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Project Title: Municipal Landfill Solar Energy Demonstration

Contract Number: EP4-41 Report Number: 4 Final Report Date: 4-8-16

Reporting Period: Final Report

Progress Summary: Milestone #1 (100% complete)

Principal Investigator: John Paulson (320)234-5682 Contract Contact: John Paulson (320)234-5682

FINAL REPORT

Executive Summary

The City of Hutchinson, with assistance from Ameresco, Inc. has completed construction of a 399.75 kW solar photovoltaic (PV) array. The system operation date was November 25, 2015. The project used the latest generation of tenKsolar photovoltaic equipment as a ground-mounted system on a capped municipal landfill site adjacent to the City's Wastewater Treatment Plant at 1300 Adams Street SE in Hutchinson. This project was engineered and designed using tenKsolar RAIS Wave equipment with a total of 975 panels rated at 410 watts each. The project was completed on time and under budget.

The total installed cost for the entire project was $3.94 per watt for a total project cost of $1,576,771. Final design, engineering and procurement were completed July 2015 with construction beginning in October 2015. Construction was completed in the end of November 2015 with the commissioning of the system. Final project payment to Ameresco, Inc. and close out occurred in early January 2016.

This project is a model in Minnesota for how to cost-effectively develop a significant solar energy resource on a landfill, or brownfield that would otherwise have little or no economic value to the City. Hutchinson's electric customers are served by a municipal utility. The City will own the solar energy facility and self-generate electrical power to offset the substantial electrical demands at its Wastewater Treatment Plant that are paid for by the City of Hutchinson sanitary sewer customers. This unique "brownfields-to-brightfields" project will be a model for more than 100 other closed landfill sites in Minnesota, many of them in the Xcel Energy service territory. Implementation of solar photovoltaic systems during the redevelopment of brownfields could also utilize this project design. The cost effectiveness of future solar PV projects can be easily enhanced by capitalizing on existing incentives such as, Made in Minnesota production incentives, Xcel Energy's Community Solar Garden program, and Xcel Energy's Solar Rewards.

This project proves that the solar PV redevelopment potential at both existing landfills and brownfields throughout Xcel Energy's service territory is significant.

This project is the first of its kind in Minnesota on a closed landfill site. tenKsolar's unique system design allowed the system to be built without any penetrations into the surface of the landfill, which will be a model for other landfill sites in the state that may wish to develop a similar solar energy installation. Typical ground penetration to anchor ground-mounted solar array installations were avoided. Ballasted construction materials were used in place of traditional anchoring techniques. These included the use of ballasted piers for supporting the array, ballasted security fencing that used concrete blocks and gravel for support, and overland conduit routing. Another key consideration that ultimately determined the size of the system was utilizing all power produced behind the meter at the City Wastewater Treatment Facility (WWTF). The array was sized so the maximum production modeled output of the system would not exceed the minimum power demand at the adjacent WWTF. The WWTF operates around the clock and uses more electricity than any other City owned facility. The proximity of the system to this type of electricity end user made it the optimum location. The WWTF has relatively consistent power demand throughout the day with various peaks that are due to changes in wastewater strength loading and flows. Close proximity of solar energy systems to the ultimate destination of that energy has a direct effect on both projects logistics and applicable agreement development. By using the energy produced behind the meter, and in close proximity to the power source, this project minimized line loss in distributing the power as well as eliminating the potential need to upgrade utility transmission systems to accommodate the additional power produced.

This project relied on a feasibility study conducted on behalf of the City by Ameresco, Inc., a certified Minnesota Energy Services Company (ESCO), that served as the City's design-build contractor for the solar energy project. Ameresco will assist with operation and maintenance of the system for a period of 14 years and guarantee the energy performance of the system under Minnesota's Energy Savings Guarantee contracting rules. At the end of this 14-year O&M period, the solar energy project will be operated directly by the City. All of the power produced by the system will directly offset the City's electric costs at its Treatment Plant. The system is operating as anticipated and has met the goals identified during project development.

Project Benefits

Various benefits from this project are being realized already. There are also long range benefits that will be realized over a much longer timeframe. The following is a summary of the various benefits related to job creation, taxes, cost effectiveness, market size, rate payer and other benefits.

The City of Hutchinson contracted with Ameresco (Eden Prairie, MN office) for installation of the solar energy system. The project required a subcontract with Hunt Electric's (Bloomington, MN) installer team for at least 2,000 labor hours over a six-month period beginning in July 2015. Ameresco's development model relied on sub-contracting locally for all of the direct labor, electrical interconnection work, and most of the other professional services that were required to complete the project. This resulted in a significant economic investment in Minnesota's growing solar energy and related businesses and will sustain and create a number of good-paying jobs in

this part of the state.

In addition, the procurement of solar panels and related equipment from tenKsolar will strengthen that firm and manufacturing employment at the tenKsolar facility in Bloomington.

There were no sales tax revenues from the procurement of equipment for these systems. Likewise, the project site is non-taxable and publicly-owned so there will be no additional market value subject to higher property tax payments as a result of this project.

There was a small amount of fee revenue for the City and State from issuance of the electrical, building and other land use permits for the project. The most significant impact on sanitary sewer rates will be from the savings on electrical costs at the Waste Water Treatment plant over the next 25 years, savings that greatly reduce the need to increase rates required to operate that facility.

State tax revenues have resulted from wages and salaries paid to employees of firms sub-contracted to do work on the project. While the project is expected to have $1.57 million of mostly direct effects on the state economy, the Governor's 2009 Green Jobs Task Force estimated that renewable energy projects have more than a five-times multiplier for measuring the indirect impact of renewable energy projects, which would be an economic impact of $7.9 million in the case of the Hutchinson project.

Solar energy systems that are developed by public agencies such as the City have project approval processes such as public hearings and televised City Council meetings that help to educate the general public about the costs and benefits of solar energy in Minnesota. In a sense, as residents of the City, every business and individual living in Hutchinson has an ownership stake in this City-owned solar energy project.

Hutchinson is committed to capturing the lessons learned from this project and sharing that information with other communities that may wish to develop solar energy project on closed landfill sites. The City's findings and conclusions will be shared with other communities in the various forums in which Hutchinson interacts with other local units of government in Minnesota and as requested by those units of government. The project was recently highlighted at a Minnesota Brownfields workshop (presentation details included in the Appendix). The intent of the workshop was to showcase and discuss renewable energy deployment on brownfields. The presentation and questions afterwards, included extensive discussion about the environmental considerations and proper site preparations for implementing solar photovoltaic on a site with underlying soil contamination. The roughly 100 people in attendance included city, county, state, and federal agencies, utility companies, engineering firms, legal firms, non-profits entities, just to name a few.

Solar energy may be one of the only options available for development of a closed landfill site. tenKsolar's unique design, which requires no penetrations of a rooftop or ground-mount area, means the cap on the landfill site does not need to be disturbed to accommodate the project. Experience with a landfill-site model for solar energy development is likely to reduce total installed costs for similar projects in the future. Efficiencies in constructing arrays using

ballasted piers will improve as more contractors and system designers learn the intricacies of this construction method. Extra time was committed to laying out the ballasted piers and minimizing adjustments that would be needed when setting the rails. There are potentially more efficient ways to construct a system such as this one. The use of adjusting pads where the rails are mounted to the ballasted piers could reduce the amount of time needed in the layout and adjusting of the piers.

