

# *Developing Solar Photovoltaic for Competitively Priced Energy*

*Rose A. Hanzlik CEM  
Constellation Energy*

## ABSTRACT

Parker Hannifin Corporation (“Parker”), in conjunction with Constellation Energy, investigated the possibility of developing a solar installation at its New Britain (Connecticut) manufacturing facility. Parker eventually developed the project after carefully considering all of the relevant factors, which included not only the electricity price (\$/kWh) comparison of solar with traditional brown power, but also future price curves, history of energy prices, and displacement cost with peak vs. blended price considerations.

## PROJECT OVERVIEW

Parker is constantly searching for alternative energy solutions that make sense economically and environmentally. Several essential elements are necessary to produce cost-competitive renewable energy. These include the site location and physical parameters, financial incentives, regional energy costs, and marketable renewable energy certificates (RECs). In 2008, Parker identified its New Britain, CT manufacturing facility (“facility”), part of its Skinner Valve Division, as a strategic site for the development of solar photovoltaic (PV).

Parker’s primary goal was to install a renewable energy technology that was competitive with market-based electricity rates, and reduce the demand for carbon-based electric generation, thereby reducing greenhouse gas (GHG) emissions. Like many large global companies, Parker receives pressure from interested stakeholders about sustainability and corporate responsibility. One such area is carbon emissions and renewable energy.





A difficulty common to companies facing such pressure is that most companies are simply not in the business of being green, and renewable energy is not completely and transparently available on the same pricing platform as brown power. Meeting the sustainable expectations of stakeholders requires thought, care, and effort to ensure the core mission of the business.

In this particular instance, solar energy allows Parker to reduce its overall energy demand, lower costs, and minimize use of brown power. This is all accomplished while avoiding the traditional pitfalls of alternative energy and appropriately addresses the bottom-line concerns of all responsible and progressive companies.

### **Objectives of the Project**

- Use sustainable business practices, while meeting the financial criteria of the business.
- Utilize the facility's newly updated roof for the application of a dedicated solar energy resource.
- Leverage federal and state incentives and apply the Connecticut Light & Power (CL&P) net metering tariff to create a financially viable project.
- Identify a competitive and qualified partner with extensive resources in renewable energy and with the ability to monetize all incentives within a power purchase agreement (PPA), and requiring no upfront capital.

In the spring of 2008, Parker finished a facility-wide roof replacement on its 190,000 sq. ft. Skinner Valve manufacturing plant. This membrane roof was ideal for a solar PV system installation. After completing an engineering site audit of the facility, Constellation Energy's Projects and Services Group (Constellation) identified the unobstructed square footage available for the solar PV system, which dictated the solar PV capacity and project development costs.

Constellation also identified financial incentives critical in achieving an economical solar production cost for Parker. Constellation performed a detailed financial analysis to determine the electricity cost from the solar arrays and compared it with the displacement cost of market-based power, including the cost reductions for non-solar electricity and utility distribution cost.

Parker achieved cost savings by utilizing Constellation's PPA, requiring no upfront capital and by monetizing all of the federal, state, and market incentives to pay down the project cost. The 200 kW<sub>AC</sub> solar PV system reduced Parker's annual energy usage by approximately 303,000 kWh, saving the company over \$900,000 over the next 15 years while at the same time reducing GHG emissions by 200 metric tons per year of CO<sub>2</sub>.

## SOLAR SYSTEM DESIGN

The power system installed at the facility consisted of thin film photovoltaic panels applied directly to the roofing material. The 1,680 solar panels were arranged on the roof membrane, where the slope follows the natural contour drainage of the roof. The panels are in a multiple array configuration, with panels connected electrically in series. Some shading allowances are created by structures; vents; and heating, ventilating and air conditioning (HVAC) equipment.

To prevent shading the solar arrays by any HVAC or other roof mounted equipment, the PV panels were mounted a distance away from equipment equal to approximately twice the height of the object. Although most shading was a result of rooftop HVAC equipment, some was also due to trees, or adjacent roofs of different elevations.

