City Of Northfield Minnesota

Solar for the City of Northfield
Citywide Renewable Energy Potentials Study

Final Report
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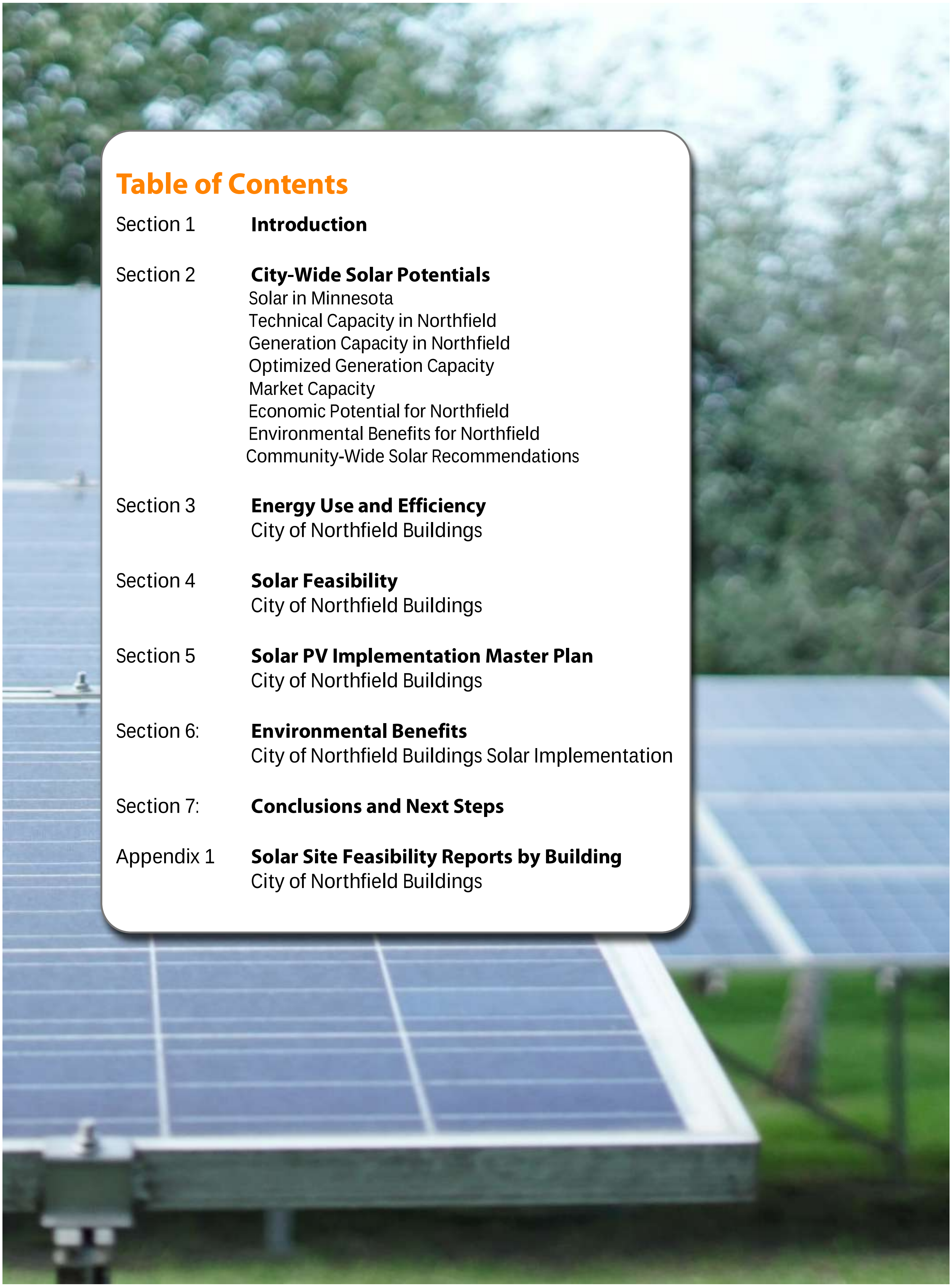

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Introduction

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Introduction

The intent of this study is to determine the overall rooftop solar pv potential throughout the City of Northfield as well as the solar pv capacity and energy potential of the primary City of Northfield facilities. Funding for this site assessment was provided by a 2019 Minnesota Clean Energy Resource Teams (CERTs) Seed Grant combined with funding from the City of Northfield and an in-kind donation of time and materials by paleBLUEdot LLC.

Although the energy generation numbers included in this report are based on site-specific solar exposure and efficiency ratios, the solar pv capacities and annual energy generation numbers included in this report should be considered preliminary. Final energy generation will vary based on exact solar pv components selected and installed. Additionally, the Order of Magnitude project budgets and Lifetime Cost of Solar numbers included in this report are preliminary and budgetary in nature. Final project costs may vary based on market conditions, specific pv components selected, final design decisions, changes in pv component cost basis, and inflation to the point of project implementation.

Section 2 provides an overview of the overall rooftop solar pv potential throughout the City. This section includes a look at total generation potential, optimized potential, market absorption projections, and recommended City Wide solar pv implementation goals through 2040. These "market absorption" projections are then compared against the City's solar pv installation goals included in the City's Climate Action Plan and identifies potential shortfall. In addition, this section reviews the potential economic and environmental impacts of this City Wide solar pv potential and provides recommendations for next step implementation steps.

Section 3 provides a summary review of the energy use and energy efficiency of the City of Northfield facilities.

Section 4 of this report provides a detailed solar concept development, detailed assessments, opinion of probable cost, potential energy generation schedule, and potential financial performance for each of the primary government facilities within the City of Northfield. These preliminary concepts are intended to provide an initial understanding of potential for each site. Additional feasibility and assessment of sites with a low benefit to cost ratio (as outlined in Section 4 and Appendix 1 of this report) may offer opportunities to identify more cost effective approaches for those sites.

Section 5 provides recommended master plan implementation priorities for all government facilities reviewed in Section 4. This solar implementation master plan looks to guide the City to 100% renewable energy for all City facilities through the application of on-site arrays, community solar subscriptions, power purchase agreements, and purchase of renewable energy credits.

The economic and environmental benefits of the recommended City of Northfield Solar PV projects are outlined in Sections 6 and 7 of this report. Decisions regarding investment in solar pv should be certain to include all community and environmental benefits in addition to the basic financial benefit to cost ratios provided in these sections.

Lastly, Section 8 outlines conclusions as well as next step considerations for the City of Northfield.

Introduction

Project Goals for City Facility Assessments and Solar PV Implementation Master Plan

The Solar PV Implementation Plan site prioritization included in this report is focused supporting the City of Northfield's goal of achieving 100% carbon-free energy for all City facilities with the option most likely to be cost effective for each site.

Renewable Energy Credits

Renewable Energy Credits (RECs) are tradable, non-tangible energy commodities that represent proof that a quantity of electricity was generated from an eligible renewable energy resource. RECs represent all of the "green" or clean energy attributes of electricity produced from renewable resources like solar PV. A REC includes everything that differentiates the effects of generating electricity with renewable resources instead of using other types of resources. Only the ultimate consumer of the REC has rights to the claim of renewable energy use; once a producer or owner of a REC has sold it, rather than consuming it themselves, they have sold the claim and cannot truthfully state that they are using renewable electricity, or that the electricity that was produced with the REC is renewable.

The City of Northfield should assume that RECs will not be available for any projects which are delivered through a "third party" project delivery method, community solar subscription, or any project which utilizes a utility subsidized approach such as the Xcel Solar Rewards program. In those project delivery methods, the City of Northfield would assume that all RECs will be purchased by the electric utility as a part of the finalized interconnection agreement.

From a Greenhouse Gas accounting perspective, this means that facilities served through community solar subscriptions or third party ownership structures will not be able to account for emissions reductions due to renewable energy use unless REC credits are purchased. In this situation, without the purchase of REC credits, the City's GHG Inventory will need to use the regional electric grid emissions factors for calculation of emissions.

Options For Meeting 100% Carbon Free Goal

In general, the carbon-free electrical service options available to the City of Northfield at each of its facilities are:

Grid Electricity

Description:
Standard electricity purchased through utility produced by a range of sources within region.

Renewable Energy Claim:
None.

GHG Inventory Impact:
GHG impacts are calculated at base electric grid rate for the region and utility.

Achieving Carbon Free:
Can be achieved by purchasing RECs in addition to electrical service (ie Xcel Renewable Connect)

Community Solar Subscription

Description:
Subscription for power produced by a shared resource. REC's are sold separately.

Renewable Energy Claim:
Subscribers are supporting solar. "Green attributes" remain with REC owner.

GHG Inventory Impact:
GHG impacts are calculated at base electric grid rate for the region and utility.

Achieving Carbon Free:
Can be achieved by purchasing RECs in addition to Subscription (ie Xcel Renewable Connect)

On-Site Solar
(Incentivized)

Description:
On-Site solar array installed under SolarRewards program through which RECs are purchased by utility for 10 years

Renewable Energy Claim:
"Green Attributes" sold to Xcel for 10 years, then retained by site there-after.

GHG Inventory Impact:
GHG impacts are calculated at base electric grid rate for the region and utility for 10 years, Carbon-Free thereafter.

Achieving Carbon Free:
Wait for conclusion of10 year agreement with Xcel. May purchase RECs separately prior

On-Site Solar
(Non-Incentivized)

Description:
On-Site solar array installed under standard Net Metering agreement. RECs retained by site owner.

Renewable Energy Claim:
All "Green Attributes" retained by site owner.

GHG Inventory Impact:
All electricity produced by array is Carbon-Free energy for site.

Achieving Carbon Free:
No further action required

Introduction

Content In This Report

Below is an explanation of the detail or basis for the components of this report:

Concept Design

For each site, this report includes a conceptual layout of the solar pv array(s), as well as annual energy generation modeled from site-specific weather data, insolation levels, and solar obstructions. Energy generation is also provided on a month-by-month basis. A preliminary breakdown of system components is also included and forms the basis for the Order of Magnitude Project Budget.

The concepts in this report are preliminary only intended to determine an overall magnitude of potential and to assess the viability of rooftop, ground mounted, and parking mounted solar. It should be noted that many options exist for the optimization of solar arrays depending on the ultimate goal for the site.

Rooftop solar array concepts (on flat roof facilities) typically focus on maximizing the annual energy production of rooftop solar arrays through a combination of maximizing array size capable of fitting on available roof areas as well as good azimuth and tilt configurations. As such, most rooftop arrays found in this report have a panel tilt of approximately 26 - 30 degrees. .

Annual Site Energy Use

For each site, an estimated value of the existing facility's annual energy use is provided. The annual energy use is based on reported annual values through the City's Minnesota B3 building benchmark reporting or 2017 City Operations Greenhouse Gas Inventory report. The EUI target values used are those provided by the US EPA ENERGY STAR Portfolio Manager. Actual on-site electricity use for each site may vary significantly depending on accuracy and completeness of the energy use reported in Minnesota B3 and the City's GHG Inventory report.

Order of Magnitude Project Budget

For each site, the Project Budget included provides a preliminary opinion of project costs based on national solar pv installation cost data provided by the National Renewable Energy Laboratory (NREL), modified for local construction cost indices. Costs shown represent 2020 dollars. Projects planned for future installation should anticipate an increase in labor costs, however, system component costs are likely to remain constant or decrease on a per kw basis. Land acquisition costs are not included in project budgets. Preliminary budgets assume cost free land use agreement for all solar arrays.

Energy Generation Schedule

All solar pv panels lose some degree of efficiency over time due to material degradation cause by unavoidable circumstances including UV exposure and weather cycles. Panel degradation and system generation losses are typically covered under panel warranty, usually at 0.7% to 1% annual losses. Studies by NREL, however, show average panel degradation rates for contemporary panels to be less than 0.5% annually. The "life span" energy generation projections included here are predicted using a 0.7% annual loss rate. Due to system loss over time, an array which meets facility annual energy need initially may, within its life span, no longer meet the same energy consumption levels. The schedule provided indicates the percentage of annual site energy use which can be met by the solar array(s) each year.