In this case, the solar energy production is closely aligned with the significant amount of energy demand at the Waste Water Treatment facility. This ability of the solar energy to supply targeted energy directly at a point of high demand is very cost-effective.

There are an estimated 100 or more closed, public and private owned, landfill sites in Minnesota, many of them larger than the site in Hutchinson. The Hutchinson Landfill is located on approximately 12 acres. This is relatively small site when compared to most of Minnesota's closed landfills. Closed landfills range in size of just a few acres to a couple hundred. There are currently 43 State owned closed landfills that cover a total of 2993 acres and an additional 513 acres of buffer adjacent to these sites. The average size of the State owned landfills is about 70 acres per site. While some of these sites are in more remote locations, many are also located in close proximity to large users of electrical power. It is likely that most of these landfill sites will prove to be suitable for development of solar energy. If 80 of these sites are developed with solar energy, at an average size of 500 kilowatts in nameplate capacity, the total potential market for a similar solar energy projects in Minnesota would be 40.0 megawatts, producing an estimated 67,000 megawatt-hours of electrical power on an annual basis, and generating about $160 million in direct economic activity as a result of its development.

This project has expanded the potential for the development of renewables in Minnesota. It also has the potential to affect changes in federal energy and climate policy that may put conventional energy sources at a disadvantage in the near future. State and local benefits include raising awareness about environmental permitting requirements for brownfield/landfill sites with potential for renewable energy technologies throughout Xcel Energy's service territory. Potential changes in federal energy goals could result in sharp increases in utility rates for those ratepayers who are most reliant on non-renewable energy sources. Increasing the share of energy that comes from renewables in Minnesota will potentially help to mitigate these cost increases. Diversification of sources for any commodity has historically helped to stabilize a commodity's costs should any one source become too expensive or scarce. There are many landfills and brownfields throughout Xcel Energy's service territory that could benefit from a similar type of installation, transforming what was once unusable land into a source of clean renewable energy.

This project and others will add to the understanding of how solar energy can be of greatest value to Minnesota's overall energy infrastructure, including how it can assist in managing demand, reducing peak usage and deferring capital costs for grid upgrades. How this can be achieved on a brownfield/landfill has been demonstrated with this project and has a high likelihood of replication in the future.

Finally, keeping more of the state's current $20 billion expenditures for energy in local economies, rather than exporting that capital to buy energy from other states and Canada, will

have long term benefits for local economies and increase the state's economic vitality. Stronger local economies, increased global competitiveness, business and job growth are all part of a general economic climate that will benefit Xcel Energy and its ratepayers.

There are no direct emissions from the production of solar electrical power using photovoltaics. As a result this solar project will offset 466 tons of carbon dioxide on an annual basis and 11,364 tons over 25 years when compared with energy generation that comes 75 percent from coal-generated power. Other annual emission reductions include, NOx = 1638 lbs, SOx = 4963 lbs, and PM10 = 54 lbs. Calculations of these emissions were calculated using emission factors from the National Renewable Energy Laboratory publication "*Source Energy Use and Emission Factors for Energy Use in Buildings*".

By leveraging federal tax incentives and financing from the developer under the state's Energy Savings Guarantee contracting rules, this project has proven to be very cost-effective. The total installed cost for the solar energy projects in the RDF proposals, including the limited energy storage demonstrations, was $4.40 per watt of nameplate capacity, which is low based on additional costs for site preparation, fencing, and interconnection costs associated with a landfill site. This project demonstrated that lower installed costs for installing solar energy in Minnesota was possible ($3.94 per watt installed) will have a direct benefit for Xcel Energy ratepayers who are likely to be asked to support the development of solar energy on landfill sites in the Xcel Energy service area.

This project has been constructed to capture the unique development challenges and opportunities from a solar energy project on a closed landfill site. This acquired knowledge is available to other communities in Minnesota, a large portion of which are in the Xcel Energy service territory. In addition, models for how to better manage the energy loads of major users such as the Waste Water Treatment plant will also have a direct benefit to Xcel Energy ratepayers to the extent that it helps manage and reduce demand at other types of high-demand, high-cost peak users.

Xcel Energy has a limited amount of visibility in the utility markets in and around Hutchinson. However, with this project, Xcel Energy and its ratepayers will receive very positive publicity in Hutchinson, which is the commercial hub for a large sub-region of the state. This positive exposure will include some businesses, such as 3M and others that Xcel Energy serves directly in other parts of the state. It will also increase Xcel Energy's exposure with residential ratepayers from other utilities, school and other local officials, legislators and other elected officials that represent the region. Energy policy is generally developed by the Public Utilities Commission and State Legislature on a statewide basis, and this exposure will be helpful to Xcel Energy in advancing its policy agenda at the State Capitol and elsewhere within the state.

Finally, Xcel Energy's reputation as a leader in renewable energy and solar energy, may encourage state policy makers and other utilities to develop stronger solar energy incentives that include all of the state's utilities. More uniform treatment of renewable energy among all of the state's utilities will level the playing field between Xcel Energy and these utilities and may result in other utilities sharing more of the costs of developing Minnesota's solar energy resources at a level that matches the effort from Xcel Energy and its ratepayers.

The location of this project at a municipally-owned facility will create opportunities for solar energy to become part of the public dialogue about Minnesota's energy future. It is likely that the project site will also become a point of interest for students from area K-12 and higher education institutions, as an element of their science, math and technology curricula.

As one of the larger cities in its region, Hutchinson is an opinion leader on issues such as public infrastructure and energy initiatives. The City has a history of working with other communities and multiple units of federal, state and local government and that will continue with a new focus on strategies for investing in solar energy.

In addition, Ameresco has offered to work with local K-12 schools in the area on an educational program that will allow teachers to incorporate the science, math and technology elements of solar energy into their curriculum.

Project Lessons Learned

The lessons learned from the project began very early on in the project's development. The projects financial pro forma was rigorously vetted. Variables such as insurance and power cost escalation can be significantly different from one project to the next. This was readily apparent when comparing insurance quotes for this project. They varied up to 25% for different insurance companies. The inputs used were conservative when determining the cost effectiveness of the project. Determining costs for insuring the system, operation and maintenance after commissioning, and the power costs escalation were extensively researched so the pro forma would reflect costs accurately. Under estimating the financial benefits of the system would increase the likelihood of an over performing system. Costs for insuring the system are known, but the other factors can only be realized over time. The original cost estimate for this project was $168,000 more than the final constructed cost. The final return on investment was 10.81% when using 20 years of net operating savings.

Reasonable measures need to be used in planning the project to determine if differential settlement of underlying soils is a serious concern. The City elected to complete the site preparation in an effort to control costs. Doing so created some uncertainty with the project engineer regarding the underlying fills ability to support the load of the system. This could have been avoided by having AMERESCO be responsible of all aspects of the site and system construction. Key considerations for others planning similar projects need to include proper compaction and load bearing capacity of the underlying soils and fill used to bring site to an even grade.

Site restoration in areas where tree removal is necessary must incorporate any necessary regrading, seeding, and stabilization methods such as erosion control blanket, hydro mulch, or disc anchored straw mulch. Tree removals along the east side of the site were anticipated to reduce excessive shading. What was not anticipated was the need for additional fill materials and restoration of the area so vegetation maintenance in the future could be more easily conducted. This work was completed independent of the AMERESCO project work, but occurred along side of the array construction.

