and accounting for depreciation, the expected payback period for the SHW system installed at Site #3 is five years.

It should be noted that in addition to the SHW system, Site #3 installed a high-efficiency boiler system. The new, efficient system rapidly scales heating load, circumventing the previous boiler system's "always-on" and idling mode that was required to meet the building's hot water demand. The new high-efficiency boiler system helps reduce overall energy usage, augmenting the effectiveness of the SHW system by increasing the conversion factor of collected thermal energy to hot water produced to 96%.

Installation of the SHW system at Site #3 resulted in 195,082 pounds of avoided carbon dioxide emissions in the year following commissioning. Assuming a 20-year life expectancy, the SHW system will result in avoided emissions of 3,901,649 pounds of carbon dioxide, equivalent to forgoing 485 household-years' worth of natural gas emissions.

SITE #4

The 5,000 square foot, newly constructed building at Site # 4 is primarily used as a community center. Onsite facilities include a gym, indoor swimming pool and other recreational facilities. This site has particularly favorable conditions for a solar thermal installation: the low two-story building requires less pipe-run and the building roof has unobstructed southern exposure year-round.

To help meet the 2,000 gallon per day hot water demand, Site #4 installed 24 flat plate solar collectors. The system installation costs totaled $168,675, including:

- **Engineering design: $21,750**
- **Management and permits: $9,000**

Site #4: Flat plate solar panels

- **Materials: $91,651**
- **Installation labor: $46,274**

Site #4 received a $50,000 grant from NYCEDC as well as a $118,570 grant from the New York State Energy Research and Development Agency (NYSERDA). In total, financial incentives accounted for $168,570, nearly 100% of the system cost. The installation was completed in October 2011 and data was collected over the course of the subsequent year.

Over the course of the data monitoring year, the system at Site #4 produced 2,579 therms, providing over 55% of the building's hot water demand, and resulting in annual energy savings of 38% and summer energy savings of 46%. In the year following commissioning, the system saved building owners over $3,300 on their natural gas bill. Given the substantial incentive coverage, Site #4 was able to achieve a payback period of less than one month.

From 2011 to 2012, the SHW system at Site #4 resulted in avoided emissions of 30,174 pounds of carbon dioxide. With a system life expectancy of 20 years, avoided emissions total 603,476 pounds of carbon dioxide, equivalent to forgoing 75 household-years' worth of natural gas emissions.

KEY TAKEAWAYS:

By analyzing the performance of the four solar thermal systems, several key lessons become clear:

- **Hot water load matters**
  Buildings with high demand for hot water are better candidates for solar thermal systems.

  This takeaway is illustrated when looking at the pilot sites with the largest and smallest hot water demands. Site #2's relatively small demand negatively impacts the payback period for the solar thermal system. The capital costs are amortizing slowly because the avoided cost from forgone natural gas use is increasing at a slower rate due to the smaller demand. As a result, Site #2 has a longer payback period: 19 years without incentives and 16 years with incentives. Compare this to Site #3, which has the largest demand; avoided energy costs are more significant, resulting in shorter payback periods: 9 years without incentives and 5 years with incentives. The results of the pilot program support the theory that buildings with larger hot water loads are better candidates for SHW systems.

- **Proper siting and orientation matter too**
  When installing solar thermal collectors, maximizing the proportion of the array facing the optimal direction will increase production.

  One of the factors contributing to the suboptimal performance at Site #2 is the orientation of the two solar thermal arrays. Positioned at 90 degree angles to each other, neither array maximizes sunlight capture, thereby limiting the overall system performance. As a result, Site #2 featured a 20% gap between expected and actual production. In contrast, at Site #4, where all 24 collectors are positioned to maximize solar capture year-round, production exceeded expected output by nearly 10%. Performance of these pilot systems illustrates the need for proper siting and orientation.

- **Financial incentives help to make solar thermal payback periods attractive**
  If interested in a solar thermal installation, taking advantage of all available incentives will ensure more attractive returns.

PAYBACK PERIODS FOR PILOT PROGRAM SITES

Site #	Payback Period with Incentives	Payback Period without Incentives	Costs Covered by Incentives
1	5 years	14 years	72%
2	16 years	19 years	26%
3	5 years	9 years	68%
4	<1 year	25 years	99%
Avg	**6.5 years**	**16.75 years**	**66.25%**

As shown in the table above, by taking advantage of federal-, state- and city-offered incentives, the average payback period with incentives is 6.5 years, an entire decade shorter than without them. Excluding Site #2, three out of four sites will achieve payback periods of 5 years or less. Although the effects of financial incentives on payback periods are clear, not all sites took advantage of additional available incentives. Program participants and industry stakeholders reported a general lack of awareness and understanding of additional available incentives. There are two key takeaways that can be made from this observation: (1) for incentive providers – it is important to develop and offer robust, well-publicized and accessible incentive programs and (2) for incentive seekers – it is important to do your homework and take advantage of incentives offered.