To avoid disrupting the flow of rainwater on the roof, the thin film panels were mounted parallel to the natural flow of water. The system was also mounted 10 feet from the edge of the roof to avoid the installation of permanent fall protection barriers.

For this installation, Constellation used Uni-Solar PVL 144 panels and a Satcon AE-225-60-PV inverter. The panels were fastened without penetrating the roof using a 3M dual locking tape, with one side of the tape on the panels and the other on the roof (see Figure 1, a view of the solar panel mounting arrangement). The tape adhered to the roof with an adhesive approved by the facility's roofing manufacturer and warranty holder. The thin film was mounted flat on the rooftop surface and was oriented to optimize the system output. The electrical harnesses from each panel were routed via the shade covers, which serve two purposes: providing a wireway for wire management and shading the top mounted electrical connections on the panels as required by the manufacturer. The wire is managed from the trays through conduits on

the roof to combiner boxes where central larger conduits were then run to an electrical room. The electrical room houses disconnects and utility tie-in equipment. Because of space limitations, the inverter was installed outdoors in a weatherproof enclosure.

The inverter converts the DC current generated by the PV system to AC and was connected on the load side of the facility's electric distribution. The inverter electrically connected into the customer's main switchboard via a new 400 amp breaker. This required an interconnection agreement with and inspection by the local electric utility.

The utility's primary concern was to ensure that the inverter was UL 1741 listed, ensuring it would shut off when the utility power was not flowing and thus avoid a backflow of electricity into the utility distribution system. The interconnection agreement included a minimum amount of insurance, and allows the utility to shut down the solar system in the event of emergencies. It also ensured safe operations and maintenance (O&M) conditions.

As part of the utility interconnection agreement, the electric utility installed a new "net meter." Also, as part of a grant award for Parker's project, The Connecticut Clean Energy Fund (CCEF) also required the installation of an approved revenue grade meter. This meter verified output associated with incentives awarded to the project, including RECs that the CCEF purchases.

The revenue grade meter was required to conform to the ANSI C12.20, *American National Standard for Electric Meters—0.2 and 0.5 Accuracy Classes*, and had to be certified to be used in the California PBI (performance-based incentive) program. This meant that it must "[meet] performance based incentive program eligibility with certificate documenting accuracy to less than 2%."

The meter installed monitors each phase individually and incorporates the function of single-phase, split-phase, and three-phase meters, to provide over 15 electrical measurements per phase.

## FINANCIAL ENERGY COST ANALYSIS

### Methodology

Table 1 compares the cost of energy produced from the solar array to the cost of the corresponding energy savings resulting from the displaced electricity from ISO New England ([www.iso-ne.com](http://www.iso-ne.com)).



**Figure 1. View of thin film PV mounting arrangement**

As part of its analysis, Constellation established a base case for the facility's 2009 electricity costs based upon its recent hourly consumption history. This is known as the "Business as Usual" case.

Changes in cost and usage caused by a solar system installation—including reduced energy, capacity, transmission, taxes, and other ancillary and retail charges—are referred to as "Displaced Peak Load from Solar."

The post-installation case compares these two data sets, providing an estimate of a solar system's net impact on Parker's calendar year electricity costs delivered to the meter. This is the "Post-Solar Case."

### **Grants and Incentives**

Federal and state incentives created favorable economics for the solar project. These incentives included the investment tax credit (ITC), bonus accelerated depreciation, and Connecticut's Clean Energy Fund. In addition to these incentives, Parker and Constellation structured the project using a power purchase agreement (PPA).

In a PPA, the customer generally has no upfront costs. The customer instead agrees to purchase power generated by the system at known prices for a set period of time. In return, the solar provider finances, builds, owns, operates and maintains the solar system at the customer site.

By shifting development costs and future operations and maintenance duties to the provider, solar systems become an attractive option to many customers.