Potential Financial Performance

Based on the modeled annual energy generation, the value of the solar energy generated is calculated for each site. Estimates include the value of energy consumed on site (where such information has been provided to paleBLUEdot) as well as a preliminary estimate of the value of excess annual energy sold to the grid. Taken together, these values represent the potential life-span economic value of the solar array, which can then be compared against the estimated project costs. Note that incomes such as the feed-in tariff rates are preliminary and require confirmation with electric utilities prior to project financial finalization.

The following are additional considerations building owners should be aware of before "going solar".

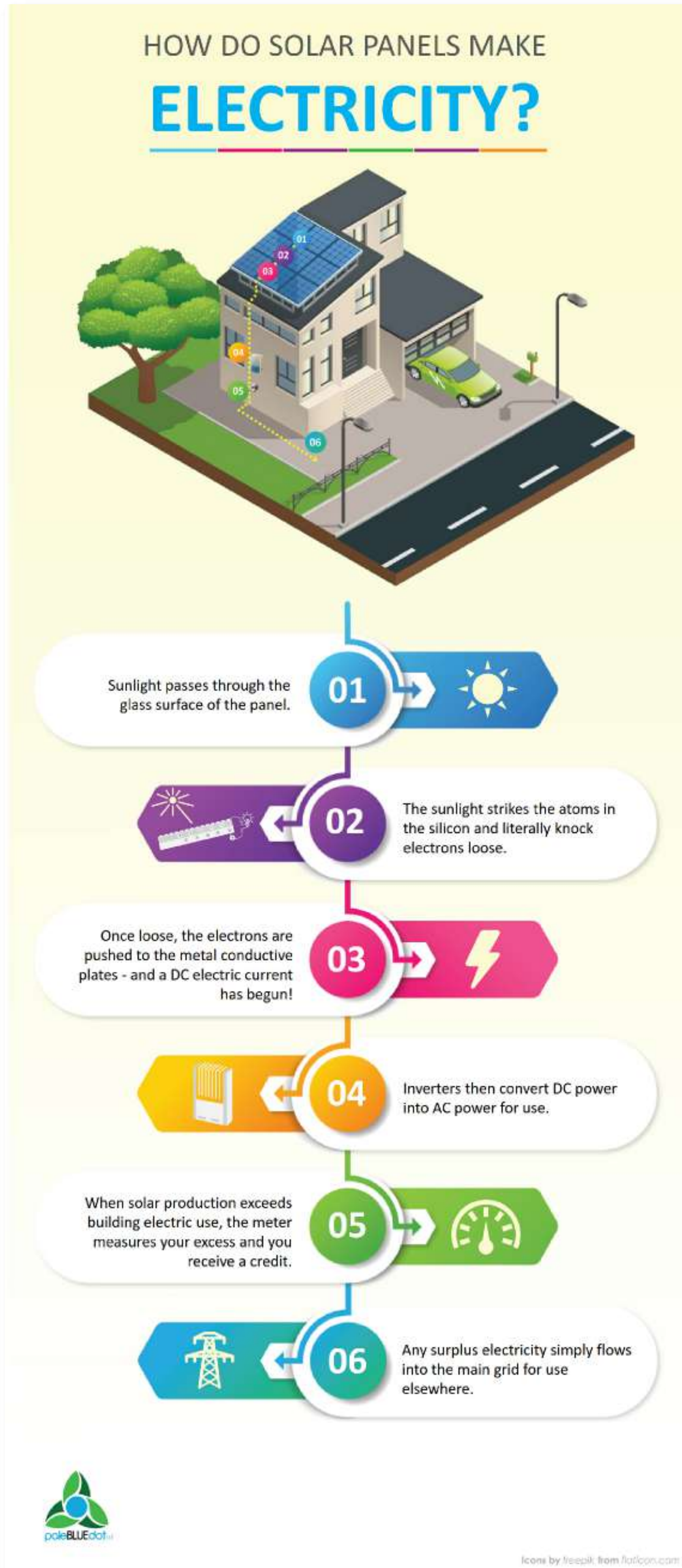
Structural Capacity for Rooftop Arrays

The feasibility assessments included in this report do not include assessments of the facilities' structures to accept the additional loading of a solar pv array. Projects which anticipate rooftop arrays should have a preliminary structural assessment to confirm solar pv loading can be adequately handled by the existing structure. The weight of a PV system varies based on the panel and racking systems selected. For rooftop arrays, two racking system configurations are common: flush or tilted mechanically fastened racking types (which require roof penetrations, or clamp on standing seams); and ballasted racking types (which use weighted components to make the array stationary through gravity and typically do not require roof penetrations). A reasonable "rule of thumb" for solar PV array assembly structural loading is 2-4lbs per square foot for typical flush or tilted racking systems, or 5-9lbs for ballasted racking systems.

How Solar PV Works

Solar electricity is created using Solar Photovoltaic panels, or Solar PV for short. The word photovoltaic, or PV, comes from the process of converting light (photons) to electricity (voltage), which is called the PV effect. The key to a solar PV panel is the semiconductor material.

Solar PV semiconductors combine properties of some metals and properties of insulators - making them uniquely capable of converting light into electricity. The simple explanation of how solar panels create electricity is that as sunlight (specifically UV light) strikes the semiconductor materials in the PV cell, the energy knocks loose electrons. Those electrons then move back and forth between semiconductor plates producing an electric current.



Introduction

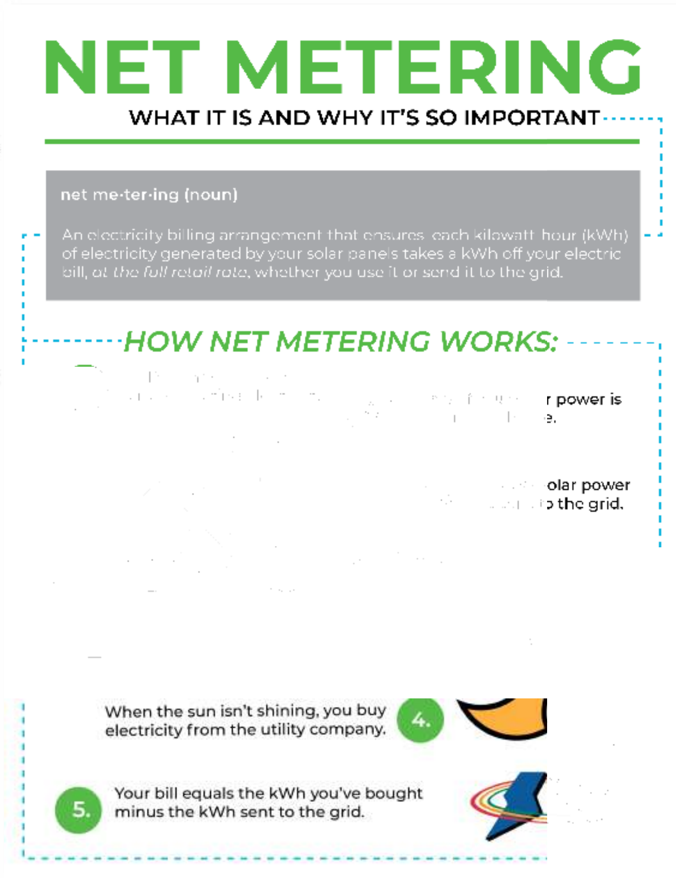
Net Metering

The site concepts in this report are based on grid-connected systems with net metering. Net metering tracks the amount of energy generated on site, as well as the amount of energy consumed from the grid. Net metering allows customers to get credit on their energy bill from excess energy generation, when the amount of energy a solar panel system generates is greater than the amount of energy consumed from the electric utility. Such interconnection is considered non-incentivized, meaning that the site/solar array owner will retain the renewable energy credit that the PV system produces and will offset the cost of energy needed when the solar panels are not producing energy (nighttime, short and cloudy days).

According to the State of Minnesota Public Utilities Commission:

> *Generally, if a customer produces more electricity than it uses, a utility will compensate or credit the customer for their excess generation depending on the option the customer elects to receive in the contract they signed with the utility. Utilities keep the rates updated in a rate book.*
>
> *The amount a customer is paid for the electricity they do not use is found in their utility's tariff (often called the compensation rate). The compensation rate depends on several factors:*
>
> *The size of the customer's system;*
> *The specific costs and retail rates of their utility (updated annually); and,*
> *Whether the customer is served by a cooperative, municipal, or public utility.*

Learn more about Net Metering in the State of Minnesota here: https://mn.gov/puc/energy/distributed-energy/net-metering/



Project Delivery Options

This report assumes all solar pv systems are direct purchase (City of Northfield owned) projects. Regional solar developers may provide services to building/site owners through alternative project delivery options such as Solar Lease Agreements, Power Purchase Agreements, or "Reverse Lease" agreements for ownership of the Federal Investment Tax Credit benefits. These alternative delivery methods use 3rd party entities for one or more aspect of the procurement and ownership of the solar array and/or Federal ITC tax benefits. 3rd party project delivery methods frequently have a solar array purchase opportunity at a future date such as in year 7, year 10, or year 20. For the City, the advantage of a 3rd party project delivery is the ability to leverage project savings due to the Federal Solar Tax Credit, currently capable of reducing the cost of a solar pv by up to 30%.

Most Solar Lease Agreements are designed so that the 3rd party, or the power company, retains the RECs produced by a solar array. As such, any entity that is motivated to claim use of renewable energy or to leverage a reduction in their operating greenhouse gas emissions would typically not be capable of making such claims under these traditional 3rd party delivery structures. It may be possible, however, to negotiate a project delivery similar to a Solar Lease in which the site owner could retain the REC's generated by the project.

Peak Shaving and Demand Charges

Customers pay for electricity in one of two ways: consumption, measured in kilowatt-hours (kWh); and demand, measured in kilowatts (kW). Most residential customers only pay for consumption. Many commercial customers are on demand charge tariffs and they pay for both demand and consumption. With demand charge billing the customer pays for the highest power load reached – the peak demand. Peak demand is defined as the highest average load during a specific time interval (usually 15 minutes) in each billing cycle. Utilities use demand charges to help recover costs associated with running power plants or buying power from other utilities on the energy spot market. Demand charges also help utilities recover transmission costs to customers with large energy needs.

Not all utility customers are on demand charge tariffs, but for large consumers of electricity those charges can be a significant part of a monthly utility bill. Utility customers who do have demand charge tariffs can see a large portion of their monthly electric bill going towards demand charges (30% to 70% is not uncommon).

The most effective way to manage utility costs for customers with demand charges is a practice called peak shaving. Peak shaving involves proactively managing overall demand to eliminate short-term demand spikes, which set a higher peak. This process lowers and smooths out the electric use “curve” and reduces peak loads, which reduces the overall cost of demand charges. Solar arrays with a battery energy storage system allows customers to peak shave. Battery energy storage systems are dispatchable; they can be configured to strategically charge and discharge at the optimal times to reduce demand charges. Sophisticated control software with learning algorithms differentiates battery energy storage systems from regular batteries. These algorithms learn a customer’s load profile, anticipate peak demand, and switch from the grid to batteries when needed most - reducing the customer’s peak load and saving on demand charge costs.

Peak Shaving and Local Utilities

Many local electric utilities and electric co-ops do not generate their own power. Instead, these utilities often purchase power from large electric generators and then distribute that electricity to their consumers. In this situation, local electric utilities typically have long-term electric purchase agreements with their electricity suppliers. In some instances, the pricing defined in the local utility’s power purchase agreement imposes increased rates for peak demand timeframes, like the peak demand rates end customers may experience. For local electric utilities which have peak power purchase rates defined, the deployment of solar arrays and solar storage systems within their local electric service area reduce the local electric grid’s peak demand and avoid costs associated with peak demand power purchase.

Energy Use Intensity (EUI)

Energy Use Intensity, or EUI, is a comparable measurement for building energy efficiency. Comparing energy uses and efficiencies between buildings and structures can be difficult without a standard or benchmark. Simply measuring the amount of energy used over a given time period does not take into account building size, configuration or type of use. EUI calculations provide a means to equalize the way that energy use is compared between various types of buildings, and evaluate the means of reducing overall energy consumption.