Anticipating all site restoration activities is needed to minimize multiple mobilizations of contractors and to reduce potential conflicts associated with having multiple contractors working on different areas of a site. Minor erosion along the north and east edge of the array occurred during construction. The material that eroded, and subsequently repaired, was the portions of the top 4" of granular material. To prevent reoccurring erosion a combination of compacted rock, topsoil, and hydraulically applied mulch were used to stabilize the areas of concern.

Anticipating off site project interference potential is very important. Three other projects adjacent to the site were ongoing at some point during array construction. No delays or interference were caused by the projects not related to the system construction. Good communication of the adjacent construction schedules, potential impacts, and implementation of best construction practices were used to prevent potential negative impacts to the project.

Project wastes can be reduced through appropriate planning to either reuse, repurpose and/or recycle these materials Waste generated by shipping materials was not originally addressed during project development. All waste materials generated from the system construction were recycled or composted. Plastic sheeting, wood pallets, wire and cable trimmings, and excess fill were reused, repurposed, recycled, or ground up for wood chips. It was valuable to understand how much of the shipping and construction materials would otherwise end up in a landfill.

This project is already stabilizing operation budget fluctuations by allowing the use of the energy savings to meet the capital improvements needs of the facility. Long term this will equate to stable rates over a longer period of time for all wastewater rate payers in the City of Hutchinson. All power generated by the project is being used to directly offset power purchased for operation of the Wastewater Treatment Facility. Annual production of the system is anticipated to produce over $43,000 annually in electricity. After insurance and operation and maintenance costs are annualized the system will save the Wastewater Treatment Facility an estimated $30,000 annually. This project will help offset rising treatment costs associated with tighter effluent limitations and increasing treatment input costs. Until recently, residents, businesses, and industry have seen rising wastewater rates due to these various factors.

Openness of project proceedings provides a public showcase which encourages outside interest in solar development. Highlighting where projects are being constructed, project specifics, and details unique to the project are important to market growth. Many projects are never heard about until there is either a problem with the system or someone takes issue with a project. This project has already begun to garner significant positive interest from various sectors. The following people/organization have visited the site already, local and state elected officials, city staff from other outstate communities, non-profit staff, legislative staff, private business employees, etc. There has also been additional interest from professional organizations to hear more about the project and include a project tour as part of a training workshop. The likelihood of this project spinning off other projects greatly increases as more people become aware of the challenges that can be overcome in constructing solar photovoltaic on an old landfill. Solar development on landfills is not specific to Minnesota either. This project has received interest from a developer pursuing implementation of solar PV on a landfill in Nebraska. This is one example of the wide ranging impact of one solar PV project in outstate Minnesota.

A combination of various incentive programs, tax credits, grants, etc. can be used to make solar PV cost effective. One of the more important considerations in project development was how to fund the project. Extensive research and assessment has been conducted on various incentives and grants available for solar photovoltaic projects. All potential financing options and available grants/incentives need to be considered when planning a solar photovoltaic project. Different scenarios and ownership considerations affect who is eligible for what types of funding. Who will own the project? Who will operate it? Who gets the Renewable Energy Credits? These are just a few of the primary considerations that need to be reviewed when trying to determine the best combination of financing and available incentives. The wide spread installation of solar in Minnesota should depress the cost, per watt installed, so that one day solar can compete with traditional power generation technologies, even at micro scales.

All of the lessons learned from this project will be shared through a variety of ways including, but not limited to, blog posts, project summary and production tracking on the City website (under development), presentations at technical conferences (Clean Energy Resource Teams, Minnesota Brownfields, Minnesota Wastewater Operators Association, Energy Services Coalition, etc.), site tours to interested groups (Minnesota Pollution Control Agency, various Minnesota City and County staff/elected officials, solar developers, local schools, etc.), case study project summary distributions, and a Grand Opening event that was held on December 2, 2015.

Usefulness of Project Findings

The redevelopment of contaminated sites is a very complex process. The extent of contamination, concentrations of pollutants of concern, and the proposed land use all play a major role in what the land can be used for. Solar PV can be installed without disturbing underlying contamination sources. If the contamination is not migrating or poses a threat to the public, it is usually left undisturbed. Traditional redevelopment of brownfields and landfills poses a great risk because the source of contamination needs to be abated. This type of redevelopment is usually very expensive because of the cost to dispose of the contaminated material. This project is a model of how to redevelop a contaminated site without needing to expose and abate the contamination. By redeveloping these types of sites with solar PV the inherent risks associated with excavating, working in and around contaminated materials, are being replaced with a bright energy solution that is expected to produce various environmental benefits spanning multiple decades.

Solar is becoming very popular throughout Minnesota for a number of reasons. Scalability of the solar PV is very important to further market penetration. This project was scaled to match the lowest instantaneous demand at the Wastewater Treatment Facility so likelihood of exporting power was reduced to nearly zero. This concept can be replicated for large and small power users. The peak production of solar PV should align nicely with reducing the peak power demands during the summer cooling season. During the hottest times of day solar PV should be at or near peak output. By locating solar PV near the user and coupling the system sizing with that users power usage curves, utilities may be able to begin to free up capacity for users that wish to expand their businesses.

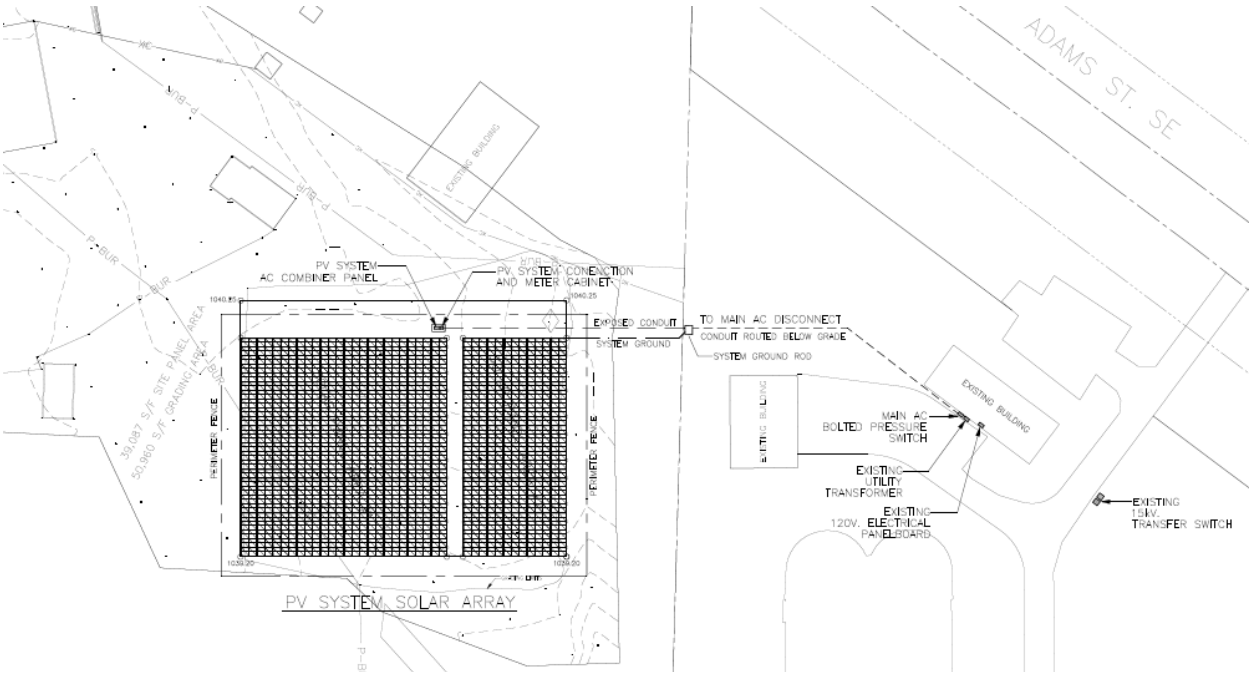
This project has effectively demonstrated that solar PV can be implemented on a contaminated site that has limited redevelopment potential because of the extensive contamination on the site. The cost effectiveness, engineering feasibility, solar PV deployment near the user, coordination with adjacent projects, zero waste generation during construction, efficient construction timelines, etc. are all examples that can be easily duplicated with future solar PV development. The City's goal is to spread these lessons far and wide so that many people can benefit from the projects that Xcel Energy has made possible.