With no upfront costs, and known energy costs for power as

Table 1. Summary of Estimated 2009 Electric Supply Costs to Meter  
 [Parker Hannifin CT Facility: 222 kW<sub>DC</sub> (200 kW<sub>AC</sub>)]

Cost Component (1)	Base Case Business as Usual (2)	Displaced Peak Load from Solar (3)	Post Solar Case (4)=(2)-(3)
MWh to the Meter Load Factor on Total Load	3,362 46.9%	303 39.4%	3,059 47.8%
Generation, Transmission, and Supply Sub-Total	\$520,204	\$50,374	\$469,830
Distribution Sub-Total	\$99,000	\$12,717	\$86,282
Total Cost per kWh	\$619,203 \$0.18421	\$63,091 \$0.20823	\$556,172 \$0.18183
Annual Savings to Parker Hannifin			
Displaced Cost Value from Solar		\$63,091	
Cost of Solar Production		(\$40,603)	
Net Savings		\$22,188	
Load Factor Improvement with Solar Reduction			
Cost per kWh Before Solar		\$0.18421	
Cost per kWh After Solar		\$0.18183	
Savings per kWh		\$0.00238	
Post Solar kWh		3,058,753	
Annual Savings		\$7,279	
Total Annual Net Savings to Parker Hannifin		\$29,467	

it is consumed, PPAs have quickly become the preferred contracting mechanism for solar projects. PPA-projects represented almost 50% of all non-residential solar PV projects in the U.S. in 2007.

### **Base Case “Business as Usual”**

Base case projections for the facility’s 2009 electricity costs required using the then-current utility rate and forward energy and ancillary charges for calendar 2009. Assumptions for the base case included:

- Recent 12 month history of interval load data
- Generation cost and capacity charges valued at 2009 market prices in ISO New England
- Transmission rate on the Federal Energy Regulatory Commission (FERC) regulated rate
- Utility charges; CL&P tariff schedule.

### **Displaced Peak Load from Solar**

To calculate the value of the displaced peak load resulting from the electricity production of the solar arrays, the facility’s hourly electricity interval data was compared to the anticipated hourly amount of electricity produced by the solar system based on the Department of Energy’s “PV Watts” model for the region. In determining the cost of the displaced electricity load, both the energy (kWh) and peak kW capacity (demand) were included, as well as the avoided utility charges (see Figures 2 and 3). Assumptions used for these calculations are as follows:

- 12-month interval load file from DOE PV watts database; estimated annual usable sunlight per year based upon Hartford (CT) region solar profile
- The peak period, as defined by the ISO New England, occurs between 7:00 AM-10:00 PM Monday through Friday except holidays
- Solar displaces high-priced energy (ISO New England forward peak prices) and capacity during peak periods

- Value based on 2009 base case energy costs.

The solar analysis also included consideration for the facility’s peak demand.

Because solar PV production generally overlaps with the traditional workday (9:00 AM to 5:00 PM), when imported electricity from the grid is the most expensive, resulting reductions create load factor savings.