With the EUI measurement, energy use is expressed as a function of a building’s total area or “footprint”. In the United States, EUI is typically expressed in energy used per square foot of building footprint per year. It is calculated by dividing the total gross energy consumed in a one-year period (expressed in kilowatt-hours or kilo-British Thermal Units) by the total gross square footage of the building.

Social Cost of Carbon

The social cost of carbon is a measure of the economic harm from climate change impacts, expressed as the dollar value of the total damages from emitting one ton of carbon dioxide into the atmosphere. The State of Minnesota Public Utilities Commission estimate the local Cost of Carbon at a range of $9.98 to $47.47 per metric ton of GHG emissions. The operation of Solar PV arrays provides a no-carbon source of electricity. As such, the long-term value of solar PV arrays could be seen as including the life-time avoided cost of carbon. Based on the State of Minnesota estimated cost of carbon, this would equal $130 to $670 in avoided community costs of carbon for every KW of solar pv installed. **This value is not included in the project estimates included in this report.**

1 SOLAR PANELS WILL DAMAGE MY ROOF.

Fact: The solar PV cells attached to rooftops use modern materials perfected in labs. Holes need to be drilled into a roof to attach solar panels, but your roof can still be protected. Reputable solar panel installation companies follow industry best practices, like using quality flashed mounts to waterproof roof penetrations

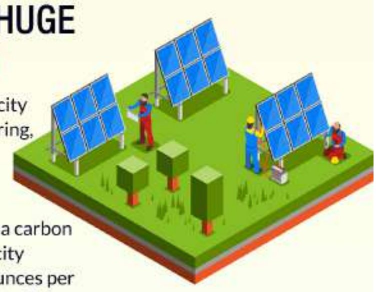
2 SOLAR PANELS DON'T WORK IN COLD CLIMATES

Fact: If there are any daylight hours in your area, solar panels can still be effective. This is why Germany—which receives about the same amount of sunshine as Alaska—is currently a solar superpower. In fact, even though Utah is known for a long winter season, the state has enough solar power potential to provide all the electricity the U.S. needs. Solar panels are built to withstand varying temperatures, and they can produce electricity from indirect light.

3 SOLAR PANELS ARE TOXIC.

Fact: Detailed analysis indicates that the large-scale implementation of solar has the potential to reduce pollution-related environmental impacts of electricity production, such as GHG emissions, freshwater ecotoxicity, eutrophication, and particulate-matter exposure. The pollution caused by higher material requirements of these technologies is small compared with the direct emissions of fossil fuel-fired power plants

4 SOLAR ELECTRICITY HAS A HUGE CARBON FOOTPRINT



Fact: The operation of solar pv modules generating electricity do not produce greenhouse gas emissions. The manufacturing, installation, and on-going maintenance of solar PV does produce a carbon footprint – what is known as "Lifecycle emissions".

The lifecycle emissions of electricity generated by coal has a carbon footprint of 35.3 ounces per KWh generated, while electricity generated by natural gas has a carbon footprint of 17.65 ounces per KWh generated. Meanwhile, the lifecycle emissions for Solar PV equates to an average of 1.4 ounces of greenhouse gas for every kWh the panel will produce over its lifetime – a 92% reduction of emissions over natural gas and a 98% reduction of emissions over coal.

5 SOLAR ELECTRICITY DOES NOT REALLY HAVE ENVIRONMENTAL AND HEALTH BENEFITS

Fact: In the United States, the actual environmental and health benefits for every solar module (individual panel) installed is:

- 10,600 lbs of greenhouse gases eliminated
- Equivalent to 94,000 Cubic Feet of Manmade Atmosphere avoided
- 69,650 gallons of freshwater saved
- Equivalent to the annual water use of 232 households saved
- Creates more jobs: nationally, solar employs 350,000 people – twice that of the coal industry.
- Elimination of over 5 pounds of particulate air pollution for every solar panel installed.

Section 02

City-Wide Solar Potentials

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City-Wide Solar Potentials

Solar In Minnesota

As of September, 2019, Minnesota has a total of 1,287.59 megawatts (1,287,590,000 watts) of solar capacity installed statewide. Approximately 70% of that capacity went 'on-line' since early 2017, with a total of over 6,349 arrays installed. As of the end of 2019 the State of Minnesota ranked 19th nationally for total solar energy production capacity.

The State's solar installation total is enough to power 179,336 homes. The share of the State's total electricity use that comes from solar power, however, is less than 2.5%. This indicates great potential for growth throughout the State. Current solar growth projections for the State equal an additional 834 MW over the next 5 years - a growth rate that ranks 29th nationally.

Costs for Solar PV installation in the State have declined 70% since 2012. Price declines have been accompanied with increasing rate of investment in solar energy. A total of $1,914,200,000 has been invested in Solar PV installations with $558,260,000 in 2018 alone. The industry currently employs 4,602 people in 209 companies Statewide. Minnesota employment figures for Solar PV rank 17th nationally, again indicating a potential for employment growth.

(source: Solar Energy Industries Association, Solar Foundation)

Solar In Minnesota - By The Numbers

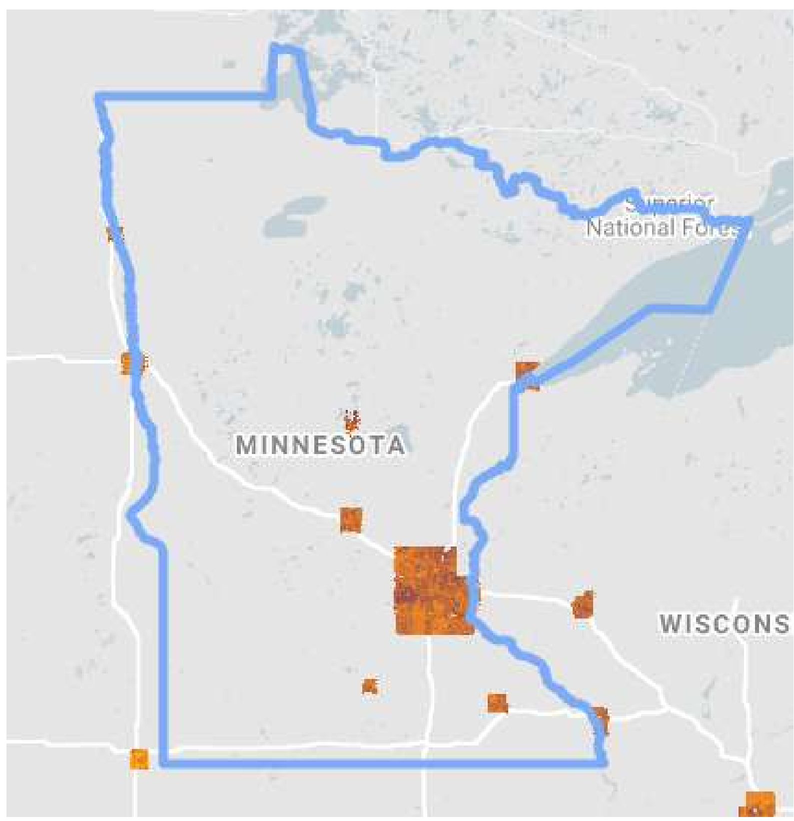
Buildings
71%
solar-viable

Roofs
770K

1.5K
existing solar installations

Capacity
16.4K
MW DC

Electricity
18.7M
MWh AC per yr



Based on 54% data coverage over buildings throughout the State, 71% of all buildings in Minnesota are solar-viable. Generation potential estimates are based on buildings viable for solar panels. Panels included in energy generation calculations receive at least 75% of the maximum annual sun in the county. For Minnesota, the average value of the threshold is 985 kWh/kW.

(source: Project Sunroof, data through 11/2018)

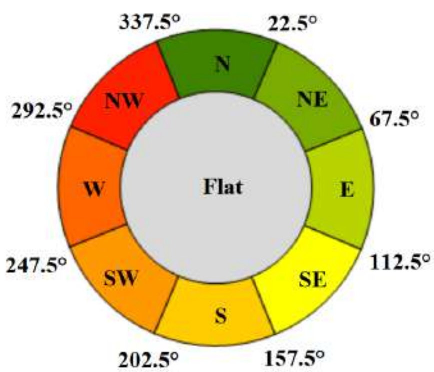
City-Wide Solar Potentials

Methodology and Data

This section calculates the total technical capacity and total generation potential for rooftop solar in the City. Total solar PV potential was calculated based on the following input, data, and methodology:

Input Data

Roof plane survey data is provided by National Renewable Laboratory (NREL). NREL data is based on lidar data obtained from the U.S. Department of Homeland Security (DHS). Insolation levels for annual sun exposure are based on data from NOAA and NREL.



Azimuth Classifications

Estimated System Losses by Azimuth

Flat	22.00%
South	26.21%
West/SW	32.60%
East/SE	33.98%

Estimated System Losses by Roof Tilt based on System Advisor Model (SAM) Assessment

flat (tilted rack)	0%
low angle	-9%
Mid Low Angle	-6%
Mid High Angle	0%
High Angle	-4%

Tilt and Azimuth

The orientation (tilt and azimuth) of a roof plane is important for determining its suitability for PV and simulating the productivity of installed modules. For this study roof plane tilt for each square meter of roof area within zip code 55057 was determined using the lidar data set. Roof tilts are organized into 5 categories:

Flat	(0° - 9.5°)
Low	(9.5°- 21.5°)
Mid-Low	(21.5° – 34.5°)
Mid-High	(34.5° – 47.5°)
High	(47.5° and higher)

For this study, the second component of roof plane orientation -the azimuth (aspect) – was identified for each square meter of roof area. Each square meter was categorized into one of nine azimuth classes, shown in the graphic to the right, where tilted roof areas were assigned one of the eight cardinal and primary intercardinal directions.

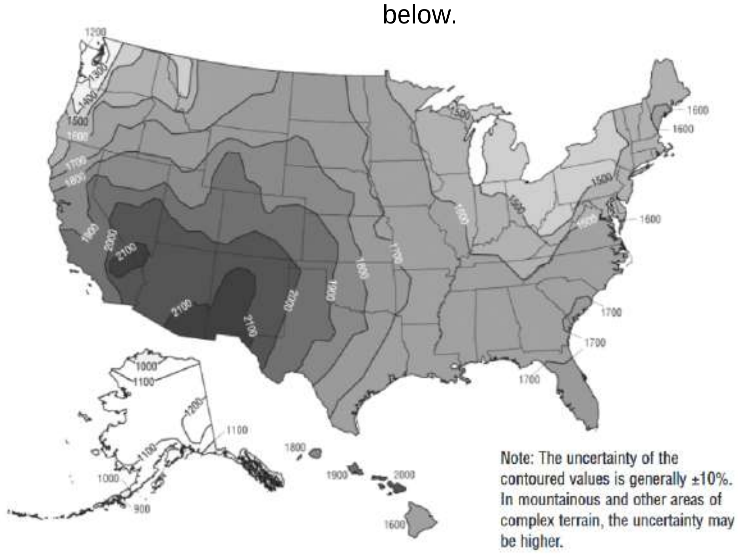
All roof planes with Northwest, North, and Northeast azimuths were excluded from this study.

Generation Potential

The potential "Nameplate capacity" potential per square foot of roof plane area was calculated. This calculation assumed a typical 350 watt capacity panel with a footprint of 79" x 40".

Next, this nameplate capacity was adjusted for assumed system losses including shading, heat loss, mismatch, snow, dirt, etc. Assumed losses were calculated for each azimuth orientation and rage from 22% system loss for flat arrays to 34% for East/Southeast orientations. Additionally, losses were calculated for roof tilt classifications based on the System Advisor Model.

Lastly, generation potential was calculated using the base Energy Production Factor for the region (annual KWH production/KW nameplate capacity), modified by the loss factors outlined above. The Energy Production Factor is based on NREL data as illustrated below.



National Solar PV Energy Production Factors

City-Wide Solar Potentials

Technical Capacity In Northfield

Technical capacity represents the total rooftop solar pv potential assuming economics and grid integration are not constraints. Based on the input and methodology previously outlined, there are an estimated 7,528 total buildings in Northfield, of those, it is estimated that 6,980 are "solar suitable" buildings.

