Best Power Int'l, LLC

P.O. Box 5126 Hopkins, MN 55343

Project Title: St. Johns Abbey Solar Addition

Contract Number: (EP4-6)	Report Number: Final	Report Date: 2/16/15
Contract Contact:	Dwight Jelle, (612) 723-8409	
Principal Investigator:	Dwight Jelle, (612) 723-8409	
Congressional District:	Minnesota 3rd (Corporate Office)	
Congressional District:	Minnesota 6th (Project Location)	

FINAL REPORT

Overview/Executive Summary:

St. Johns Solar Addition is a 182 kWDC expansion of the existing 400 kWDC St. John's Solar Farm in Collegeville, MN that was commissioned in 2009. It incorporates an on-site side-by-side comparison of competing solar technologies in the Midwest; linear axis tracker technology currently in place and fixed tilt technology of the new array.

The St. John's Solar Farm and the new addition is owned, operated, and maintained by Best Power Int'l, LLC (BPI) who has a 20-year lease in place with St. John's Abbey. Granular data obtained from the two arrays is available upon request such that researchers and developers can determine which technology is best suited for energy needs and constraints of a particular location Minnesota and in the upper Midwest.

General performance data of the two arrays can be found on the following links:

Tracking: http://live.deckmonitoring.com/?id=saint_johns_solar_farm

Fixed: https://www.sunnyportal.com/Templates/PublicPageOverview.aspx?plant=58949155-b6e2-41bc-b5ac-829f0a8ea3d3

An aspect of the project involved developing performance models of the tracking technology of the existing arrays and the fixed technology of the added arrays were developed. Comparative modeling of the two technologies used generic but identical data at the same location. There were significant differences between the two technologies depending on the goals of the energy provider or consumer. A tracking facility produces 13.9% more energy per kilowatt installed on an annual basis than a fixed system of the same power rating but a fixed system produces a slightly better economic return than a tracking system of the same power rating in a flat, open site due to lower construction costs. Under challenging topographic issues such as slopes and shade, a fixed system is also more economical than a tracking system due to the flexibility in the design of the components. The tracking system produces 69% of its energy in the summer months (April through September) while the fixed system produces just 62%.

The project goal is to install additional fixed-array photovoltaic (PV) capacity at the St. John's Abbey Solar Farm which can be compared to power production from the existing tracker array and increase the market penetration of renewable energy in Minnesota.   Comparing the direct energy production differences, completing upgrades to the monitoring system, having the ability to monitor weather impacts, and providing a comparison of costs between the two systems will provide knowledge and benefits now and into the future for Xcel Energy ratepayers and others.

This project provided many benefits, some during the construction of the project and others that will be achieved over time. By producing approximately 230 MWh's of renewable energy each year, the addition will reduce carbon dioxide emissions by approximately 303,140 pounds per year. The project will result in a significant reduction in other air pollutants such as sulfur dioxide (460 lbs), nitrogen oxides (345 lbs) and mercury (0.0043 lbs)[1].

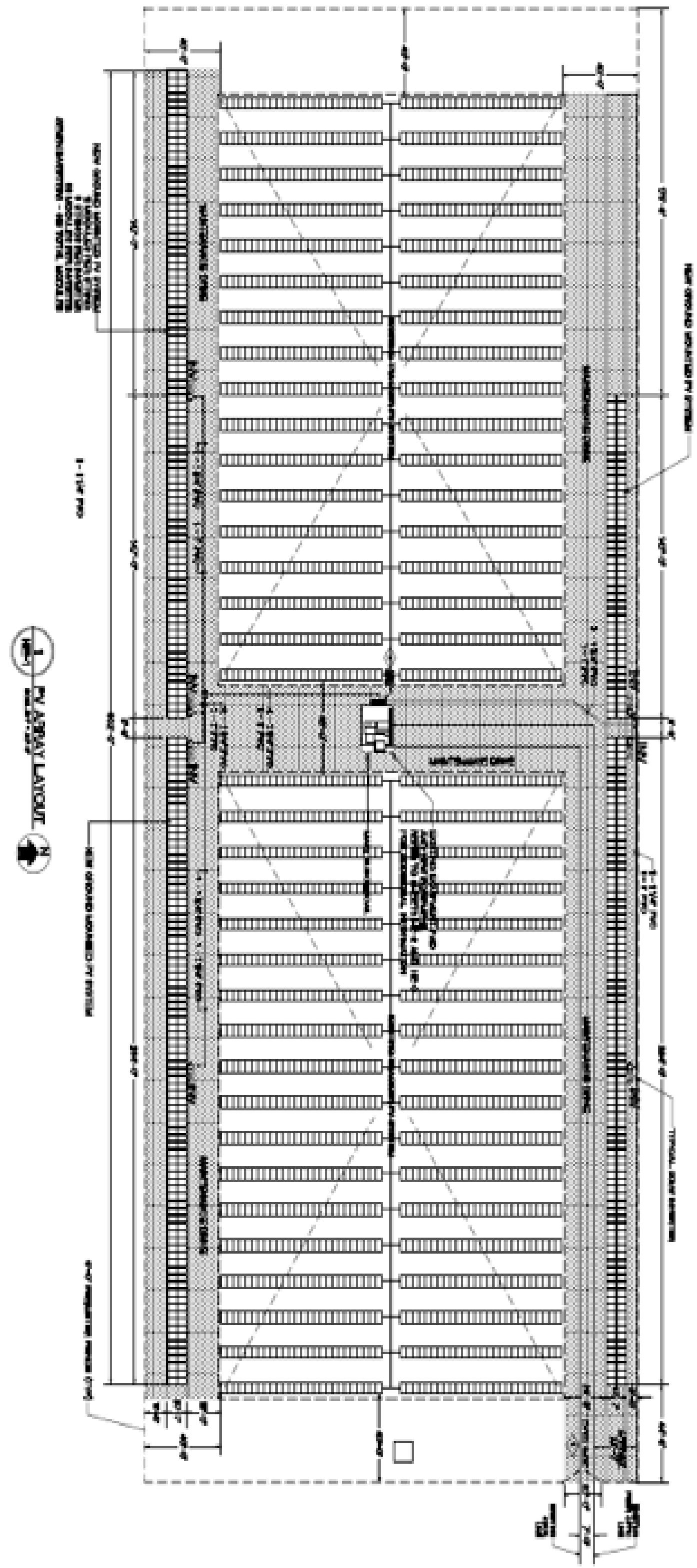
By completing the project within budget, the St. John's addition provided one of the best values in total resource costs in this round of RDF funding. Also, the addition was constructed within the fence of the existing facility, which was an effective use of existing real estate thus lowering the grant amount needed for the system.