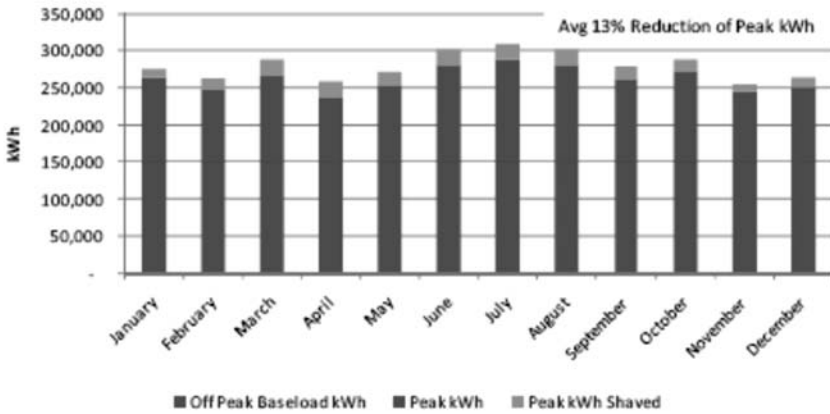


Figure 2. Post Solar Impact on Facility’s Peak kWh Post Solar Case

**Post Solar Case**

The Post Solar Case represents the anticipated grid electricity requirements and cost (based on wholesale forward price curves) for electricity for the facility after the solar system is installed and is in operation. The solar system primarily displaces energy during the on-peak periods but also a small percentage during the off-peak hours (weekends and holidays) as well. Because the solar system produces the majority of the electricity during the peak hours, it displaces the highest cost energy purchased by Parker. This improves both the unit cost for electricity and the load factor for the facility. (See Figure 4 depicting the historical trends of calendar 2009 round the clock (RTC) and 5X16 forward energy and ancillary charges for the ISO New England.)

**Load Factor Improvements**

The solar production occurs during the daylight hours, and has a natural peak shaving affect. Since the facility’s peak energy requirements

occur sometime between midmorning and early afternoon, the solar system positively impacts the overall load factor of the facility. The load factor improvement also results in energy savings, since the resulting non-solar peak kW and kWh are reduced from the base case.

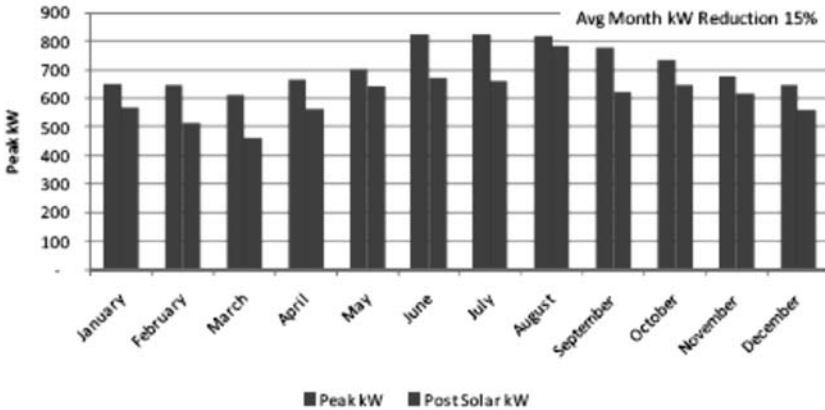


Figure 3. Post Solar Impact on Facility's Peak kW Demand

To show the cost differential between peak power pricing (5X16) and blended round the clock (RTC) pricing, a historical trend is illustrated in Figure 4. In this graph, wholesale energy, ancillary charges, and estimated local distribution charges (CL&P) were included to create a relevant comparison to the solar production cost.

## TAKEAWAY LESSONS

Any customer interested in pursuing solar at their facilities need to take into account several factors:

- 1) **Space:** Generally speaking for roof mounted arrays, commercial facilities need at least 80,000 sq. ft. of unobstructed space to make a project feasible. If installed on a roof, it needs to last long enough to make the solar installation practical—that is, upwards of 15 years.
- 2) **Energy Use:** For an 80,000 sq. ft. installation, a customer's energy