These solar suitable buildings have an estimated 11,911 roofplanes which are either flat or with an azimuth orientation of East, Southeast, South, Southwest, or West, with a total estimated square footage of 3.8 million square feet. The chart below shows a further breakdown of roof orientation by roof tilt classifications as well. The potential installed technical energy capacity for all rooftops meeting selection criteria totals 65 Megawatts DC.

Generation Capacity In Northfield

Generation capacity represents the total amount of energy generation potential of the total Technical Capacity of the City. As previously outlined, the generation capacity is calculated using City-specific annual energy production factor (annual KWH production/KW nameplate capacity) which is based on the region's weather patterns and annual insolation levels (exposure to sun's energy). This energy production factor is then modified by estimated system losses by azimuth and estimated system losses by roof tilt (see page 2-3).

The chart below illustrates the total generation potential by roof azimuth and by roof tilt classifications. The Grand Total solar PV energy generation potential for the City is 65,085,866 KWH annually, approximately 25% of the City's total electric consumption (based on US Energy Information Agency data, City of Northfield Greenhouse Gas Inventory).

Generation Capacity In Northfield

			Flat		Low Tilt		Mid-Low Tilt		Mid-High Tilt		High Tilt	
Subtotal Flat												
Suitable Buildings	1,239	19.14%	**1,239**		0		0		0		0	
Suitable Roof Planes	2,280	19.14%	**2,280**		0		0		0		0	
Square Footage	720,772	19.15%	**720,772**		0		0		0		0	
Capacity (KW dc)	11,496	19.15%	**11,496**		0		0		0		0	
Generation (KWH)	14,346,829	22.04%	**14,346,829**		0		0		0		0	
Subtotal South Facing												
Suitable Buildings	1,853	28.62%	0		**429**		**1,179**		**243**		**1**	
Suitable Roof Planes	3,409	28.62%	0		**789**		**2,170**		**448**		**2**	
Square Footage	1,077,940	28.64%	0		**249,450**		**686,079**		**141,683**		**728**	
Capacity (KW dc)	17,192	28.64%	0		**3,979**		**10,943**		**2,260**		**12**	
Generation (KWH)	19,099,735	29.35%	0		**4,274,528**		**12,144,088**		**2,667,962**		**13,157**	
West + Southwest												
Suitable Buildings	1,679	25.93%	0		**293**		**1,081**		303		2	
Suitable Roof Planes	3,089	25.93%	0		**539**		**1,989**		558		3	
Square Footage	976,768	25.95%	0		**170,403**		**628,793**		176,480		1,092	
Capacity (KW dc)	15,579	25.95%	0		**2,718**		**10,029**		2,815		17	
Generation (KWH)	15,887,234	24.41%	0		**2,667,195**		**10,166,500**		3,035,511		18,028	
East + Southeast												
Suitable Buildings	1,703	26.30%	0		**272**		1,125		303		3	
Suitable Roof Planes	3,133	26.30%	0		**500**		2,070		558		5	
Square Footage	988,503	26.26%	0		**157,990**		654,397		174,506		1,610	
Capacity (KW dc)	15,766	26.26%	0		**2,520**		10,437		2,783		26	
Generation (KWH)	15,752,067	24.20%	0		**2,422,236**		10,363,724		2,940,064		26,044	
Grand Total			**Subtotal: Flat Roof**		**Subtotal: Low Tilt**		**Subtotal: Mid-Low Tilt**		**Subtotal: Mid-High Tilt**		**Subtotal: High Tilt**	
Suitable Buildings	6,474		1,239	19.14%	994	15.35%	3,385	52.30%	850	13.13%	5	0.08%
Suitable Roof Planes	11,911		2,280	19.14%	1,828	15.35%	6,229	52.30%	1,564	13.13%	10	0.08%
Square Footage	3,763,983		720,772	19.15%	577,843	15.35%	1,969,270	52.32%	492,669	13.09%	3,430	0.09%
Capacity (KW dc)	60,033		11,496	19.15%	9,216	15.35%	31,409	52.32%	7,858	13.09%	55	0.09%
Generation (KWH)	65,085,866		14,346,829	22.04%	9,363,959	14.39%	32,674,312	50.20%	8,643,537	13.28%	57,229	0.09%

City-Wide Solar Potentials

Optimized Generation Capacity In Northfield

Though the total energy generation outlined above is reasonably feasible, for purposes of establishing City-Wide potentials expectations it is appropriate to modify the total generation to reflect the likely most cost efficient installation potentials given current technologies and cost parameters. Solar PV installations which have less than ideal orientations capture less light per panel and therefore generate less energy per dollar spent. Establishing an Optimized Capacity establishes the cost effective solar pv installation potential based on current technology.

Identifying the installations most likely to be highly cost effective ultimately requires a site-by-site assessment, however, typical installation performance characteristics can be extrapolated to establish reasonable city-wide estimates. For the latitude and geography of Northfield, it can be assumed that all solar suitable roof planes that are flat or south facing should ultimately be reasonably cost effective installations.

For West and Southwest facing roof planes, it is likely that all low and mid-low roof tilt installations would be cost effective, while mid-high and high roof tilt installations with West or Southwest orientation may produce self-shading for many of the solar productive hours making those installations viable on a case-by-case basis. Like wise, for East and Southeast facing roof planes, it is likely that all low roof tilt installations would be cost effective, while mid-low, mid-high, and high roof tilt installations facing East may produce self-shading, making those installations also viable on a case-by-case basis.

On the chart below, all solar suitable roof planes with roof tilt and azimuth orientation combinations likely to be consistently cost effective are shown and are considered to be the City's Optimized Generation Capacity. It should be noted that installations outside of these selections may still be cost effective but require individual feasibility assessment. The total Optimized Generation Capacity in Northfield is estimated to be 48,702,495 KWH annually, approximately 18.65% of the City's total electric consumption.

Optimized Generation Capacity In Northfield

			Flat		Low Tilt		Mid-Low Tilt		Mid-High Tilt		High Tilt	
Subtotal Flat												
Suitable Buildings	1,239	26.16%	**1,239**		0		0		0		0	
Suitable Roof Planes	2,280	26.16%	**2,280**		0		0		0		0	
Square Footage	720,772	26.15%	**720,772**		0		0		0		0	
Capacity (KW dc)	11,496	26.15%	**11,496**		0		0		0		0	
Generation (KWH)	14,346,829	29.46%	**14,346,829**		0		0		0		0	
Subtotal South Facing												
Suitable Buildings	1,853	39.11%	0		**429**		**1,179**		**243**		**1**	
Suitable Roof Planes	3,409	39.11%	0		**789**		**2,170**		**448**		**2**	
Square Footage	1,077,940	39.11%	0		**249,450**		**686,079**		**141,683**		**728**	
Capacity (KW dc)	17,192	39.11%	0		**3,979**		**10,943**		**2,260**		**12**	
Generation (KWH)	19,099,735	39.22%	0		**4,274,528**		**12,144,088**		**2,667,962**		**13,157**	
West + Southwest												
Suitable Buildings	1,374	29.00%	0		**293**		**1,081**					
Suitable Roof Planes	2,528	29.00%	0		**539**		**1,989**					
Square Footage	799,196	29.00%	0		**170,403**		**628,793**					
Capacity (KW dc)	12,747	29.00%	0		**2,718**		**10,029**					
Generation (KWH)	12,833,695	26.35%	0		**2,667,195**		**10,166,500**					
East + Southeast												
Suitable Buildings	272	5.74%	0		**272**							
Suitable Roof Planes	500	5.74%	0		**500**							
Square Footage	157,990	5.73%	0		**157,990**							
Capacity (KW dc)	2,520	5.73%	0		**2,520**							
Generation (KWH)	2,422,236	4.97%	0		**2,422,236**							
Grand Total			**Subtotal: Flat Roof**		**Subtotal: Low Tilt**		**Subtotal: Mid-Low Tilt**		**Subtotal: Mid-High Tilt**		**Subtotal: High Tilt**	
Suitable Buildings	4,738		1,239	26.16%	994	20.97%	2,260	47.71%	243	5.14%	1	0.02%
Suitable Roof Planes	8,717		2,280	26.16%	1,828	20.97%	4,159	47.71%	448	5.14%	2	0.02%
Square Footage	2,755,897		720,772	26.15%	577,843	20.97%	1,314,872	47.71%	141,683	5.14%	728	0.03%
Capacity (KW dc)	43,955		11,496	26.15%	9,216	20.97%	20,971	47.71%	2,260	5.14%	12	0.03%
Generation (KWH)	48,702,495		14,346,829	29.46%	9,363,959	19.23%	22,310,588	45.81%	2,667,962	5.48%	13,157	0.03%

City-Wide Solar Potentials

Market Capacity

Adequately anticipating the potential for new solar PV installations must consider not only the potential technical and generation capacities, but also the likely market capacity. As an emerging energy sector, there is little data upon which to base projections for likely installation of rooftop solar PV in the private sector. Additionally, the solar PV market is rapidly changing in both sophistication as well as in pricing and cost effectiveness. As noted in the Solar in Minnesota section of this report, the installed cost of solar PV in Minnesota has dropped 70% since 2012 and is expected to continue to decline in the coming years. Projections of solar PV installations should anticipate a continued increase in the number of solar pv installations year over year.

Market History

According to the Department of Energy, since 2005 the residential solar PV market has grown at an annual rate of 51%. A growth rate that has resulted in a residential solar PV capacity 95 times larger in just 12 years. In the State of Minnesota, the new installed capacity that went on line in 2016 was 258.9 MW; equal to 150% of the cumulative total of all solar PV installations in the state for all previous years. According to the City's Climate Action Plan appendix reports, in the City of Northfield, there are a total of 81 existing solar PV installations totaling 554 KW capacity, approximately 1.28% of the State total number of installations, or 0.04% of total generation capacity (compared to the City of Northfield's population at 0.36% of State total). These numbers indicate the City of Northfield's solar pv adoption rates are approximately 3 times higher than the State average adoption rates, however, the average array size is a fraction of the average array size in the State – likely due to the influence of utility scale and large commercial scale arrays throughout the State.

State Market Projections

The Solar Energy Industries Association (SEIA) projects solar PV installation capacity in the State to increase 834 MW by 2024. This is equal to a sustained increase of installed capacity of 12.9% annually. The timeframe of this projection overlaps partially with the currently established Federal Income Tax incentive program. For years 2022 and beyond, the tax incentive is expected to be phased out for residential solar pv installations, but a smaller incentive (10%) will remain for commercial property owners while cost projections anticipate a continued decrease in installation costs.

City-Wide Solar Potentials

Northfield Market Absorption Projections

Scenario A: Maintaining Current City Adoption Rate and Average Array Size (6.8 KW)

Simply anticipating the City's share of additional solar installations within the state over the next 5 years by maintaining the City's current adoption rate (1.28% of State installations and 0.04% of installed generating capacity) with an assumed maintained average array size of 6.8 KW would mean an increase of 359 KW of installed capacity within the City by 2024, for a total of 913 KW citywide. This is equivalent to approximately 1.5% of the total rooftop technical capacity potential or 2.1% of the optimized capacity potential within the City.

As the market continues to mature through the 2020's it may be reasonable to assume a reduction in the growth rate of new installed capacity beginning in year 2031. For purposes of this study, we recommend a 50% reduction of the annual rate of growth for 2030. This would result in a growth rate of 12.9% through 2030 and a 6.5% growth rate for years 2030 through 2040. The chart below shows projections through 2040 using the assumed Statewide growth rates and maintaining the City's current adoption rates and average array sizes.

Scenario A: Northfield Rooftop Solar PV Projection Based on Potential Market Absorption Maintaining Current Adoption Rate and Average Array Size (6.8 KW)

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of City Electric Consumption	This is Equivalent to adding (x) Average Residential Arrays Annually:	Or Equivalent to adding (x) Commercial Arrays Annually:
2024	913	989,667	**0.38%**	**13**	**2.2**
2030	1,900	2,060,439	**0.79%**	**24**	**4**
2040	3,917	4,246,631	**1.63%**	**30**	**5**

This projection indicates a significant shortfall from the City's current goal of 10% on-site solar by 2030 and 20% on-site solar by 2040 as established in the City's Climate Action Plan.