By having this comparative facility available, researchers, solar developers, and facility owners will have the opportunity to evaluate the differences in technologies to make better decisions about solar resources in the future.

Press Release Day with Xcel Energy. St. John's Abbey, Best Power, TV and Radio

[1] Source: Xcel Energy 2013 Corporate Responsibility Report

Site Construction Plan



Project Benefits:

The project proposal contemplated benefits in four major areas: Economics, Energy Pricing, Environmental, and Xcel Energy electric ratepayers. The benefit goals have been accomplished with the following outcomes:

Immediate benefits realized at completion of the project:

1. Taxable Income will be generated based on fees paid to contractors in the amount of approximately $100,000.
2. Because of the efficiency of the new addition, this project provided one of the lowest resource costs compared to other projects awarded during this RDF cycle.
3. Local construction jobs were created. Approximately 5-full-time people worked on the project site for 6 weeks. Bad weather stretched the job duration from 4 weeks to 6 weeks, thus reducing the amount of full-time workers required.
4. The purchase of $173,000 of materials and services were purchased from Minnesota suppliers and contractors providing an economic stimulus to the Minnesota economy.
5. The project provides a full-scale comparison between a fixed racking technology and single axis tracking technology at the same location with the same owner/operator. Information to make better decisions learned from this project can be utilized to lower the cost of solar energy in the future.
6. The project has provided hands on demonstration on what is involved when adding on to an existing solar facility.
7. The project provides a comparison of string inverters to a central inverter at the same facility with the added benefit of the same owner/operator.
8. The project will provide additional educational benefits that will be administered by St. Johns University. The existing facility has been shown to hundreds of students and interested groups from around the state of Minnesota. More tours are planned. This additional capacity has a research component that will enhance the education experience and promote increased utilization of the facility.
9. Press coverage in print, radio, and television helps to educate people in the St. Cloud area about solar energy.
10. The knowledge obtained through this demonstration project has allowed project team members to expand their service offerings and their ability to deliver similar solar projects in Minnesota. By adding this knowledge, better decisions about design and construction of future facilities will lower the cost of future projects.
11. Data from the project has concluded that there are significant differences in technologies and that selection of technologies will depend on the shape of the parcel, the topography, and the goals of the entity using the power as well as the entity producing the power.
12. A camera was added to the facility that will help better understand the impacts of weather on the two systems. *Link to the camera http://152.65.12.88; User Name: guest; Password: guest2014*

Benefits realized over time:

1. Taxable income in the amount of approximately $587,000 will be generated based on the grant amount and electricity generated during the first 15 years of operation.
2. During the 15 years of production under the initial power purchase agreement, the facility will produce approximately 3,290 MWh's of renewable energy, all of which will count towards Xcel Energy's Renewable Portfolio Standard.
3. The project will produce the following annual environmental benefits during its first year while producing 230 MWh of energy:
   - The equivalent of 349,646 pounds of carbon dioxide (CO_2) not released
   - The equivalent of 2,990 pounds of sulfur dioxide (SOx) not released

- The equivalent of 1,380 pounds of Nitrogen oxides (NOx) not released
- Approximately 170,350 pounds of coal not used

Project Lessons Learned:

1. **Site Issues:** Being that BPI developed the initial project, most site issues were well documented and known prior to facility design. We had an issue locating the existing underground high voltage wiring causing a slight delay. Completing an accurate as-built drawing after construction and having it available is helpful for future on-site construction and maintenance of a facility.
2. **Financing:** BPI has been interested in getting local banks to understand and finance a local solar project for the past several years. It has been a problem to find a local financing partner for solar projects. Working with Voyager Bank in Eden Prairie, we were able to educate them on the risks of solar lending and come up with a solution for this project. It is important to start very early in the process to obtain financing.
3. **Contractor Experience:** Despite the fact that the existing facility was installed five years ago, it was difficult to find qualified contractors for some phases of the work. Some experienced solar contractors were not interested because the project was too small. There is a real need for experienced crews to install projects between 100 kW and 1,000 kW. Due to the programs at Xcel Energy, there seems to be several firms that are experienced at the 40 kW level. A contractor selected to do ta specific portion of the work may have experience with solar, but the crews on site may not have that experience. By not having solar experience, specifically at the transitional scale between small residential and large commercial, new lessons had to be learned that slowed down the process. Gearing up a solar workforce with the right equipment for mid-level solar projects is important and needs to be considered when selecting a contractor.
4. **Interconnection Process:** Despite five pretty strong years of solar experience, Xcel Energy lacks the process and perhaps the assignment of the right people, to effectively process interconnect applications. Even though we had an existing interconnect agreement that only needed a minor amendment, it took over nine months to get the amendment processed. Also, the interconnect forms required work well for traditional energy generators such as natural gas or coal, but are not conducive to solar plants due to different power characteristics and number of inverters that may be needed. We would encourage Xcel Energy to review this process and make improvements.
5. **Completion of Design and Engineering:** Early coordination with an engineering team is critical. BPI originally thought that we could add onto the existing 500 kWAC inverter due to the fact that the inverter had excess capacity. Because the type and orientation of the panels from the addition are different than the existing system, we discovered there would be variable voltage that would reduce the energy production of the entire system as a whole. The existing inverter did not have multiple power-point tracking (MPPT) which may have accommodated the variable voltage of the additional capacity installed. Most new models come standard with this feature. The solution was to add inverters that would work for the addition. This added a significant cost to the project.
6. **Procurement of Equipment:** Selecting a product is the beginning of a 20+ year relationship and demands critical review of the product specification, warranty and overall company viability. While price is a critical component of equipment selection, company viability is more important. A warrantee has no benefit if the company goes bankrupt? Selecting a product with a viable, long-term warranty is especially difficult in the ever-changing fast pace of the renewable energy business. We learned that the solar panels drive the design of the entire system and the selection needs to be made early. All other components of the plant depend on the specifications of the panel. Because the panel pricing has been moving dramatically for the past 12 months, it was financially difficult to commit to a panel early. Because the interconnection process takes so long, and the interconnect application needs a system design, making the commitment to a specific panel has to be well thought out.
7. **Obtain Permits and Licenses:** This process went well and was easy to do. The State inspectors were available and knowledgeable. Because we had built the existing facility and it was well received, city

approvals went very well.

8. **Rack Design:** The fixed racking industry has gone through major changes in the last 12 months with a major price war. Getting early quotes on racking with limited site information can be misleading because racking companies are assuming the best site conditions so that early quotes are competitive. We learned that having very good soil information and understanding snow and wind loading is important to reliable pricing quotes. We went with a 35-degree rack for this project that is ideal for maximum energy production at this latitude. Most of the racking design and cost depends on snow loading in the St. Could area. Snow loading determines the post spacing of the foundations. Usually tilt angle will matter due to wind loads. Since snow loading was governing the design, there was no cost increase to go from 30-degrees to 35-degrees.
9. **Equipment Delivery:** The trucking industry was hard to deal with during the delivery process. Being that the site is somewhat remote, it was difficult to have people and equipment on-site when the trucks "decided" to arrive. We had three major deliveries and all three arrived at times that were not scheduled and without advanced notice. Having a plan B to unload trucks is critical. The truckers also could not deal with the fact that the existing cornfield did not have an address. Creating a map and providing a GPS address provided some value, but the dispatching entity did not always pass that information on to the trucker. Trying to get access directly to the trucker is also helpful.
10. **Solar Panel Installation:** The contractor selected for this work took the position that since the solar panels are electrical equipment that they had to be installed under the supervision of licensed electricians. This position added to the cost for this portion of the project by over 50%. The state of Minnesota should realize that this activity is not an electrical function and only adds to the cost of solar energy without adding value. The panel is merely an appliance with a plugin that is more related to framing than it is electrical work.
11. **Financial Comparison:** We expected that a fixed system, being that it is less expensive, would provide a much better economic return than a tracking system. When performing cost and production models we found that the fixed system only provided a small increase (0.3%) in financial return over a 15-year period with the assumptions we made including the same price of energy and identical, flat site conditions. The use of trackers on larger sites, with greater economies of scale, may prove to be more cost effective than fixed systems.