A time lapse video of the project's construction can be seen at the City of Hutchinson website:

http://www.ci.hutchinson.mn.us/departmentsfacilities/public-works/park-garage/greenstep-cities/

Technical Progress

The solar energy project, totaling 399.75 kilowatts (kW), was configured on the site as follows:



As-built drawing of project

The output estimate, based on system nameplate capacity 399.75 kW. The facility is estimated to produce 587,587 kilowatt-hours for the first full year of production and assumed to degrade at a rate of 0.4 percent per year. The 25 year expected system output is 14,342,475 kilowatt-hours and includes the degradation factor. The system is currently operating as it was originally intended with no component failures.

Projected annual and monthly solar PV system outputs are:

	Estimated Annual System Production Output
Year 1	587,938 kWh

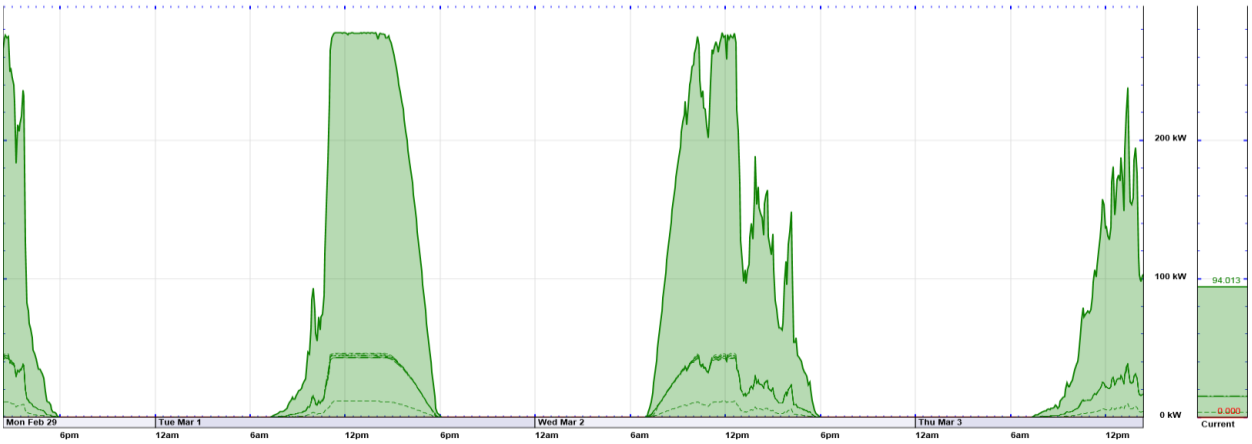
Year 2	579,028 kWh
Year 3	576,133 kWh
Year 4	573,253 kWh
Year 5	570,386 kWh
Year 6	567,534 kWh
Year 7	564,697 kWh
Year 8	561,873 kWh
Year 9	559,064 kWh
Year 10	556,268 kWh
Year 11	553,487 kWh
Year 12	550,720 kWh
Year 13	547,966 kWh
Year 14	545,226 kWh
Year 15	542,500 kWh
TOTAL:	6,430,073 kWh

Estimated Year 1 System Production Output

January	30,607 kWh
February	37,496 kWh
March	53,005 kWh
April	58,339 kWh
May	69,249 kWh
June	69,153 kWh
July	67,199 kWh
August	61,474 kWh
September	50,350 kWh
October	40,956 kWh
November	24,682 kWh
December	20,594 kWh

Real time system production information can be found on the City of Hutchinson website:

http://www.ci.hutchinson.mn.us/departmentsfacilities/public-works/park-garage/greenstep-cities/



e-Gauge continuous monitoring system screen shot

The implementation of a solar PV system on a landfill makes this project very unique. Preparation of the site without excavating was much different than if ground penetrations could be made.

October 1, 2015 Site Preparation Complete

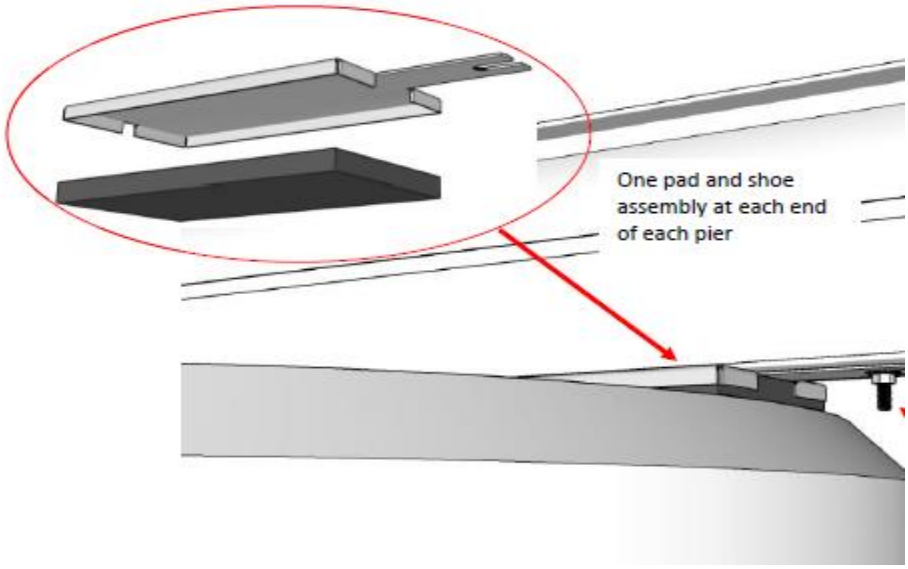
This project site had a 4 feet difference in height from one corner of the array to another. Since excavation was not permitted for the project there was 2258 cubic yards of common borrow material placed and compacted to level the site. Once the common borrow was graded and compacted 5675 square feet of Type 5 geotextile fabric was placed on top. The fabric was then covered with 320 cubic yards of granular borrow to allow for drainage and adjustments of the piers. Typically ground mounted solar PV installation would include either helical piles or drilled footings in the ground with height adjustments of the supporting posts accommodating changes in the grade on the grounds surface.

Pier placement prior to installation of racking

A ballasted concrete pier system was used instead. The piers were precast concrete that were 30 inches in diameter and 18 inches high. There were 410 piers placed on top of the granular borrow. Each pier was placed by establishing a grid using string and adjusting the height of each pier within 1/8 inch tolerances. Since the piers are 1100 pounds each this was a time consuming

process. Placing each pier in the right place was critical to the layout of the array. If the elevation or location of the pier was off to much the rails supporting the panels may be out of square. An important note is that there is a little flexibility in how precise the piers need to be placed. The utilization of a t-track in the piers as well the rail mounting configuration made the installation a more forgiving process if the piers were perfectly spaced. The elevation of the piers was the most critical factor so that an adjacent row was not higher/lower than the next row which may have caused some minor shading. The elevations of each individual pier were adjusted using leveling sand and survey equipment. The extra effort during the pier placement process proved to be worth the extra time so that once installation of the supporting rails began the construction progressed quickly. The rails are able to move independently of the adjacent rail. Adjustments can be made to the rails by adjusting the thickness of the pads that are between the rail and pier. Flexible conduit spans the distance between the support rails to allow for some movement of the piers without causing detrimental impacts to the rails.