City-Wide Solar Potentials

Northfield Market Absorption Projections
Scenario B: Based on Potential Market Absorption and Increasing City Adoption Rate to Population Share (measured by KW installed)

As noted earlier, the City of Northfield has a higher than State average adoption rate in terms of number of arrays installed per capita, but a ***lower*** than State average in terms of generating capacity (KW) installed per capita. If it is assumed that the City's future solar adoption rate, when measured by KW installed per capita, to match the State average over the next 5 years, it would mean an increase of 2,998 KW of installed capacity within the City by 2024 for a total of 3,552 KW citywide. This is equivalent to approximately 5.9% of the total rooftop technical capacity potential or 8.1% of the optimized capacity potential within the City.

As the market continues to mature through the 2020's it may be reasonable to assume a reduction in the growth rate of new installed capacity beginning in year 2031. For purposes of this study, we recommend a 50% reduction of the annual rate of growth for 2030. This would result in a growth rate of 12.9% through 2030 and a 6.5% growth rate for years 2030 through 2040. The chart below shows projections through 2040 using the assumed Statewide growth rates and increasing the City's current adoption rates and average array sizes.

Scenario B: Northfield Rooftop Solar PV Projection Based on Potential Market Absorption and Increasing City Adoption Rate to Population Share
(measured by KW installed)

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of City Electric Consumption	This is Equivalent to adding (x) Average Residential Arrays Annually:	Or Equivalent to adding (x) Commercial Arrays Annually:
2024	3,552	3,850,992	**1.47%**	**110**	**18.7**
2030	7,395	8,017,579	**3.07%**	**94**	**16**
2040	15,242	16,524,484	**6.33%**	**115**	**20**

Though improved over Scenario A, this projection indicates a shortfall from the City's current goal of 10% on-site solar by 2030 and 20% on-site solar by 2040 as established in the City's Climate Action Plan.

Northfield Market Absorption Projections
Scenario C: Adoption Rate Required to Meet City's Climate Action Plan Goals (measured by KW installed)

As noted in Scenarios A and B, neither of those potential market absorption rates will reach the level of solar pv adoption needed to meet the 2030 and 2040 on-site solar goals included in the City's Climate Action Plan. The Scenario below illustrates the needed solar adoption rates to meet these goals.

This Scenario would result in an annualized growth rate of 400% through 2024, a 26% annual growth rate for years 2025-2030 and a 10% annual growth rate for years 2030 through 2040. The total solar pv installed by year 2040 would equal nearly 100% of the currently available optimal rooftop generating capacity.

Scenario C: Northfield Rooftop Solar PV Adoption Rate Required to Meet City's Climate Action Plan Goals
(measured by KW installed)

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of City Electric Consumption	This is Equivalent to adding (x) Average Residential Arrays Annually:	Or Equivalent to adding (x) Commercial Arrays Annually:
2024	9,412	10,204,165	**3.91%**	**326**	**55.4**
2030	24,084	26,111,041	**10.00%**	**503**	**86**
2040	48,168	52,222,081	**20.00%**	**600**	**102**

City-Wide Solar Potentials

Economic Potential

As with all energy sources, solar PV installations require investment up-front for construction and installation as well as annual maintenance costs. When measured on a per unit of energy consumed, these costs are similar, or more competitive than, the costs associated with other energy sources. Unlike almost all other forms of electricity, however, a significant portion of the initial and on-going costs associated with solar PV are capable of remaining in the local economy. This means that for communities who plan carefully for the increase in renewable energy, a local economic development potential exists.

Economic Potential for Northfield

According to the National Renewable Energy Laboratory (NREL), the 15.97 MW of additional solar pv capacity which could be installed in the City by 2040 under Scenario B has a total construction value of $39 million (2020 dollars). The potential share of those investments for the local economy totals 50 jobs and $16 million in local income potential during construction and 10 jobs and $680,000 in local income potential for maintenance annually through the lifetime of the installations. Below is a breakout of the Northfield Economic Development potential of new installed solar pv capacity through 2040 based on the Scenario B market absorption projection numbers:

Northfield Local Economic Impacts - Summary Results Based on Scenario B

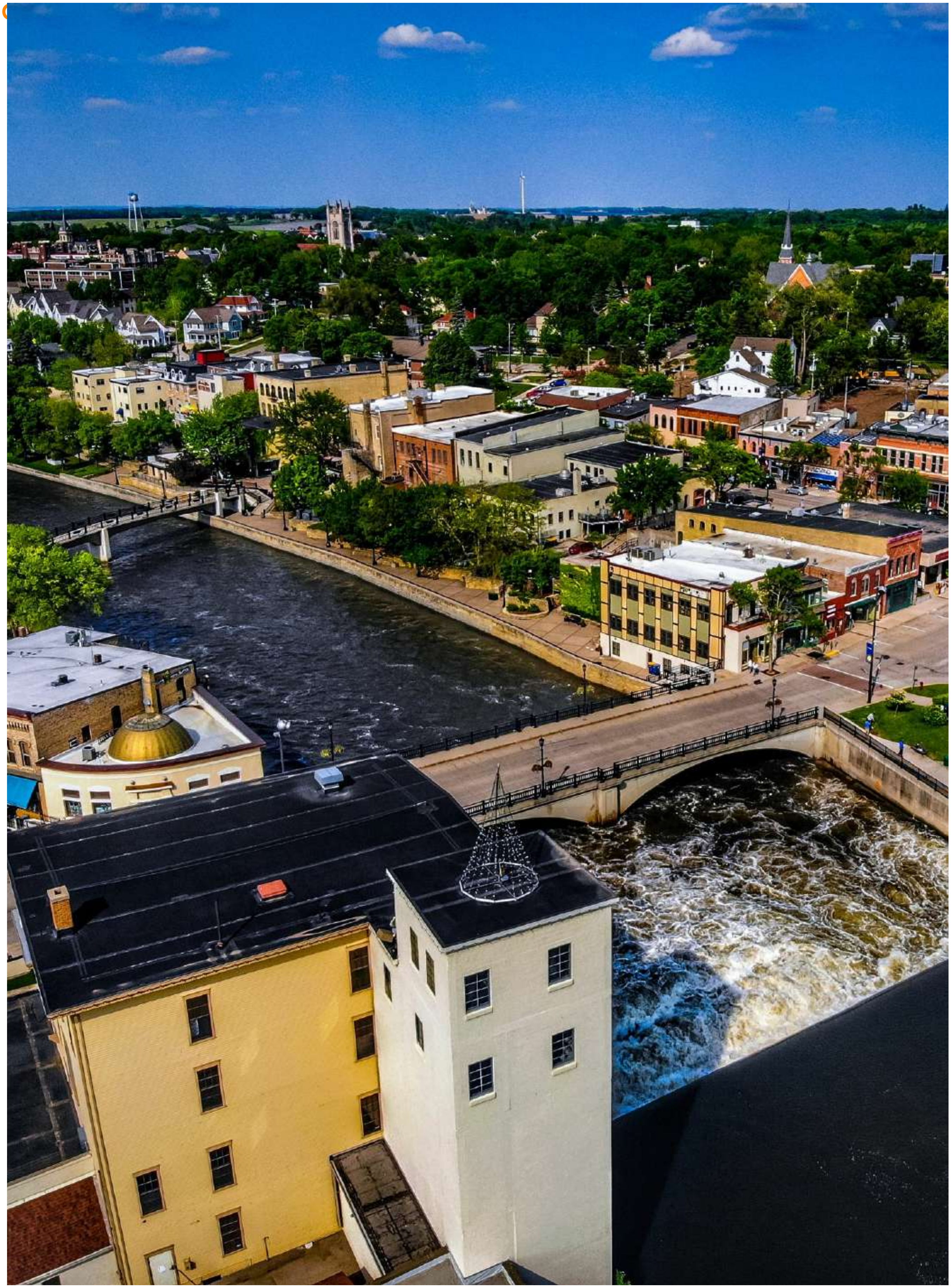
	Jobs	Earnings	Output	Value Added
During construction period		**Million$ 2020**	**Million$ 2020**	**Million$ 2020**
Project Development and Onsite Labor Impacts	18	$2.45	$3.34	$2.73
Construction and Interconnection Labor	11	$2.11		
Construction Related Services	6	$0.34		
Equipment and Supply Chain Impacts	18	$1.16	$4.72	$2.33
Induced Impacts	15	$0.92	$2.54	$1.38
Total Impacts	**50**	**$4.53**	**$10.60**	**$6.44**
	Annual Jobs	**Annual Earnings**	**Annual Output**	**Annual Output**
During operating years (annual)		**Million$ 2020**	**Million$ 2020**	**Million$ 2020**
Onsite Labor Impacts	7	$0.50	$0.50	$0.50
Local Revenue and Supply Chain Impacts	1	$0.09	$0.26	$0.17
Induced Impacts	1	$0.10	$0.27	$0.15
Total Impacts	**10**	**$0.68**	**$1.03**	**$0.81**

Additional Economic Benefit

In addition to the local re-investment share of the construction and maintenance costs, Northfield residents and business owners who invest in solar PV will have direct economic benefit in the form of savings. These savings represent increased economic potential within the City and include:

1) All residents and businesses who install solar PV prior to the phase out of the Federal Tax Incentive will be able to save 10-26% of the cost of installation. At the projected additional installation through 2022 outlined in the previous section, this could mean $675,000 up to $1.17 million in savings and local re-investment potential.

2) Many owners who install solar pv see a decrease in their annual energy costs (including solar pv project finance costs). Though savings vary, a reasonable estimate of the out-of-pocket savings for residents and businesses in Northfield is $38,000 to $75,000 annually by 2022 (assuming third party ownership structure or community solar subscriptions, long-term savings for direct ownership can be significantly higher)



City-Wide Solar Potentials

Environmental Benefits for Northfield

The core environmental benefits of Solar PV electric energy generation relate to improved air quality, reduced greenhouse gas emissions, and reduced water consumption.

Greenhouse Gas and Electricity

Greenhouse gas emissions form, primarily, from the burning of fossil fuels. The carbon footprint of electricity is the total greenhouse gas emissions throughout the life-cycle from source fuel extraction through to end user electricity. According to the Intergovernmental Panel on Climate Change (IPCC), the median greenhouse gas emission, measured in metric tonnes, for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Metric Tonnes GHG/GWh
Hydroelectric	4
Wind	12
Nuclear	16
Biomass	18
Geothermal	45
Solar PV	46
Natural gas	469
Coal	1001

The Water/Energy Nexus

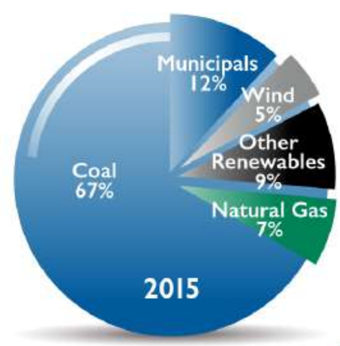
Water and energy are inextricably linked in our current modern infrastructure. Water is used in all phases of energy production. Energy is required to extract, pump and deliver water for use, and to treat waste-water so it can be safely returned to the environment. The cumulative impact of electricity generation on our water sources can be significant, and varies by fuel source. According to The River Network, the average fresh water use for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Gallons/GWh
Hydroelectric	29,920,000
Wind	1,000
Nuclear	2,995,000
Biomass	2,000
Geothermal	2,000
Solar PV	2,000
Natural gas	1,512,000
Coal	7,143,000

Current Northfield Electric Grid Profile

According to the US EPA, based on the Electricity Supply by Energy Source for their Upper Midwest region, the average greenhouse gas emissions per 1 Gwh of electricity is 365 Metric Tonnes. Using the River Network average fresh water use by fuel type, the average water use per 1 Gwh or electricity in Northfield is 5,306,500 gallons.

Based on these numbers, by 2022 under Scenario B, the additional solar pv installed in the City of Northfield can reduce its Greenhouse Gas emissions by 1,406 metric tonnes (27,889,310 cubic feet of man-made greenhouse atmosphere), and its water footprint by 20.43 Million Gallons.