Usefulness of Project Findings:

The project findings in lessons learned and technical progress have been valuable during this RDF reporting period, but will provide more value over time as weather impacts and energy comparisons can be studied over a longer period of time. It is likely that 3 to 5 years of observations will be required to have detailed, meaningful conclusions.

The direct cost and energy comparisons of the two systems that BPI provided for this report was valuable in that time was taken to make the comparison and make it public. Understanding the complexities of providing energy based on the vast amount of technical choices is important and this study has provided more clarity to those complexities.

This project has documented through modeling the energy characteristics of two technologies, fixed arrays and single-axis tracking arrays. Actual production data from this facility will determine the accuracy of the models so that this information will be useful to solar system designers, owners and electric users. The data has shown that, depending on the goal of the system; different technologies provide different energy and capacity results. To date in Minnesota, the general goal has been to produce the most amount of energy per dollar invested to maximize the renewable energy created because of the Renewable Energy Standard (RES), not capacity. In the future, as the penetration of solar increases, peak energy, time of day production, and seasonal variations will all be important in future system design and implementation as the value of each of these characteristics may be different for the entity purchasing or using the power.

Technical Progress:

The purpose of this addition to the St. Johns Solar Farm was to study the differences in a fixed rack system to a single axis tracking system at the same location. There are installations of each type in Minnesota, but to our knowledge, there is not a location that employs both technologies.

Typically, a solar energy system will have a goal for energy production. It may be to maximize the energy produced on an annual basis to satisfy a renewable energy portfolio, or to perhaps maximize summer energy production where the cost of electricity may be at a premium due to demand. There also may be a desire to maximize morning or afternoon energy production depending on a facilities need. Depending on the goal, different technical solutions such as a tracker or a fixed rack will provide the solution. As solar energy production matures and becomes more dominant, these goals will change depending on the needs of the sellers, buyers and users of the energy.

Also to be summarized are the installation differences, cost differences, and weather impacts between the two systems.

System Description:

The new addition consists of a static south facing 181.72 kWDC ground-mounted photovoltaic (PV) array tilted at 35-degrees (fixed). The existing solar farm consists of a single-axis tracking 400 kWDC ground mounted PV array (tracking). The new addition started construction on November 4, 2014 and was commissioned for trial energy on December 24, 2014.

Panorama of the site. Existing system to the left and the addition to the right

Fixed System:
181.72 kWDC
35-degree fixed tilt racking – 2-high portrait
295 Watt Trina 72-cell Multi-crystalline panels
7 SMA 20,000US-TL String Inverters

Single Axis Tracking System:
181.72 kWDC
Tracking East to West – Single Panel
220 Watt Silicon 60-cell Multi-crystalline panels
1 AE Solaron 500 Central Inverter

Generation Comparison:
To model the generation of the two systems, we used the National Renewable Energy Laboratory (NREL) PVWATTs irradiation data. Adjustments to account for snow were made based on past results from the existing tracking system as well as experience from the 600 kWDC fixed rack system that Best Power Int'l (BPI) owns and operates located on the Minneapolis Convention Center. In addition, actual data from the two systems has been modeled during January of 2015.

A comparison of the energy generation annually, seasonal, monthly, and daily between the two systems is presented. For the purposes of this comparison, we have used the new fixed rack addition of 181.72 kWDC as the baseline and prorated the existing single axis tracking system to the same size. While not a perfect comparison, past data from the single axis tracking system has important value due to the last 5 years of operating experience. The fixed system was designed to produce the maximum energy possible on an annual basis. The optimum angle of the panels at this latitude (45.5-degrees) is approximately 35-degrees.

Annual:
Based on a PV Watts simulation, along with weather experience at the existing site, we have found that the tracking system will produce approximately 13.9% more energy on a calendar basis than the fixed rack that was designed for maximum annual production. Both systems were modeled assuming the same system losses and inverter efficiencies to make the comparison equal.

Fixed Rack: 229,900 kWh/year
Single Axis Tracking: 261,800 kWh/year (13.9% more)

Seasonal:
Based on the same PV Watts simulation, it is interesting to compare the summer (April through September) and winter generation totals between the two systems (See Table 1). Because of the orientation of the tracking panels (essentially flat at 12:00pm), the tracking system produces a much larger percentage of its energy during the summer months when the sun is directly overhead. If the fixed system were placed at a much flatter angle (i.e.: 10-degrees compared to 35-degrees) so that during the summer months, the sun is closer to a right angle, the difference between the two systems would be much smaller but the total energy produced would be compromised for the fixed system being that 35 degrees is ideal at this latitude for maximum energy production.