Rail mounted to pier with flexible conduit



Adjustment pad and shoe between rail and pier

Routing of the parallel power cables was also unique because of the project site being a landfill. All cable was routed in conduit, above ground, on the site. Preconstruction planning included discussions of the unique construction methods that needed to be used to complete project tasks that would usually be routine. How the cable was routed and where it could go into the ground off the site were included in these discussions. Once the cable was off the landfill site it was directionally bored to the transformer that the power was being delivered to. Gopher State One Call was notified in accordance with State requirements.

T-post fencing with ballast rock installed

Ballasted fencing was installed around the installation as well. The fencing used an inverted T with plates welded onto the T so that ballast blocks and rock could be placed on the plates for ballast. The appearance and function of the fence does not appear to be different than a traditional fence installation.

The solar PV system is the fifth generation Titan solar modules that was released by tenKsolar in April 2014 and the 975 panels are each rated at 410 watts. The redundant cell architecture used in RAIS-WAVE modules enables the efficient construction of larger modules that also equated to a reduction in labor hours for installation because few panels needed to be installed.

Reflective panels adjacent to solar PV panels

The modules, when combined with the reflective gain from the reflective panels manufactured by 3M Company, make the tenK panels some of the most powerful production modules offered in the industry. E-Gauge monitoring is installed at the site for recording output data in real time. The E-Gauge system includes monitoring of 6 individual, equally sized, sub-arrays so that each can be compared to one another for easier identification of production issues or maintenance needs.

At the core of the solar technology that was used is the proprietary RAIS-WAVE module architecture (Redundant Array of Integrating Solar), in which cells in each module are interconnected in a mesh rather than series. When combined with a unique digital control algorithm and embedded low-voltage redundant electronics that were also developed by tenKsolar, the module virtually eliminates serial constraints found in other solar modules.

To extend this redundancy from the modules to the Wastewater Treatment Facility, and take full advantage of the proprietary control methods in the module, a simplified conversion process is used to create grid-quality alternating current (AC). A proprietary stepped-pulse transformer (SPT) technology uses a simplified set of automotive-grade, low-voltage electronics to step-pulse the energy into a solid-state transformer. Unlike conventional inverters, no active electronics are exposed to grid-level voltages, improving up-time performance and reducing operating and maintenance costs. The panels produce a variable voltage which does not exceed 57 volts DC. The step-pulse transformer increases the voltage to 480 volts which can then be utilized at the Wastewater Treatment Facility. The technology also uses fully embedded, anti-islanding controls that have been third-party validated and certified in most international solar markets. Anti-islanding is the detection of power generation by a source such as solar PV that immediately stops feeding power when an outage occurs. This prevents back feeding power from a solar PV

generation facility to the utility during a power outage. Because of the controls residing in its electronics, tenKsolar is able to interconnect SPTs in parallel, allowing the AC conversion process to operate redundantly. If one fails, the energy that would normally be lost is able to flow to another SPT. At times of low solar radiation, a reduced number of SPTs still operate, improving overall system efficiency. As a result, each tenKsolar installation delivers full, 480-volt AC grid-quality power directly from the array.

Within the array, the maximum voltage is 57 volts DC, compared to conventional arrays at 600-1000 volts, and each module has full, built-in ground-fault and arc-fault protection. The modules are intelligent, and can sense an active connection. In case of a fire, de-activating the system from the grid anywhere on the AC side causes the modules to stop internally, avoiding safety issues for firefighters and first-responders. These same safety and embedded assembly features also simplified the installation process.

Beyond the improvements in reliability from eliminating all single points of failure and the high-voltage active electrical components in conventional solar arrays, tenKsolar panels take advantage of cell independence within the module to add illumination from static reflection. A proprietary spectroscopic reflector-based racking system developed by tenKsolar and 3M gathers additional light from the unused gaps in typical solar arrays to increase energy delivered by the system. This results in a much higher level of energy density for the system as a whole.

With its low-voltage systems design and integration, tenKsolar was able to supply its product for this project at competitive pricing. The non-reflected efficiency of a tenKsolar system is at or above conventional systems when just environmental losses in the system are considered. When including the energy gain from reflection, the efficiency of a tenKsolar system is 20-40 percent higher than a conventional system, which has been validated in comparisons against other commercially deployed systems.

The RAIS-WAVE modules are certified by third-party agencies to all of the applicable standards, including UL1703 and UL1741, and the stepped-pulse transformers are also certified to UL1741 and other standards.

Appendix

Completed Project Photo
Final Budget Report
MN Brownfield's Presentation

Completed Project Photo 12-9-2015

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

City of Hutchinson

Solar Project Reporting

Grant #EP4-41

	Budget	RDF Cost Share	City Cost Share	Paid Expenditures Aug-2015	Sep-2015	Oct-2015	Nov-2015	Dec-2015	Total Costs Paid	Remaining Balance	% Complete
Direct Costs											
Salaries & Wages	$ 86,381	$ -	$ 86,381	$ 1,506	$ 771	$ 887	$ 730	$ 1,455	$ 5,349	$ 81,032	6.2%
Fringe Benefits	28,793	-	28,793	566	324	$ 372	$ 305	$ 597	2,163	26,630	7.5%
Equipment	770,595	654,500	116,095	-	189,200	26,000	555,395		770,595	-	100.0%
Consultants / Subcontracts	667,171	303,869	363,302	-	38,950	114,300	268,547	245,374	667,171	0	100.0%
Supplies	8,555	-	8,555	-			8,555		8,555	-	100.0%
Construction Materials	29,876	-	29,876	-			4,821		4,821	25,055	16.1%
Travel	7,000	-	7,000	-					-	7,000	0.0%
Other Direct Costs	94,118	-	94,118	-	57,386	4,000	32,732		94,118	-	100.0%
Total Direct Costs	$ 1,692,489	$ 958,369	$ 734,120	$ 2,072	$ 286,631	$ 145,559	$ 871,084	$ 247,425	$ 1,552,771	$ 139,718	91.7%
Indirect Costs - Administration	50,000	-	50,000				12,000	12,000	24,000	26,000	48.0%
TOTAL COSTS	**$ 1,742,489**	**$ 958,369**	**$ 784,120**	**$ 2,072**	**$ 286,631**	**$ 145,559**	**$ 883,084**	**$ 259,425**	**$ 1,576,771**	**$ 165,718**	90.5%