- **Data is key to increasing transparency of the benefits of solar thermal systems**
  Collecting and disseminating real metering data will help to advance the understanding of solar thermal systems and increase deployment.

The conclusions and recommendations from the Solar Thermal Pilot Program depend on the collection and analysis of a robust cross-section of data from the various sites. This information will help building owners interested in installing SHW systems to justify investments by reducing the uncertainty around the economics and performance. As more and more building owners install SHW systems and achieve strong results, the case for such systems will only strengthen, speeding future adoption.

POTENTIAL BENEFITS OF SCALING SOLAR THERMAL IN NEW YORK CITY

The pilot program data suggest strong viability for scaling solar thermal adoption in New York City's building stock. To gain further traction, installing solar thermal systems in additional buildings is critical. Beyond the Solar Thermal Pilot Program, strong candidates for solar thermal installations are New York City buildings that are required to convert from heavy forms of heating oil to cleaner fuels under the NYC Clean Heat program.[4] Of the nearly 7,000 buildings catalogued in the NYC Clean Heat program database, the National Renewable Energy Laboratory (NREL) identified 4,565 buildings as particularly impactful.[5] If comparable incentives were offered to these 4,565 buildings to install SHW systems, 9% of the residential buildings would achieve a 5-year payback period and 50% would achieve a 10-year payback. Similarly for commercial buildings, 5- and 10-year payback periods would be achieved for 8% and 24% of the buildings respectively. To the extent that the buildings in the NYC Clean Heat database are representative of the larger New York City building stock, there is a strong case for continuing to offer financial incentives to encourage scaling, particularly when the benefits of SHW adoption are threefold: (1) energy cost savings, (2) emissions reductions and (3) job creation and economic impact.

(1) Energy cost savings for buildings

On average, the four pilot program sites will save system owners over $2,300 per year and more than $46,000 over the 20-year system lifetime. These four systems alone will yield more than $180,000 in total savings. Similar savings can be expected for the 4,565 NREL-identified buildings; using the average annual pilot program savings, the 4,565 buildings could yield total savings of more than $200 million over 20 years.

(2) Emissions reductions

Over the 20-year system lifetime, total avoided emissions for all four sites exceeded 5 million pounds of carbon dioxide. This is equivalent to 627 household-years of avoided natural gas emissions as a result of just four solar thermal systems. Installing solar thermal systems for 20 years on the 4,565 high-potential buildings could result in over 6 billion pounds of avoided emissions or over 700,000 household-years.