Dairyland Electric Electric Fuel Mix

Scenario B: Carbon and Water Footprint Reduction Potential

(Based on Potential Market Absorption and Increasing City Adoption Rate to Population Share)

Year	Annual Generation (GWH)	GHG Emission Reduction (mTons)	GHG Emission Reduction (Cubic Feet of Atmosphere)	Water Footprint Reduction (Mgallons)
2024	3.85	1,406	27,889,310	20.43
2030	8.02	2,926	58,064,198	42.53
2040	16.52	6,031	119,672,146	87.65

Community-Wide Solar Recommendations

In support of the City's on-site solar goals included in its Climate Action Plan (10% generation by 2030, 20% by 2040) we recommend the following:

1) Maximize new installations in years 2020 and 2021 for both Residential and Commercial scale projects in order to leverage the greatest potential for local cost savings from the Federal Solar Investment Tax Credit. Actions to support this include:

   a) Develop and distribute information on the advantages of solar with a particular focus on the current tax incentive savings available for both homeowners and businesses. Information should also include detailed information on the advantages of Xcel Solar Rewards program and opportunities for financing such as MNPACE.

   b) Develop and provide a solar benefits educational seminar for residents and businesses, content to include information on the tax incentive savings potential as well as tools and resources for solar procurement and financing.

   c) Organize and lead a Commercial Group Purchasing campaign in 2020 and 2021 to competitively bid contractors to offer maximum cost savings based on power of quantity buying. This program could be combined with City facilities. Program should explore the inclusion of cash purchase as well as third party purchase options.

   d) Organize and lead a Residential Group Purchasing campaign in 2020 and 2021 to competitively bid contractors to offer maximum cost savings based on power of quantity buying.

   e) Develop and distribute a "Solar Ready Guide" outlining steps building owners can take for new construction and renovation projects to make buildings solar ready and decrease the cost of future installations.

   f) Establish a requirement that all City owned new construction projects and significant renovation projects as well as any projects which receive City funding are to be Solar Ready.

   g) Establish a requirement that all City owned new construction projects and significant renovation projects as well as any projects which receive City funding are to include a detailed solar feasibility assessment with projected financial payback (cash purchase and 3rd party ownership options) to be included at time of building permit application. (Strategy encourages awareness of solar potential and potential long-term economic savings)

   h) Promote PACE program utilization for initial project financing.

Community-Wide Solar Recommendations (continued)

2) Maximize new installations in years 2022 and beyond. Actions to support this include:

    a) Become a SolSmart Community Gold level

    b) Establish an incentive for all privately owned new construction projects and significant renovation projects that are designed to City's Solar Ready Guidelines (incentive may include credit on building permit application and/or expedited permit processing)

    g) Establish a requirement that new construction projects and significant renovation projects within the City (private and publicly owned) are to include a detailed solar feasibility assessment with projected financial payback (cash purchase and 3rd party ownership options) to be included at time of building permit application. (Strategy encourages awareness of solar potential and potential long-term economic savings)

    h) Promote PACE program utilization for initial project financing.

    I) Coordinate with County to explore the development of new incentive programs, particularly those aimed at low and moderate income residents. Program opportunities may include development of LIHEAP (Low Income Home Energy Assistance Program) based funding sources.

    j) Conduct a Green Economy Business and Economic Development Potentials study to identify strategies in leveraging economic opportunities in the Green Economy and emerging renewable energy field. Study should focus not only on national, state, and metro area trends, but should identify strengths, weaknesses, opportunities, and threats unique to Northfield. The goal of establishing a robust business atmosphere capable not only of serving Northfield renewable energy and green economy needs but fulfilling a unique economic niche within the region.

3) Identify and develop quality large array locations to support faster solar PV adoption. Actions to support this include:

    a) Conduct a study to identify ideal ground mounted solar pv array sites. Ideal sites will be locations adjacent to large energy consumers and sites without "higher and better" uses. Potentials may include sites such as capped landfill locations. Arrays should be directly tied to single offtaker, or development designed to retain REC's within the community.

    B) Conduct a study to identify ideal "car port" solar arrays (solar arrays mounted on structures over surface or structured parking locations), particularly at large surface parking locations. Arrays should be directly tied to single offtaker, or development designed to retain REC's within the community.

Section 03

Energy Use and Efficiency

City of Northfield Buildings

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Energy Use and Efficiency - City of Northfield Buildings

The initial facility reviews conducted on the City of Northfield buildings as a part of this Solar Master Plan was a review of each facility's energy use history. The total annual electric use and overall building energy use (including natural gas) was identified, recorded, and reviewed. The data reviewed and recorded in this report was obtained through the City's B3 Benchmarking account as well as City provided utility billing histories.

Understanding both total electric use and overall energy efficiency of a building are important first steps in prioritizing buildings to receive solar pv for a number of reasons:

Annual Electric Use

One of the important considerations when considering the appropriateness of installing on-site solar pv is the subject building's overall electric use. At the most base level, the amount of electricity consumed each year by a given building establishes the size of the array most appropriate for a site and is the foundation of the array's economic payback calculations.

Overall Energy Efficiency

paleBLUEdot has conducted a high-level review of the City of Northfield's facility energy use against the regional database of peers available through the B3 database, as well as the national database of peers available through the US EPA ENERGY STAR database. From this review, we have identified those buildings which perform above average in energy efficiency. See Table 3.1 for a review of the energy use and energy efficiency comparison against State and National peer groups. Buildings highlighted in light orange perform better than average against State peer groups, while buildings highlighted in light blue perform better than National peer groups. Buildings highlighted in red significantly under perform compared to State or National peer groups.

Improving Performance

In general, this report recommends that any building with a Peer Rating (percentile performance level) of 65 or less receive an energy and building envelope audit to identify opportunities for improved energy efficiency.

Table 3.1: Summary of Energy Use and Energy Efficiency Comparison to Peer Groups

General Information	Electric Use Data						Peer Comparison				
Name	Period	SF	Electric kWh	Total Electric Dollars	Electric Demand Dollars ** (Estimated)	Demand Share of Cost (%)	ENERGY STAR Score (Percentile)	MN Peer Rating (Percentile)	Number MN of Peers	*** Site EUI	High Performance EUI (75th Percentile)
City Hall	2019	25004	191,574	$19,271.63	$5,412.00	28.1%	73	51	1,093	56.9	50.7
Police Department	2019	20000	199,070	$20,226.63	$4,656.00	23.0%	28	25	20	91.2	50.7
Wastewater Treatment Plant	2019	1	3,584,843	$264,632.16	$45,696.00	17.3%	8	21	42	23,663.1	N/A
Water Department Office	2019	7500	225,011	$28,520.71	$11,328.00	39.7%	N/A	31	1,093	154.9	50.7
Northfield Community Resource Center *	2019	58000	545,280	$62,611.00	$11,451.00	18.3%	N/A	N/A	N/A	32.1	14.0
Outdoor Pool/Old Memorial field	2019	0	105,600	$12,529.00	$1,834.00	14.6%	N/A			N/A	N/A
Ice Arena	2019	30000	582,055	$59,208.53	$20,016.00	33.8%	N/A	3	67	91.1	14.3
Maintenance Facility	2019	24960	65,553	$7,420.26	$2,652.00	35.7%	N/A	71	109	33.7	10.4
Liquor Store	2019	4400	119,812	$34,751.15	$221.00	0.6%	N/A	13	439	122.8	16.8
Northfield Area Fire & Rescue *	2019	0	153,270	$15,987.00	$4,224.00	26.4%	N/A			35.6	18.7
Grand Total		**169,865**	**5,772,068**	**$525,158**	**$107,490**	**20.5%**					

* Facility owned by City of Northfield but operated by others or through joint partnership.

** Customers pay for electricity in one of two ways: consumption, measured in kilowatt-hours (kWh); and demand, measured in kilowatts (kW). Demand charges are fees applied to the electric bills of commercial and industrial customers based upon the highest amount of power drawn during any (typically 15-minute) interval during the billing period. Demand charges can comprise a significant proportion of commercial customers' bills. See Section 1 for additional information.

*** EUI stands for Energy Use Intensity. It is the energy use per square foot at a property (energy divided by square foot). EUI enables you to compare different sized buildings. See Section 1 for additional information.

Section 04

Solar Feasibility

City of Northfield Buildings

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Solar Feasibility - City of Northfield Buildings

The goal of the solar feasibility concept development is to explore the general potential for solar pv on each site with the goal of achieving a Zero Net Energy site (a site which generates as much electricity within a year as it consumes within the same timeframe).

Prioritization was given to rooftop solar arrays, with ground mounted and "carport" arrays being included only for sites which required them to achieve Zero Net Energy, or for building sites which can reasonably be assumed to have a structure incapable of supporting a rooftop array. Prior to proceeding further with the planning of any rooftop solar pv array, an assessment of the structure of each building included in this section should be conducted. All sites which have a ground mounted array in this section should have a civil engineering review of the site areas anticipating solar arrays to verify appropriate soil and site conditions.

A preliminary opinion of cost as well as a preliminary 30 year energy generation and value projection have been developed for each site. Costs are intended to illustrate Order of Magnitude and are preliminary in nature. Cost unit prices are based on 2017 national averages provided by the National Renewable Energy Laboratory, modified using local construction cost indicies. The 30 year value projections include estimates of base and solar buy back electric rates based on information available from the subject utility. Electric rates should be validated prior to proceeding further with the planning of any site.

Solar Feasibility Assessment

The detailed Solar Feasibility Assessment for each of the sites can be found in Appendix 1 of this report. The Solar Feasibility Assessment included a review of overall solar feasibility as well as development of solar pv concept designs for each recommended site. These efforts consisted of:

Determining the feasibility of solar energy :

- Conducting remote review of each recommended site using satellite data of each subject building and site.
- Identifying current and planned future building and site conditions which create impediment to solar pv installations.
- Identifying and record solar obstructions impacting potential solar pv performance.

Solar PV Concept Design.

- Creating concept design(s) for building and/or site solar PV array at each recommended site. Concept designs include overall array configuration, tilt, azimuth, and preliminary panel and inverter selections.
- Modeling annual solar pv performance based on detailed design components, historic local weather data, and site-specific solar obstructions.
- Creating a solar pv concept design report for each recommended site. Reports (found in Appendix 1 of this report) include:
    - Summary metrics including energy production, performance ratio, and kWh/kWp; Locations of array segments shown on map;
    - Monthly and annual production values;
    - System loss factors and detailed loss tree; records of condition set assumptions;
    - Preliminary bill of materials;
    - Preliminary electrical concept design assumptions;
    - Preliminary Mechanical layout assumptions;
    - Detailed concept plan/layout;
    - Detailed construction cost estimate;
    - 30 year energy production, value, and cost savings projections year-by-year.

Table 4.1 summarizes the results of the detailed site solar feasibility assessments for each of the sites, including rooftop and ground mounted array potential and first year energy generation. Appendix 1,"Solar Site Feasibility by Building" provides a brief summary of each as well as detailed preliminary array concepts, 30 year projected generation and value, and opinion of probable costs.

Solar Feasibility - City of Northfield Buildings

Concept Design

This report includes a conceptual layout of the solar PV array(s) for each site, as well as annual energy generation modeled from site-specific weather data, insolation levels, and solar obstructions. Energy generation is provided on a month-by-month basis. A preliminary breakdown of system components is included and forms the basis for the Order of Magnitude Project Budget.

The concepts in this report are intended to determine an overall magnitude of potential and to assess the viability of rooftop or ground-mounted solar. It should be noted that many options exist for the optimization of solar arrays depending on the overall goal for the site.

Rooftop solar arrays on flat roof facilities are typically designed to maximize annual energy production through a combination of maximizing the array size capable of fitting on available roof areas, as well as optimizing azimuth (compass direction of the array) and tilt configurations. As such, most rooftop arrays found in this report have a panel tilt of approximately 22 to 26 degrees. Alternative panel tilts of 30 to 36 degrees may yield slightly higher efficiency per panel (annual energy produced per panel), however the rooftop area required to produce the same total energy would increase as much as 25%. This means that for flat roof sites where the entire rooftop is required for energy generation, the site's annual electric production could drop by as much as 25% for a slight increase in per-panel yield efficiency. Rooftop arrays included in this report could implement either mechanically fastened or ballasted racking systems. Preliminary estimates assume ballasted racking components.