WWTF Solar PV

John Paulson

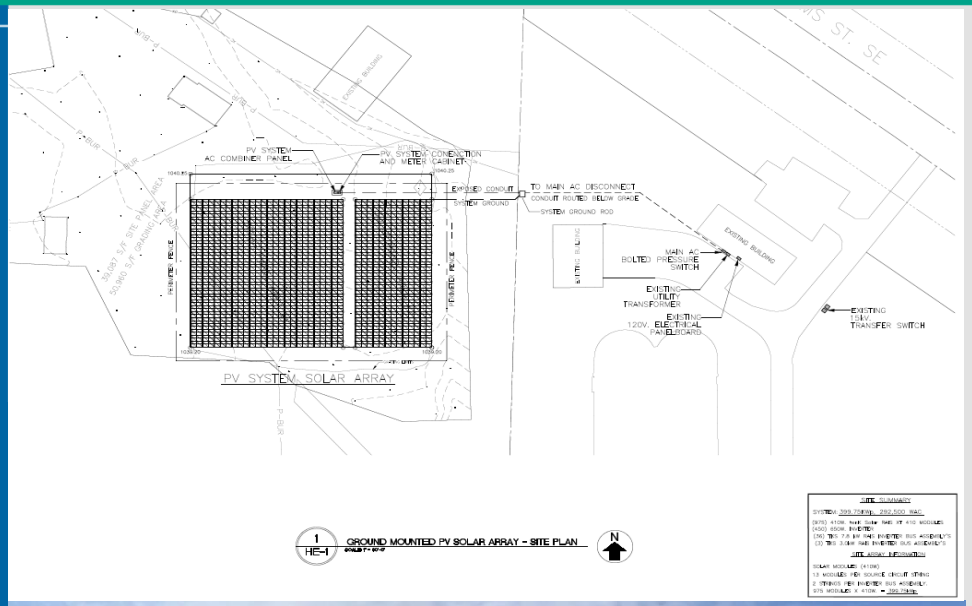
Project/Environmental/Regulatory Manager

Marc Frank,

Project Manager

Minnesota Brownfields Solar Workshop

February 3, 2016

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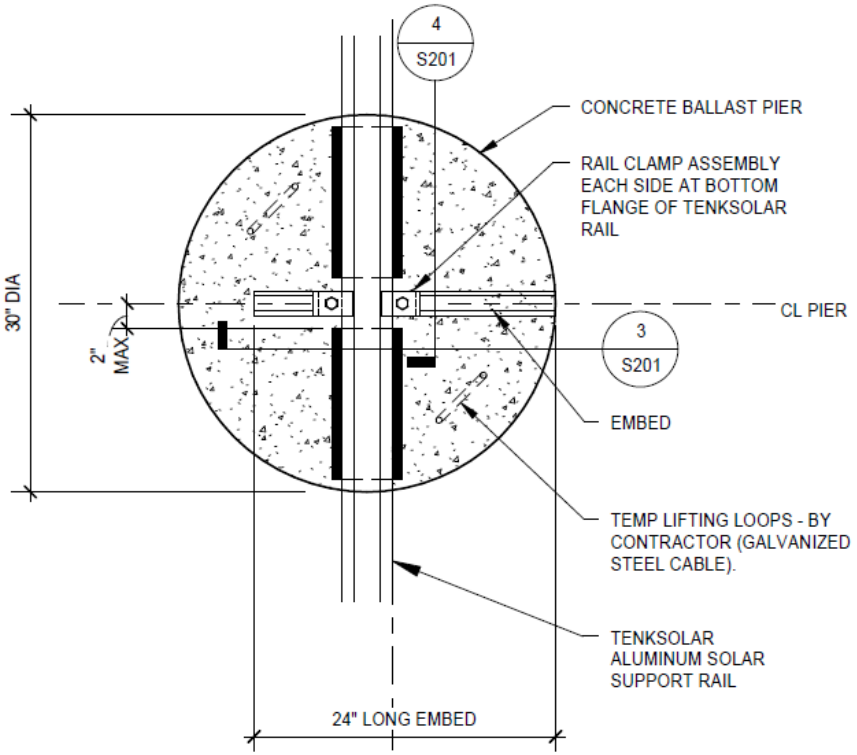
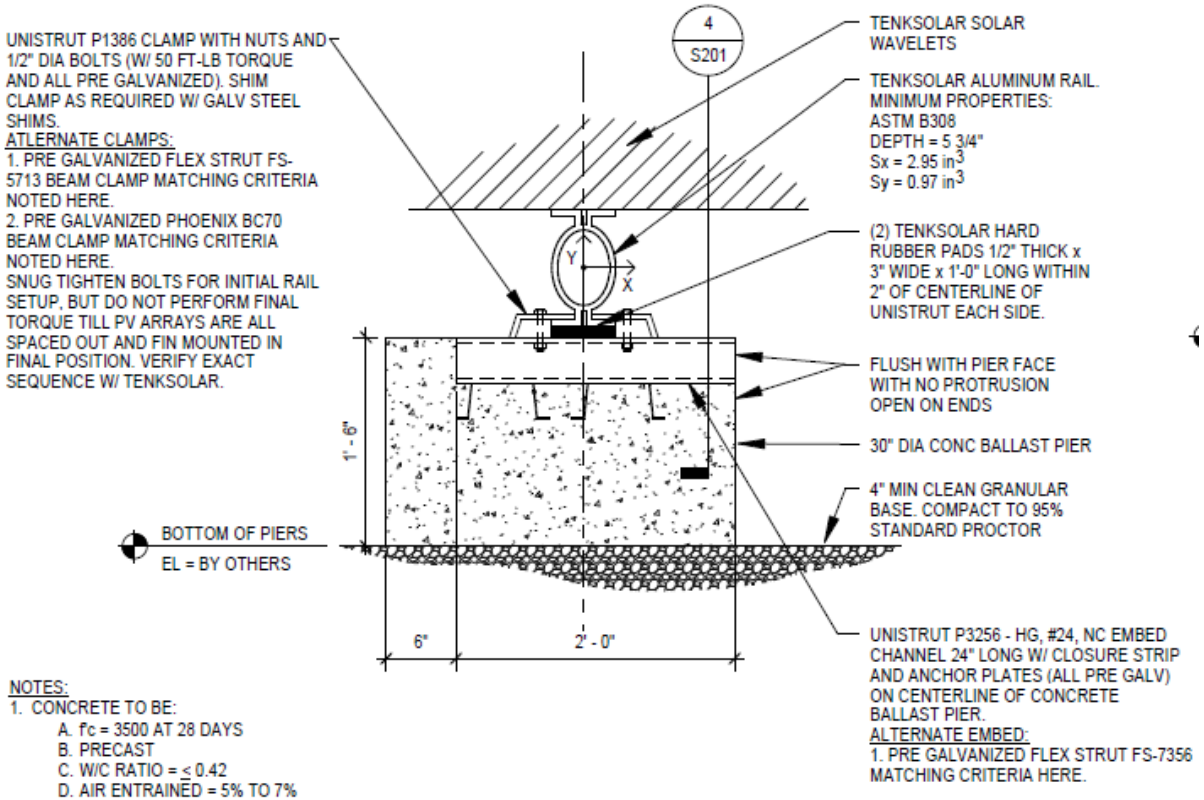