Season	**Tracking**	**%**	**35° Fixed**	**%**
	kWh		kWh	
Summer	181,255	69%	142,699	62%
Winter	80,544	31%	87,171	38%
Total	**261,799**		**229,870**	
kWh/KW	1,441		1,265	
Capacity Factor	16.45%		14.44%	

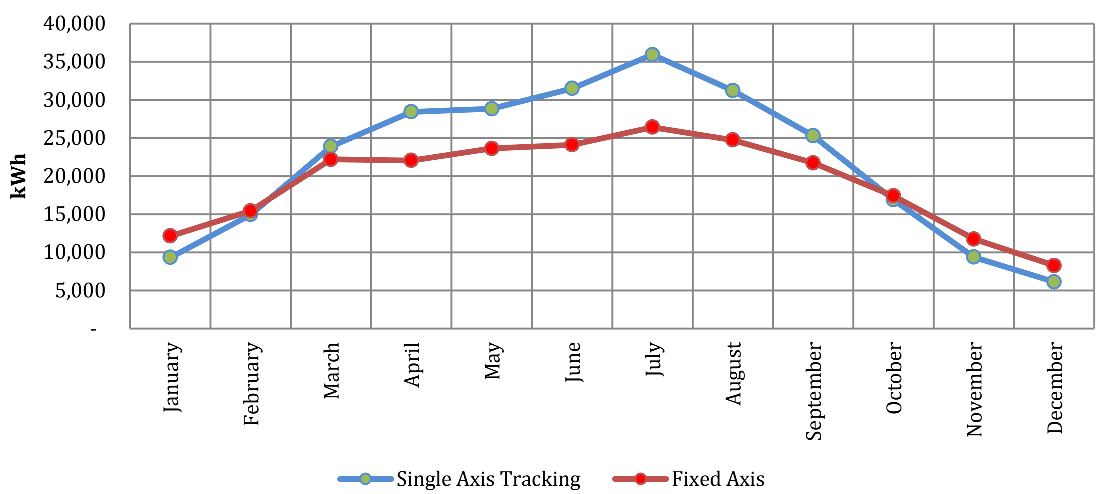
Table 1 Seasonal Variation

Monthly:
Based on the same PV Watts simulation with adjustments to match local conditions, there are significant monthly variations in production between the two systems. The fixed system produces 30% more energy than the tracking system in January, but the tracking system produces 31% more energy than the fixed system in July. See Table 2 for monthly totals and Figure 1 for a graph of the annual generation.

Month	Tracking	35° Fixed	Difference	% of Fixed
	kWh	kWh	kWh	
January	9,324	12,139	-2,815	77%
February	14,956	15,446	-490	97%
March	23,900	22,191	1,709	108%
April	28,444	22,062	6,382	129%
May	28,842	23,635	5,208	122%
June	31,503	24,107	7,396	131%
July	35,933	26,415	9,519	136%
August	31,223	24,736	6,486	126%
September	25,309	21,744	3,566	116%
October	16,885	17,395	-510	97%
November	9,359	11,741	-2,382	80%
December	6,120	8,258	-2,139	74%
Total	**261,799**	**229,870**	**31,929**	**14%**

Table 2 – Monthly Energy Comparison

Figure 1 - Monthly Energy Comparison

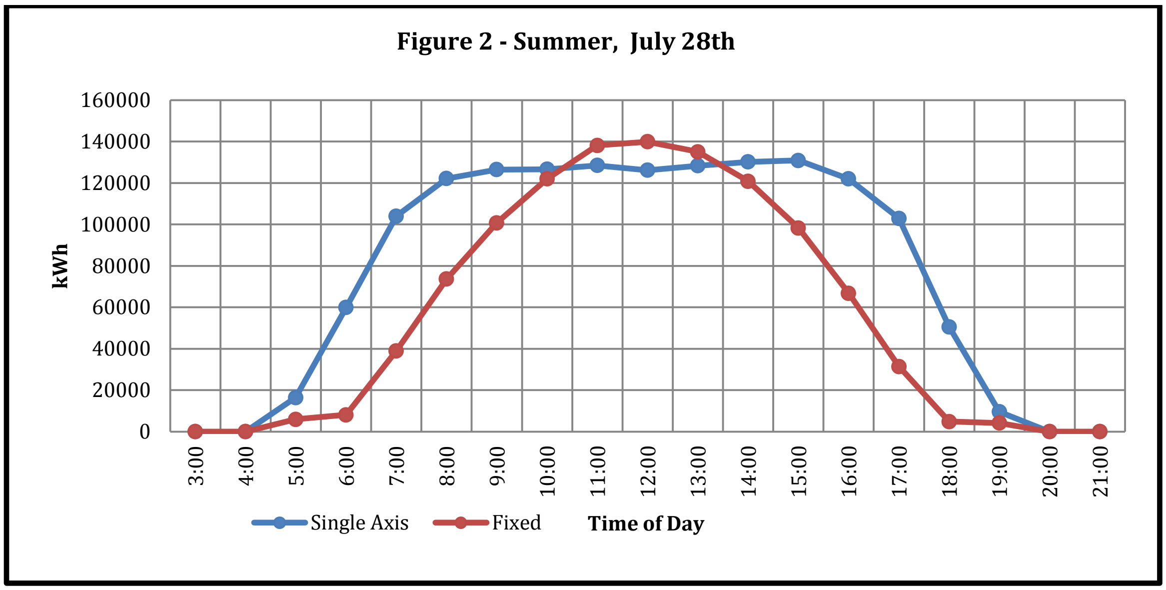


Daily:
A large part of the value of electrical energy is a result of supply and demand during the day. When the demand is the highest, utilities are forced to deploy generation resources that are more expensive to satisfy that demand. Part of the value of solar energy is that it generally produces energy when the load is within its peak demand period during the summer months.