How To Read Concept Design Documents

Annual Production Report – this document provides a summary of the solar array size and annual performance.

System Metrics: an overview of the proposed array size, efficiency rating, and total annual electrical generation.

Monthly Production: an estimate of electric generation by month, responding to varying weather and sun conditions.

System Losses: all solar arrays have "losses" representing a reduction in total energy generated from the maximum potential of the panels. This provides an estimate of losses by category, such as shading or high panel temperature in strong sunlight conditions.

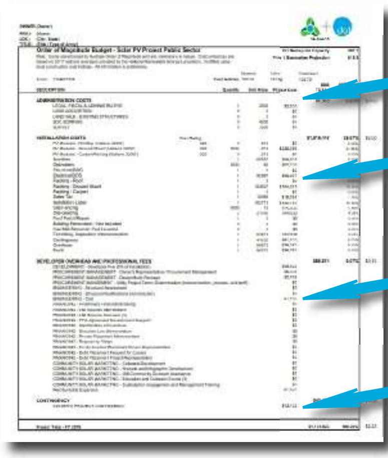
Array Concept – the second page of the "Annual Production Report" provides an illustration of the solar array concept and a summary of the array components planned.

Components: an overview of the solar array components used in modeling the potential production. Specific components such as the solar module or inverters used will have slight performance differences.

Detailed Layout provides an illustration of the solar PV array design concept used in this feasibility assessment. Alternative array locations and configurations are possible and may affect the potential array's ultimate cost and performance.

Solar Feasibility - City of Northfield Buildings

Project Budget - For each site, the Project Budget includes a preliminary opinion of project costs. This estimate is based on national solar PV installation cost data provided by the National Renewable Energy Laboratory (NREL) which have then been modified for local construction cost indices. Costs shown represent 2020 dollars. Projects planned for future installation should anticipate an increase in labor costs, however, system component costs are likely to remain constant or decrease on a per-kilowatt basis.



Administrative Costs: provide an allowance for general project costs such as legal/contract review and soil borings (for ground mounted arrays).

Installation Costs: provides a detailed opinion of the actual solar array construction costs. This section is what a building owner might anticipate paying a solar contractor to construct the array.

Professional Fees: provides an allowance for possible professional fees, such as design assistance or RFP/procurement assistance the site owner may choose to engage.

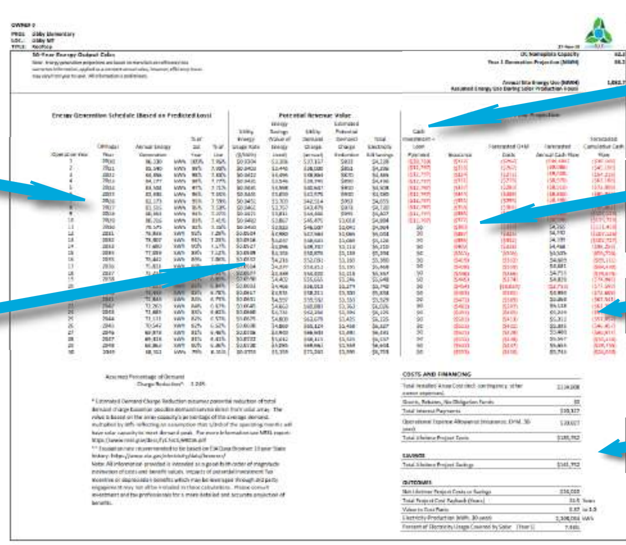
Contingency: provides an allowance for a recommended project contingency to cover unexpected costs. This value should be seen as protecting a project budget and under the control of the site owner.

30-Year Energy Generation - All solar PV panels lose some degree of efficiency over time due to material degradation caused by unavoidable circumstances, including UV exposure and weather cycles. Panel degradation and system generation losses are typically covered under panel warranty, usually at 0.7% to 1% annual losses. Studies by NREL, however, show average panel degradation rates for contemporary panels to be less than 0.5% annually. The "life span" energy generation projections included here are predicted using a 0.8% annual degradation factor. "Degradation"refers to the decline in output that all solar panels experience over time. Due to system degradation over time, the percentage of facility annual energy need that is met by an array initially will not be the same level met by an array in later years. To assist site owners in anticipating this change over time, the schedule provided indicates the percentage of annual site energy use which can be met by the solar array(s) each year**.**

Based on the modeled annual energy generation, the value of the solar energy generated is calculated for each site. Estimates include the value of energy consumed on site as well as the value of annual energy sold to the grid. Taken together, these values represent the potential life-span economic value of the solar array, which can then be compared against the estimated project costs.

Energy Generation Sched: an estimate of annual array performance.

Potential Revenue: an estimate of the value to the site of the solar energy generated with assumed electric rate inflation.



Financing: an allowance for array loan or bonding finance.

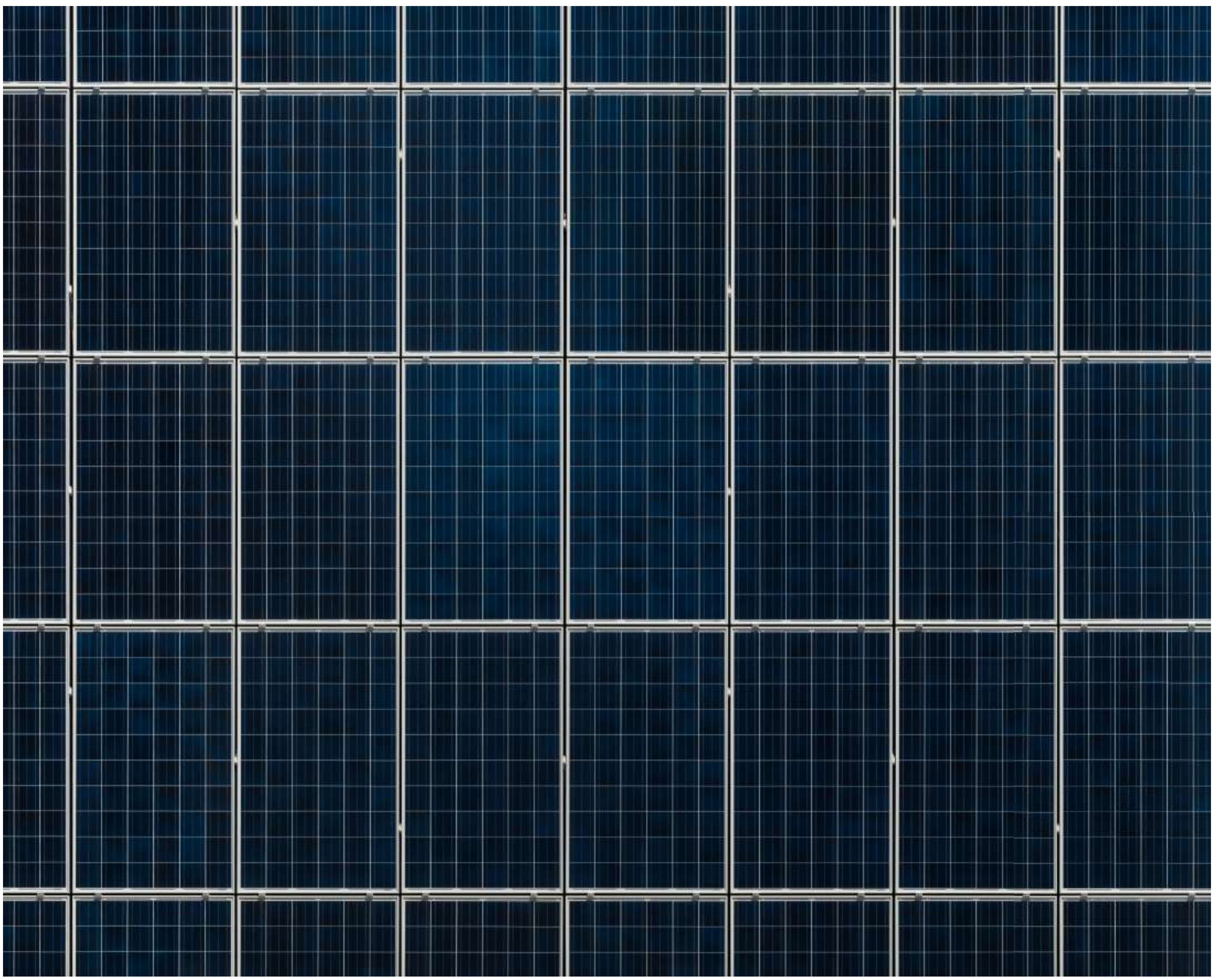
Annual Expenses: allowances for insurance and maintenance expenses.

Simplified Cash Flow: an estimate of array cash flow / pay back annually for 30 year term.

Solar Feasibility - City of Northfield Buildings

Table 4.1: Summary of Solar Feasibility

General Information	Solar Feasibiltiy Concept									
Name	Nameplate Capacity - Rooftop	Nameplate Capacity - Ground	Nameplate Capacity - Carport	Estimated Year 1 Generation	Estimated 30 Year Generation Total	Annual Generation Percent of Consumption	Net Zero Possible With On-Site Solar	Value	Concept Retains REC's (10 year)	Cost (Estimated Total Lifetime)
City Hall	30.50			40,230	1,076,811	21.00%	No	$169,327	No	$109,221
Police Department	83.00	83.30		224,500	6,009,051	112.77%	Yes	$861,483	Yes	$480,686
Wastewater Treatment Plant	161.40			220,000	5,888,602	6.14%	No	$701,490	Yes	$461,071
Water Department Office	15.40			20,980	561,559	9.32%	No	$91,035	No	$59,108
Northfield Community Resource Center	397.30	80.90		568,530	15,217,486	104.26%	Yes	$1,987,027	Yes	$1,364,180
Outdoor Pool/Old Memorial field		81.30		112,500	3,011,217	106.53%	Yes	$367,544	Yes	$265,371
Ice Arena	227.20		235.20	605,600	16,209,716	104.05%	Yes	$2,078,084	Yes	$1,703,102
Maintenance Facility	53.60			74,390	1,991,151	113.48%	Yes	$195,505	Yes	$171,589
Liquor Store	17.50			23,860	638,646	19.91%	No	$109,466	No	$66,546
Northfield Area Fire & Rescue	59.20	69.60		169,780	4,544,395	110.77%	Yes	$632,020	Yes	$393,355
Grand Total	**1,045**	**315**	**235**	**2,060,370**	**55,148,633**	**35.7%**		**$7,192,981**		**$5,074,228**



Section 05

Solar Implementation Master Plan

City of Northfield Buildings

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Solar Implementation Master Plan

Implementation Plan Goal

The goal of this solar implementation plan is to recommend a path towards 100% carbon-free electricity by 2030 for all of the City facilities included in this report's assessments. This goal is in line with the City of Northfield's adopted Climate Action Plan. For a review of the general strategies the City can implement on each building site to achieve carbon free electricity, please see "Options For Meeting 100% Carbon Free Goal" in Section 1.

Prioritization Methodology

The prioritization for sites to receive on-site solar installations in this report are based on multiple factors including:

- Solar capacity and efficiency supported by the site's physical parameters
- Estimated Value to Cost ratio
- Estimated on-site solar cost per kWh compared to utility provided cost per kWh
- Estimated on-site solar cost per kWh compared to Community Solar and Renewable Energy Credit cost per kWh

Community Solar Subscriptions

In 2017, the City of Northfield entered into a 25 year shared solar, or "community solar" agreement. The agreement is for an initial subscription of 1,912,500 kWh annually. Due to typical solar aging degradation rates, the actual "delivered" electricity will reduce slightly, resulting in a total of 1,695,725 kWh "delivered" by year 25. Community solar subscriptions support renewable energy development and typically benefit the subscriber with a reduction in their monthly electric bill.