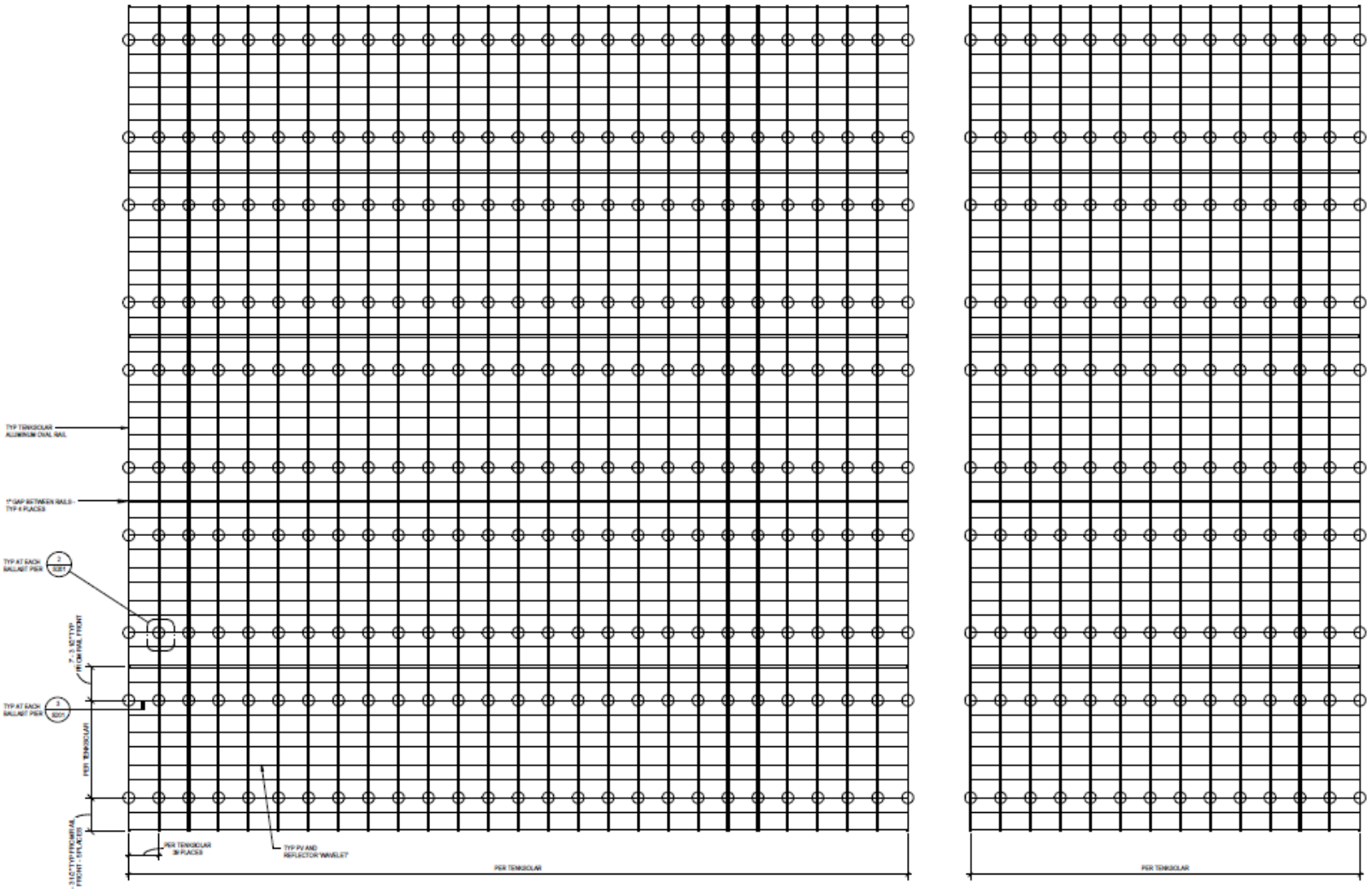
NOTES:
1. TEMP LIFT LOOPS TO BE GALVANIZED CABLE RATED FOR LIFT LOADS WITH SAFTY FACTOR = 5.

PLAN AT TOP OF BALLAST PIER (BOTTOM FLANGE OF TENKSOLAR RAIL)

2 / S201 — 1" = 1'-0"

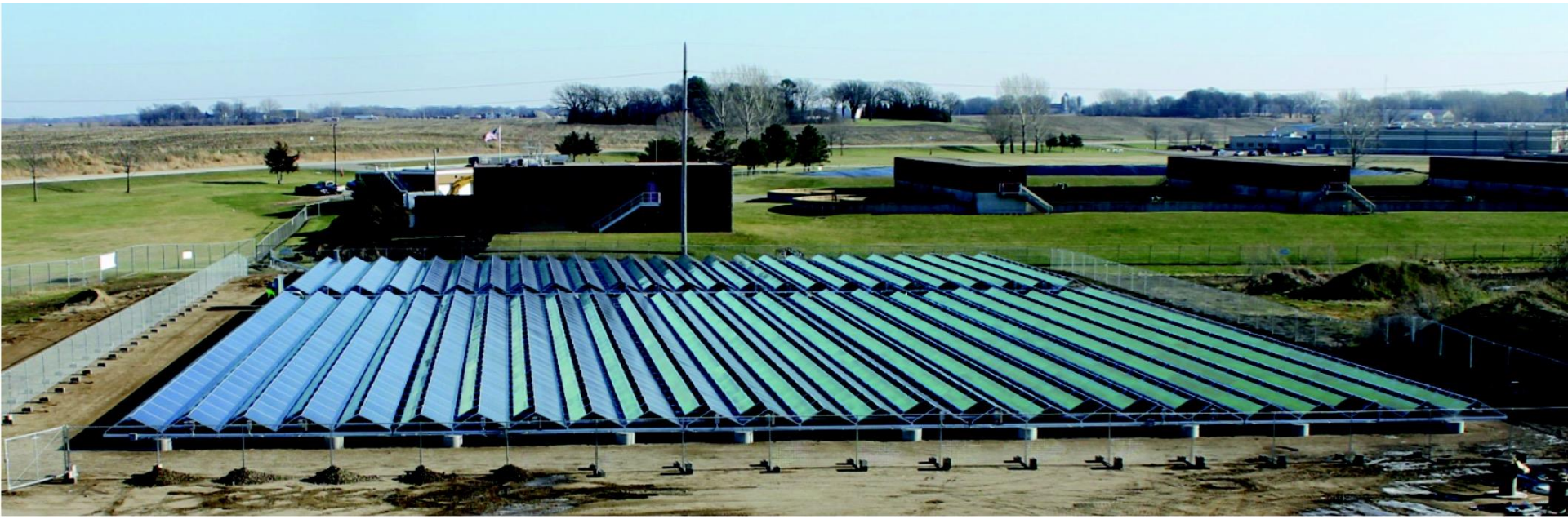


3
S201
SECTION AT BALLAST PIER
1" = 1'-0"



1 S201 3/32" = 1'-0"

FOUNDATION PLAN



City of Hutchinson Solar PV Project History

- **December, 2010: Performance Contract for City-Wide Lighting Upgrade**
  - **Guaranteed Savings – over achieved by $25k ($32k vs $57k = 78% highher)!**
- **October, 2011: Westwood:** Renewable Energy Suitability Study
- **June – Sept, 2012**: Staff and Council discussions regarding Solar PV project
- **October, 2012:** Signed "***Agreement Letter"*** to Develop a Solar PV System
- **March 2013:** Xcel Energy RDF Proposal Submitted
- **March 12, 2014**: **Xcel Award Letter received by the City**
- **April 23, 2014**: Planning meeting to move forward
- **May – September:** Updated Xcel Award requirements
  - **Further developments per the Term Sheet and site requirements**
- **October 14, 2014**: Term Sheet executed with AMERESCO
- **December 23, 2014:** Energy Service Agreement w/AMERESCO
- **June 19, 2015:** Xcel Grant Contract approved
- **October – November 2015:** Construction of System ***11/25/15 Commissioned***