As shown in Figures 2 and 3, there are significant differences in power produced between the two types of systems depending on what time of day it is. The fixed system follows a bell curve producing the most power when the sun is at right angles to the panels that occurs generally around noon. In mid-summer, the tracking system produces a minor peak in the morning, levels off through the midday and has a minor peak in the afternoon before falling off in the late afternoon, tracking the sun at right angles throughout the day. In the winter the tracking system produces a large peak in the morning and afternoon, all relating to the angle of the sun on the panels. The closer to right angle the sun gets to the panels, the more power produced.

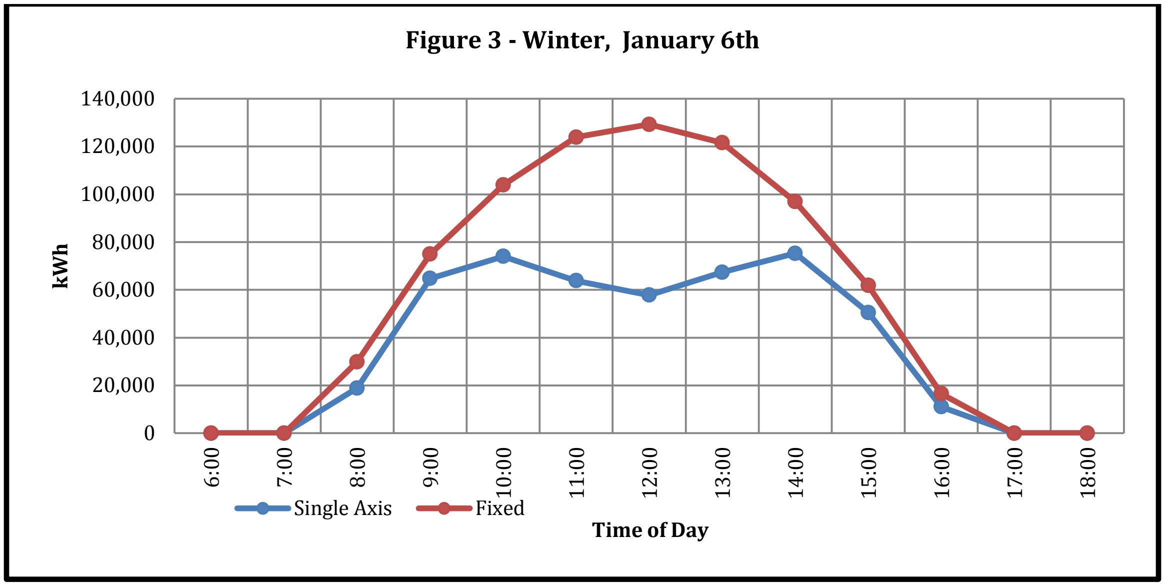
One of the clear advantages of the tracking system is that is produces more energy earlier in the morning and later in the afternoon than a fixed system. Xcel Energy, in the Midwest market has its peak need in the summer, late in the afternoon. The tracking system produces the same amount of energy as the fixed system 2 hours later in the day because it maintains a better angle towards the sun. As shown on Figures 2 and 3, the energy production values for the two systems are dramatic on a sunny day in July as well as a sunny day in January.

The Midwest Independent System Operator (MISO) is the entity that controls the transmission grid throughout a large part of the Midwest. MISO defines summer peak loads that generally occur within its system between the hours of 12:00pm and 6:00pm, excluding weekends and holidays. Table 3 lists the data for July 28th, a particular sunny day showing that a tracking system produces 32% more energy during peak MISO periods of 12:00pm-6:00pm than a fixed system, and produces 22% more energy during Xcel Energy peak periods of 9:00am-900pm.