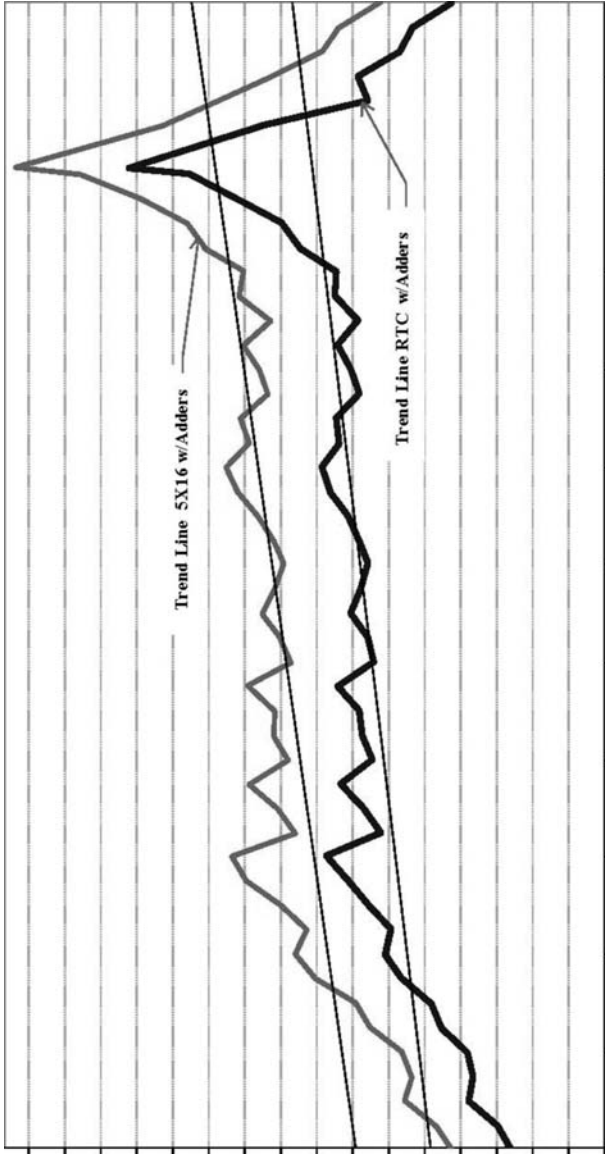


Figure 4. Forward Energy and Ancillary Charges for ISO New England (CL&P)

consumption should be at least 2 million kWh per year to allow for a cost competitive solar project.

- 3) **Grants and Incentives:** In addition to the federal incentives, many states, local governments, and utilities have additional incentives available. These funds can be used to pay down the solar project cost, and if sizeable, can dramatically reduce the cost of solar production.
- 4) **Geography:** Does solar make sense in your location? This analysis is/can be performed by solar system providers, because solar production performance is site specific and determined by the location of a potential project.
- 5) **Price:** The simplest approach is to compare the electricity cost with proposed future solar rates for solar production. Other contracting alternatives, lease vs. turnkey vs. PPAs may impact solar production cost. Your solar provider will provide options for you.

The first three factors in a solar system feasibility analysis are generally “go/no go” considerations. These factors are important and significantly affect the economics and feasibility of a solar project. Solar providers pre-screen potential projects taking these factors into consideration. In combination, these factors ultimately dictate the cost of solar generation.

It would be a mistake to simply compare current energy rates against the solar provider’s cost of power. In the Parker case, Constellation also took into account time-of-use pricing, peak load displacement, load factor improvements, and forward energy projections to determine the actual cost of displaced power.

Parker’s project made use of a power purchase agreement. In a PPA, the customer pays for the solar generation as it is consumed and at a fixed known rate. Parker decided to go with this approach because it eliminated the need for upfront capital and provided price certainty in a volatile energy market. Other customers, faced with similar choices, may decide to go with a different approach depending on their appetite for risk, availability of capital and a required internal rate of return for the investment.

The installation of a solar power generation facility is a long-term

commitment. With adequate suitable space, and appropriate underlying demand, coupled with available financial incentives, contracts can be structured to meet varying customer objectives. Working with an experienced and financially secure partner is imperative because such projects will be in production for 15+ years. The Parker project has proven that solar production can provide competitively priced energy.

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#### ABOUT THE AUTHOR

**Rose A. Hanzlik**, CEM, is the Midwest Senior Business Development Manager for Constellation Energy's Projects and Services Group. Constellation is headquartered in Baltimore, Maryland, with multiple regional offices in the U.S. Ms. Hanzlik has 20 years of energy industry experience in both supply and demand side applications of energy. As Business Development Manager, Ms. Hanzlik evaluates and implements strategic relationships, as well as develops innovative solutions for large users of energy. These include energy consulting, business development and sales of energy related projects. Ms. Hanzlik holds a Bachelor's Degree in Mechanical Engineering from the University of Dayton. She is a member of the Association of Energy Engineers and is a Certified Energy Manager. Ms. Hanzlik can be reached via email at [rose.hanzlik@constellation.com](mailto:rose.hanzlik@constellation.com).