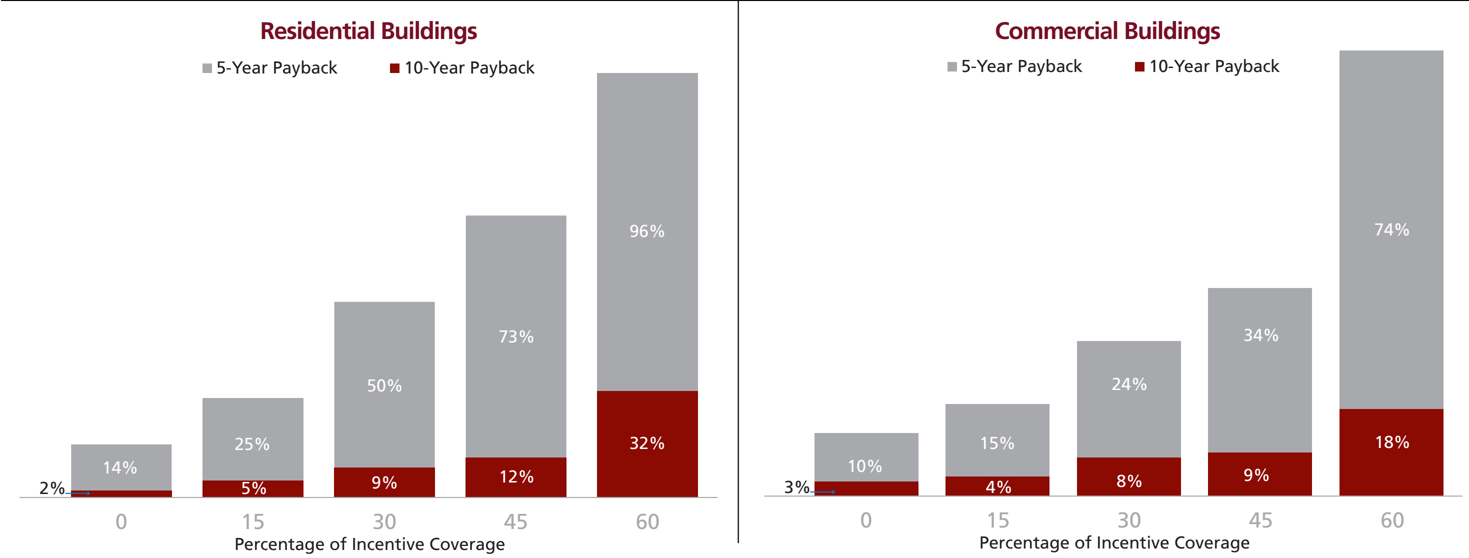
(3) Job creation and economic impact

Applying the average SHW system installation cost, adjusted to reflect larger system size[6], to the 4,565 buildings catalogued in the NYC Clean Heat database yields approximately $8 billion of potential economic activity. Of that potential, 22% of the costs, or $1.8 billion, is attributed to installation. Assuming that 40% of installation costs are for labor, and that the average salary for a solar thermal technician installing one system per month is $50,000[7], we estimate that installing solar thermal systems on 4,565 buildings, just 0.5% of New York City's building stock, will create 1,200 new jobs. When considering that there are nearly 1 million buildings in the five boroughs, the potential for job creation is significant.

Although these figures are likely to vary substantially by building, given the number of variables involved (e.g., building type, energy intensity,

[4] http://www.nyccleanheat.org/
[5] The "low-hanging fruit" buildings are currently burning #4 or #6 fuel oil and have favorable site conditions: high hot water load, are less than 12 stories and have large, open roofs.
[6] 12 times larger on average.
[7] Salary for Solar Thermal Installers and Technicians, 2012, Recruiter.com

PERCENT OF BUILDINGS WITH 5- AND 10-YEAR PAYBACK PERIODS FOR VARYING LEVELS OF INCENTIVE COVERAGE



building system efficiency, relative cost of replaced fuel at given point in time), they do offer strong evidence of real benefits to building owners, the City and the local economy. The results of the Solar Thermal Pilot Program support the need for continued support to scale solar thermal adoption in New York City.

SUPPORTING SOLAR THERMAL MARKET GROWTH IN NEW YORK CITY

Following completion of the Solar Thermal Pilot Program, analysis of data collected from the four pilot sites points to several potential next steps to further facilitate market growth:

- **Focus solar thermal deployment on buildings with favorable site conditions**
  The data suggest that optimal sites for SHW systems are relatively low buildings (10 stories or less) with large, consistent hot water loads and sufficient roof space with unobstructed southern-facing exposure. This ideal building profile characterizes the following categories of buildings: mid-size mixed-use residential commercial buildings; food manufacturing facilities; hotels and motels; university dormitories; hospitals, nursing homes and healthcare facilities; car washes; fire stations; correctional facilities; and swimming pools. Installation of SHW systems at these types of buildings is likely to achieve above-average results including: higher system production, shorter system payback periods and more positive cash flow for system owners.

- **Increase availability and applicability of incentive programs**
  Payback periods for SHW systems diminish with the addition of financial incentives. As seen in the graphs above, by increasing the incentive coverage for installation costs, the percentage of buildings with 5- and 10-year payback periods increases exponentially. For pilot sites, financial incentives averaged $110,000 and yielded an average of $190,000 in 20-year savings. This demonstrates SHW's potential for effectively leveraging incentives, as for each $1 contributed, $1.9 of savings were generated. Renewing current programs, expanding eligibility of existing programs and developing new programs targeted at SHW installations could thus provide both environmental and economic benefits to New York City.

- **Promote awareness of solar thermal technologies**
  Poor industry visibility is partially attributable to a lack of availability of real performance data – solar thermal systems are not commonly metered. To the extent possible, systems should be equipped with performance monitoring meters. This could be facilitated by (1) offering financial incentives for the purchase and installation of meters or (2) making incentive programs performance based. Metered data will allow system owners to evaluate production and performance and communicate value and savings in order to get solar thermal on the radar.

By supporting the growth of the solar thermal market in New York City by focusing deployment at preferable sites, increasing the availability and applicability of incentive programs and promoting awareness of the solar thermal technologies through robust metering, New York City could further the development of a cost-effective, clean technology that has the potential to transform the nature of hot water and space heating. Scaling deployment in New York City will result in substantial energy cost savings for building owners, significant emission reductions, improved air quality and the creation of skilled, local jobs for New York City residents. ■

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For more information, please visit the Solar Thermal Pilot Program website at:
www.nycedc.com/SolarThermalPilot

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