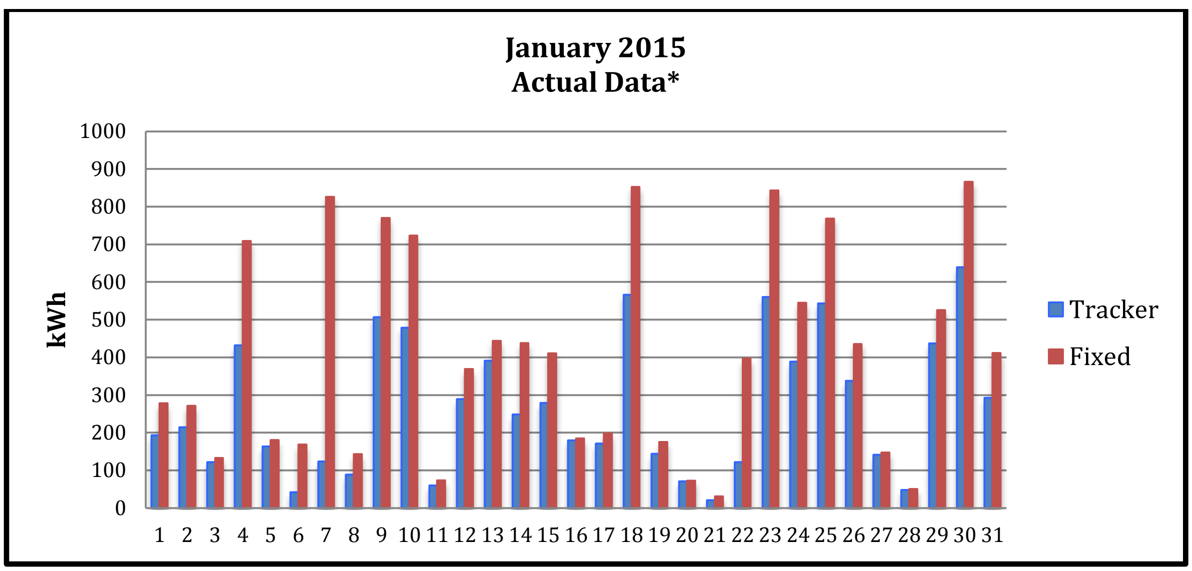


July 28 – PV Watts Data			
Time	Tracking	Fixed	% Difference
	kWh	kWh	
12:00pm-6:00pm	719	543	32%
9:00am-9:00pm	1,089	894	22%
Total Day	1,388	1,018	36%

Table 3 Hourly Generation Comparison on July 28th (PV Watts data)



Actual Data:
The new addition has been generating electricity since December 24, 2014. We have compared the actual data of the two systems for the month of January, 2015. The tracking system was prorated to a 181.72kWDC system to match the power rating of the fixed system. As shown in Figure 4, the fixed system outperformed the tracking system every day during the time period studied. From Table 2, the fixed system should produce approximately 30% more energy in January on average. For the time period studied, the fixed system (12,452 kWh) produced 50% more energy than the tracking system (8,304 kWh). The major reason for this difference is weather. During this period, there were three snow events that impacted each system differently, in all three cases, favoring the fixed system. Other differences could be degradation on the tracking panels, as well as underperforming strings in the tracking system.



* Both systems rated at 181.72 kW. Because there are different manufactures of the panels and inverters between the two systems, the comparison is not identical. It is estimated that the equipment differences could amount to a 2% difference either way.

Cost Implications:

One of the major factors that determine which solar energy technology to use is cost. There are several factors that result in cost implications for the two types of systems. In order to make a direct comparison on the two technologies, we have assumed that all site conditions are the same for both technologies. This comparison assumes only minimum grading, a relatively simple grid interconnect, and a 600V design.

From our research and pricing during the summer of 2014, on the same piece of generally level ground at a 1.0 MWDC scale, we found the total system capital cost of $2.15/Watt for a single axis tracking system and $1.95/Watt for a fixed racking system. Therefore the tracking system costs 9.3% more than a fixed system.

- **Land Area:** Due to the technology, a tracking system will require slightly more land than a fixed system if maximum generation is desired. A tracking system tilts from 45-degrees east to 45-degrees west needing a wider row spacing to avoid shading. Therefore a tracking system will require more lease payments or purchased land than a fixed system.
- **Site work**: Topography is a major factor in determining the cost of a solar system. Tracking systems require generally level land whereas a fixed system can follow a certain amount of undulating topography without major grading costs. Tracking systems must also be built in specific blocks to take full advantage of the technology whereas fixed systems have essentially unlimited design variations to take advantage of the shape of the land parcel.
- **Racking Cost:** Assuming a site with acceptable soils and generally flat topography, foundation and racking costs for a tracking system in the 1 MWDC size scale will cost approximately $0.40/Watt installed. On the same piece of land, a fixed system of the same power rating would cost approximately $0.25/Watt installed. This is the major cost difference between the two technologies. A tracking system requires motors or actuators and other moving parts adding to the complexity and cost.
- **Maintenance Cost:** A tracking system will require additional maintenance due to mechanical moving parts. We have found this cost difference between the two systems to be very low. Tracker maintenance can be performed at the same time as inverter maintenance so no extra trips are typically required.
- **Balance of system:** The remaining system costs including panels, inverters and system wiring are similar between system types. There are differences, but not significant.
- **Natural Resources:** While not currently a cost factor for solar installations, a tracking system and a fixed system require approximately the same amount of natural resources (steel, aluminum, sand, copper, etc.) to build. The tracking system produces 13.9% more energy than a fixed system while using approximately the same amount of natural resources.
- **Insurance**: Because insurance costs are based on the value of the system, insurance for a single axis tracking system will be higher than for a fixed system of the same power rating.
- **Financing**: Financing costs relate to the initial capital cost of the system. A tracking system will require more financing costs than a fixed system.
- **Energy Production**: As shown in the data above, the tracking system will produce 13.9% more energy on an annual basis than a fixed system thus providing more value.
- **Energy Value:** As shown in the data above, the tracking system produces more energy during peak times in both the MISO and Xcel Energy footprints. Energy during peak times is more valuable than energy produced in non-peak times.