5+ Year Working Relationship

Solar PV Project Specifics

- **Solar PV size = 400 KW = 470,070 kwh/year guaranteed (80% derated from actual) (Actual = 587,587 kwh/year) ~15% of the WWTP Annual Load**
- **Utility costs = 0.737/kwh and annual increases = 1.5%**
- **Solar System Payback = 18 years (~14 years using higher than guaranteed system output)**
- **At year 30, system has generated $370,000 – after paying for itself**
- **Pricing = $1,467,000**
  - **Xcel Grant = $958,360**

Solar PV Site Land Use Challenges

- **Emergency Services Training Site (Police & Fire)**
- **Stockpiling Public Works Materials**
- **State Bonding $ used for improvements 1999**
  - Office of M&B approval to proceed
- **City Dump Site 1950-1980**
  - Phase I Assessment 1999
  - VIC Program April 2002
  - Phase II Assessment June 2002
  - Additional Assessment September 2002
  - Restrictive Covenant July 2007
    - *No disturbance without MPCA approval*
  - RAP November 2007

Solar PV Site Land Use Challenges

- **RAP and Covenant Requirements**
  - Construction Contingency Plan
  - Site Health and Safety Plan
  - Routine inspections of site and LEL monitoring
  - **NO PENETRATIONS ANTICIPATED!**
- **Design Considerations**
  - Compacted clay fill over existing cover
  - Geotextile
  - Clean granular over Geotextile
  - **DIFFERENTIAL SETTLEMENT**
    - *Undisturbed 10 years (Manufacturer White Paper)*
  - Density Testing

Xcel RDF Grant Award

Xcel Energy®

414 Nicollet Mall
Minneapolis, Minnesota 55401-1993

March 12, 2014

Jeremy Carter
City of Hutchinson
111 Hassan St SE
Hutchinson, MN 55350

Re: RDF Grant Award EP4-41

Dear Jeremy:

Congratulations! Your project *Municipal Landfill Solar Energy Demonstration* has been approved by the Minnesota Public Utilities Commission to receive funding from the Renewable Development Fund ("RDF") by written Order dated March 11, 2014. Please note that this Order may be subject to reconsideration or rehearing by the Commission. The next step in the funding process is to negotiate a grant contract between you and Xcel Energy.

With the assistance of legal counsel, we are beginning preparation of the RDF grant contract. In order to finalize these contracts, we need to perform due diligence for which certain information is required. To that end, enclosed please find a list of items that we will need to review for the development of the grant contract. Your prompt attention to this request will help to expedite the process. The materials may be submitted as they become available and all do not need to be submitted at the same time.

As the RDF grant contract is a legally binding agreement and may affect your legal rights, we encourage you retain a lawyer to represent you throughout this process. If you would like to have future communications directed through your lawyer, or a copy of those communications copied to your lawyer, please let us know.

If you proposed modifications to the standard RDF grant contract we may be requesting additional information which may be dependent upon the unique characteristics of your request. That request will be made at a later date. After the grant contract has been finalized and executed, we will submit the contract to the Department of Commerce for the required compliance review.

We look forward to working with you so that your project can begin as soon as possible. Please feel free to contact me at 612.330.6739 if you have any questions.

Sincerely,

Mark G. Ritter
RDF Grant Administrator

Attachment

Xcel Due Diligence Submittals

- Currently all required info has been submitted by City
- Final submittal document will be the Signed contract between the City and Ameresco.

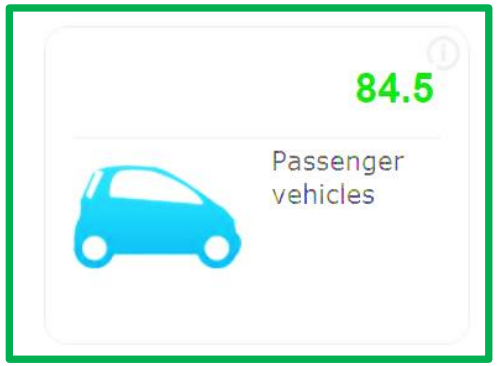
City of Hutchinson Critical Path Schedule (EP4-41)

Task		Task Description	Project Schedule: Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
1		**Agreements/Financing**														
	1.1	MPUC approved Power Purchase Agreement														
	1.2	Secure Financing														
	1.3	Interconnection Agreement														
	1.4	Conditional use agreements														
2		**Design**														
	2.1	Site analysis														
	2.2	Prepare facility design														
	2.3	Prepare facility specifications														
3		**Procurement**														
	3.1	Identify suppliers														
	3.2	Procure PV panels and appurtenant equipment														
4		**Permitting**														
	4.1	Obtain zoning permits														
	4.2	Obtain construction and building permits														
	4.3	Environmental review														
	4.4	Preparation of on-site safety plan														
	4.5	Completion of a construction contract for installation														
5		**Construction**														
	5.1	Site Preparation (i.e. leveling, access, security, etc.)														
	5.2	Construction and assembly														
	5.3	System testing														
	5.4	Commission PV facility														
	5.5	On-site demonstration														
	5.6	Presentation to RDF Advisory Board														

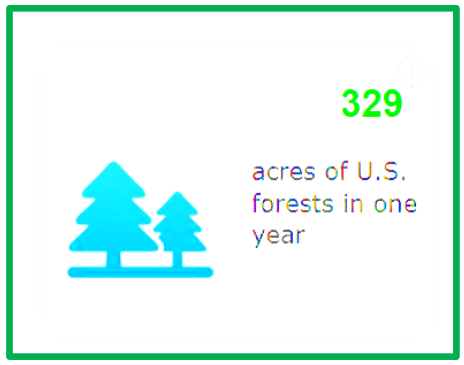
Benefits to the City of Hutchinson

Estimated Environmental Savings

On an annual basis = 401 Metric tons of Carbon dioxide Equivalent:

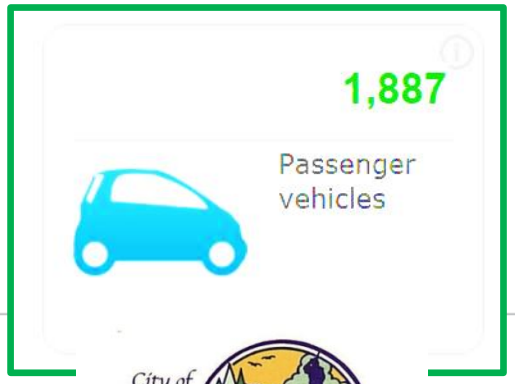


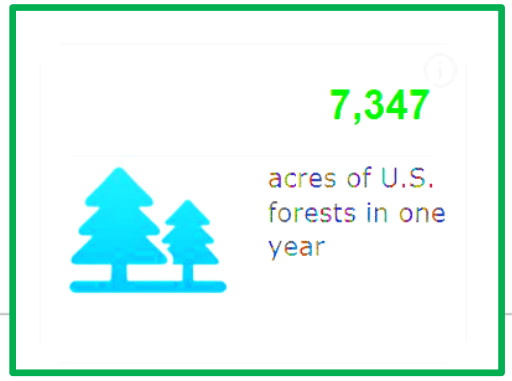
Greenhouse gas emissions from:



Carbon Sequestered by:

On an 30 year basis = 8,964 Metric tons of Carbon dioxide Equivalent:





City of Hutchinson

Questions and Comments

“Project funding provided, in part, by customers of Xcel Energy through a grant from the Renewable Development Fund.”