The initial conclusion would lead to the tracker being a better financial solution because it only costs 9.3% more, but produces 13.9% more energy on an annual basis. However, it is more complicated than that. BPI ran a financial model assuming that the PPA rate (or the value of energy) was the same for both technologies at $100.00/MWh over a 25 year time period that escalates at an annual rate of 2.5%. Assuming current IRS rules of MACRS depreciation and a 30% federal tax credit, the fixed system provides a slightly better return to an investor over a 15, 20 and 25-year time period (approximately 0.3%). Based on the model's parameters, the value of energy during the first year would need to increase to $105.00/MWh (or 5%) to make the financial return for the tracker equal to that of the fixed system at $100.00/MWh.

Please note that there are many variations that go into a financial model. Also, individual investors will have different needs from a rate of return or tax criteria standpoint that makes the models hard to compare.

Weather Impacts:
An important part of this comparison, as time goes on, will be the observations made regarding reductions in generation due to snow and ice impacts. Having a fixed system at 35-degrees and a tracking system that rotates to a maximum of 45-degrees at the same site experiencing the same conditions will be valuable to determine the energy loss due to snow and ice cover.

We have compared snow impacts at St. Johns (tracking) and the Minneapolis Convention Center (fixed at 30-degrees) but each snowfall at different locations varied considerably with temperature, wind conditions, and amount of snow. This facility will provide same location results. We have installed a camera as part of this project that will allow frequent observations. See Figure 4 below to see a progression of snow melting on site from December 26 through December 28, 2014. The high temperature during this period was 21° F. From the camera, it appears that the tracking system had shed most of the snow on the morning tilt on the 26th. However, data obtained throughout the week suggested that the tracking system had snow impacts not captured by the camera while the fixed system performed at full capacity by the afternoon of December 28th.

12/26/14 10:52am 12/27/14 12:39pm 12/28/14 11:38am

Figure 4 – Photo Progression from on-site camera

The tracking system stows at night parallel to the ground, which under calm conditions would collect snow. It stows in this position to reduce its exposure to high winds. We have noticed that since the tracker rotates to 45-degrees, depending on temperature and wind impacts, the snow generally slides off. However, in some cases the snow sticks to the panels if the temperature is high enough. We are finding that when the snow sticks to the panels, the direct sunlight that the fixed system experiences works better for melting snow and ice.

Because winter generation is so low at this latitude compared to summer periods, snow impacts may not be a significant issue in any case. The snow months in this climate that impact panels for several days and weeks at a time occur, for the most part, in December and January. For a tracking system, January and December produce 5.9% of the annual energy. For a fixed system it is 8.9%. Any impacts due to snow may be minimal on an annual basis in either case.

Summary:

Modeling of the two technologies using generic but identical data at the same location has shown that there are significant differences between the two technologies depending on the goals of the energy provider or consumer. The following is a summary of the modeling outcomes:

- Assuming a flat, open site with identical energy rates, a fixed system produces a slightly better economic return than a tracking system of the same power rating of 1MWDC due to lower construction costs.
- Under challenging topographic issues such as slopes and shade, a fixed system is more economical than a tracking system due to the flexibility in the design of the components.
- A tracking facility produces 13.9% more energy per kilowatt installed on an annual basis than a fixed system of the same power rating. The Direct Current (DC) capacity factor (electricity produced relative to the maximum it could produce at continuous full power operation) for a tracker is 16.45% while a fixed system is 14.44%.
- A tracker produces more energy earlier in the morning and later in the afternoon than a fixed system during the summer months.
- A tracker produces 22% more energy than a fixed system during the Xcel Energy peak period of 9:00am to 9:00pm during a sunny, late July day.
- A fixed system produces 8% more energy in the winter months from October through February than a tracker.
- The tracking system produces 69% of its energy in the summer months (April through September) while the fixed system produces just 62%.
- Reductions in generation differences due to snow and ice impacts are complicated and not conclusive at this time.

Project funding provided by customers of Xcel Energy through a grant from the Renewable Development Fund.

LEGAL NOTICE

APPENDIX – PHOTOS


Post Layout


Pounding Posts


New DC Wire


Racking Assembly


Final Racking Adjustments


Racking Nearing Completion


New Electrical Equipment


1 of 7 new 20kW Inverters

APPENDIX – PHOTOS CONTINUED

Panels Being Delivered

Racking Install On Press Day

North row of Panels Complete

Existing Tracking system w/addition

Panoramic view of both systems