As reviewed in Section 1, Community Solar subscriptions do not typically benefit the subscriber with the "Green Attributes" of the solar array. The "Green Attributes" of the community solar array are traditionally sold to the electric utility "offtaking" the electrical production. The result of this traditional community solar arrangement is that the community solar subscriber can claim to be supporting renewable energy, but cannot claim the greenhouse gas emission reductions or other "green attributes" of the solar array. The GHG emissions calculated for all of electricity the City receives through community solar subscriptions are required to be at the same emission rate as electricity supplied by the local electric grid. If the City wishes to offset the GHG emissions of city building electrical use, all electricity obtained through a solar subscription should be offset through the purchase of Renewable Energy Credits (REC). RECs may be purchased through the electric utility or separately through 3rd party providers.

For the purposes of establishing solar implementation recommendations for this report, paleBLUEdot assumes all electricity needs met through community solar subscriptions shall be offset by REC purchases prior to 2030 in support of the City's 100% renewable energy goal outlined above. See Table 5.1a for a review of the 2019 community solar subscription eligibility and allocation by City building.

In addition to the City's primary buildings, other premises receiving electrical service such as street lights and pump station locations, are also eligible for the Community Solar subscriptions and should be included in the City's carbon-free electricity Implementation Plan. See Table 5.1b for a review of additional premises eligible for Community Solar subscription.

Table 5.1a: 2019 Community Solar Subscription Eligibility and Allocation By City Building

General Information		Electric Use Data	Current Community Solar Subscription				
Name	Address	Electric kWh	Location (County)	Eligible for Existing Solar Subscription	Existing Solar Subscription	Existing Subscription Level (kWh)	Subscription Percent of Consumption
City Hall	801 Washington St	191,574	Rice	Yes	Yes	185,367	96.8%
Police Department	1615 Riverview Drive	199,070	Rice	Yes	Yes	178,476	89.7%
Wastewater Treatment Plant	1450 Highway 3 North	3,584,843	Dakota	No			0.0%
Water Department Office	1101 College St	225,011	Rice	Yes	Yes	214,700	95.4%
Northfield Community Resource Center	1651 Jefferson Parkway	545,280	Rice	Yes			0.0%
Outdoor Pool/Old Memorial field	801 7th St E	105,600	Rice	Yes	Yes	92,471	87.6%
Ice Arena	1280 Bollenbacher Drive	582,055	Rice	Yes			0.0%
Maintenance Facility	1710 Riverview Dr	65,553	Rice	Yes	Yes	65,706	100.2%
Liquor Store	116 Fifth Street West	119,812	Rice	Yes	Yes	126,406	105.5%
Northfield Area Fire & Rescue	301 5th St W	153,270	Rice	Yes			0.0%
Grand Total		**5,772,068**				**863,126**	**15.0%**

Table 5.1b: 2019 Community Solar Subscription Eligibility and Allocation - Other City Premises

Name	Address	Electric kWh	Location (County)	Eligible for Existing Solar Subscription	Existing Solar Subscription	Existing Subscription Level (kWh)	Subscription Percent of Consumption
Other City Premises							
Street lights	314 WOODLEY ST E		Rice	Yes			N/A
Crosswalk signal	2200 DIVISION ST S	0	Rice	Yes			N/A
Streetlight and crossing signal	120 3RD ST W	1239	Rice	Yes			0.0%
Well 6 - Electric	510 JEFFERSON PKWY	182,000	Rice	Yes			0.0%
Sechler Park	1700 ARMSTRONG RD	13,656	Rice	Yes			0.0%
Riverside Lions Park	710 S POPLAR ST	3847	Rice	Yes			0.0%
Well 5	1701 ARCHIBALD ST	29551.63	Rice	Yes	Yes	29551.63	100.0%
Roosevelt Park - warming house	980 ADAMS ST	1214	Rice	Yes			0.0%
Streetlights	115 6TH ST W	1752	Rice	Yes			0.0%
EV Station and parking lot	413 WATER ST	6614	Rice	Yes			0.0%
Streetlight and/or traffic signal	600 HIGHWAY 3 S	1160	Rice	Yes			0.0%
SIGNAL LIGHT	1255 HIGHWAY 3 S	10587	Rice	Yes			0.0%
Streetlight and signal	2301 HIGHWAY 3 S	3386	Rice	Yes			0.0%
Babcock Rodeo Grounds	700 HIGHWAY 3 S	10579	Rice	Yes			0.0%
Well 3	1500 MAPLE ST	30065.68	Rice	Yes	Yes	30065.68	100.0%
Steetlights	1120 HIGHWAY 3 S	4736	Rice	Yes			0.0%
Street lights, Parking lot lights	209 WATER ST S	16238	Rice	Yes			0.0%
Bridge Square	21 BRIDGE SQ	0	Rice	Yes	Yes	0	N/A
Memorial Park	800 5TH ST E	0	Rice	Yes	Yes		N/A
Streetlights	915 HIGHWAY 3 N	15250	Rice	Yes			0.0%
Sechler Park	1700 ARMSTRONG RD	4840	Rice	Yes			0.0%
Lift Station	951 BABCOCK LN	16110	Rice	Yes			0.0%
Riverside Lions Park	700 LINDEN ST S	6387	Rice	Yes			0.0%
Sechler Park	1200 ARMSTRONG RD	1488	Rice	Yes			0.0%
Babcock Park	1204 HIGHWAY 3 S	4320	Rice	Yes			0.0%
PUMPING STATION	1101 COLLEGE ST	28215.66	Rice	Yes	Yes	28215.66	100.0%
Well 4	500 AMES ST	29799.6	Rice	Yes	Yes	29799.6	100.0%
LIBRARY	210 WASHINGTON ST	41585.15	Rice	Yes	Yes	41585.15	100.0%
Riverwalk lights	413 WATER ST	1151	Rice	Yes			0.0%
Signal light at Post	700 5TH ST W	3262	Rice	Yes			0.0%
Garage - Booker Bus, etc.	201 LINDEN ST S	1851	Rice	Yes			0.0%
Riverside Lions Park	800 POPLAR ST	5720	Rice	Yes			0.0%
SIGNAL LT/HWY 3 & WO	1103 HIGHWAY 3 S	11329	Rice	Yes			0.0%
Spring Creek Park - shelter, lights	500 JEFFERSON PKWY	10137	Rice	Yes			0.0%
Riverwalk lights	250 WATER ST S	9	Rice	Yes			0.0%
Street lights	304 DIVISION ST S	2983	Rice	Yes			0.0%
Water Tower/Archery Range	10353 HALL AVE	13685	Rice	Yes			0.0%
Bridge Square	21 BRIDGE SQ	0	Rice	Yes	Yes	0	N/A
Central Park	421 4TH ST E	0	Rice	Yes			N/A
Odd Fellows Park	1001 FOREST AVE	902	Rice	Yes			0.0%
Streetlights	600 HIGHWAY 3 N	14393	Rice	Yes			0.0%
Sechler Park	1700 ARMSTRONG RD	7407.06	Rice	Yes	Yes	7407.06	100.0%
Streetlights	140 2ND ST W	3016	Rice	Yes			0.0%
WELL 2	1101 COLLEGE ST	28215.66	Rice	Yes	Yes	28215.66	100.0%
Compost site	2101 ARMSTRONG RD	1514	Rice	Yes			0.0%
Streetlights	140 2ND ST W	29654	Rice	Yes			0.0%
Way Park	725 SAINT OLAF AVE	7343	Rice	Yes			0.0%
Street Light	301 5TH ST W	25401	Rice	Yes			0.0%
Ped crossing flashing beacon	2 GREENVALE AVE W	410.96	Rice	Yes	Yes	410.96	100.0%
Ped crossing flashing beacon DQ	898 HIGHWAY 3 N	412.35	Rice	Yes	Yes	412.35	100.0%
Streetlights	4 FRANCIS CIR	4304	Rice	Yes			0.0%
Grand Total		**637,721**				**195,664**	**30.7%**

Solar Implementation Master Plan

Solar Feasibility Overview

Based on the detailed solar feasibility assessments in Section 4 and Appendix 1 of this report of the primary City of Northfield facilities, the sites are capable of generating over 83 million kWh over a 30 year life span, with the first year generation at over 3.1 million kWh. The site concepts included in this report would achieve "net zero" electricity - meaning the site generates as much electricity in a year as it consumes - for 6 of the 10 sites reviewed. While additional energy generation is possible on many of these sites, the additional on-site generation strategies required to meet the existing electricity use on the site would be cost prohibitive. The 4 remaining sites would require a reduction of on-site energy demand, or further concept development in order to achieve net zero.

The full portfolio of solar PV projects outlined in Section 4 of this report represent $7.1 million of investment including estimated financing and annual operation costs. These estimates do not anticipate leveraging the Federal ITC or tax depreciation values which would require a 3rd party ownership structure. The full portfolio outlined in Section 4 has a 30-year life span value of over $10.5 million, providing an average 1.48 to 1 benefit to cost ratio. The projected benefit to cost ratio can be further improved on each project through exploration of alternative funding scenarios. The opinion of potential installed cost per watt for these projects varies from less than $2 to more than $3.50. The primary drivers for increased project costs are decreased efficiencies for small projects and/or costs associated with the construction of carport or structures for appropriate solar array exposures.

Implementation Priority Level

Based on the detailed solar feasibility assessment, some of the sites appear to be optimally suited for solar PV installations while others are moderate. Though there are multiple ways to judge the value of solar installation potential at any site (environmental impact, social impact, economic impact), this review uses only the economic impact for the identification of site implementation priority of concepts with the intent of meeting the City's stated goal of 100% renewable energy for all City facilities by 2030.

As outlined in Table 5.2, the priority level for each site is based on a combination of factors as overviewed in the Prioritization Methodology section. A combination of metrics shown on the table were used to establish the recommended priority levels as follows:

- Projected total economic value to cost of each solar array over a 30 year life span, communicated as a single number.
- Calculated 30 year life span cost per kWh comparison for carbon free electricity of on-site renewable option vs utility provided electricity combined with purchase of RECs.
- Consideration of on-site renewable option cost per kWh compared to current community solar subscription cost combined with purchase of RECs.

Reviewed against these metrics, the Priority Levels are:

> Priority Level 1: Value to Cost Ratio of 1.39 or greater AND an Effective Cost per kWh Difference From Base Rate + REC of -$0.01 or less (projected cost savings) AND an Effective Cost per kWh equal to or less than Solar Subscription + REC. (Lower projected costs than all other Carbon-Free options)
>
> Priority Level 2: Value to Cost Ratio of 1.14 or greater AND an Effective Cost per kWh equal to or less than Base Rate + REC (Equal or lower projected costs than all other Carbon-Free options)
>
> Priority Level 3: Effective Cost per kWh Difference From Base Rate + REC of $0.02 or more (Higher projected costs than all other Carbon-Free options)

Please see the following pages for a summary of all sites and the recommended prioritization for solar implementation by organization as well as by Priority Level.

Recommended Implementation Prioritization By Priority Level

Table 5.2 provides a detailed overview of the solar feasibility and projected annual energy generation potential for each site, organized by priority level. The "On-Site Solar Priority Level" for each site is identified. The priority levels range from 1 to 3. In general, sites with a "1" priority designation are likely solar pv sites with good or strong economic payback potential and should be implemented as soon as feasible by the City.

Sites with a "2" priority designation are likely sites with reasonable economic payback but may have less favorable electric utility rate structures and may benefit from further exploration of project parameters/approaches to increase cost efficiency of electric consumption prior to implementing on-site solar.

In general, sites with a "3" priority level may be more cost effectively addressed through the purchase of REC's meeting the site's energy consumption. These sites may also benefit from further exploration of project parameters/approaches to increase cost efficiency of electric consumption. Priority level 3 sites are not currently recommended for on-site solar array installation.

Table 5.2: Recommended Implementation Prioritization

General Information	Solar Feasibiltiy Concept													
Name	Nameplate Capacity - Rooftop	Nameplate Capacity - Ground	Nameplate Capacity - Carport	Estimated Year 1 Generation	Estimated 30 Year Generation Total	Annual Generation Percent of Consumption	Net Zero Possible With On-Site Solar	Value	Concept Retains REC's (10 year) *	Cost (Estimated Total Lifetime)	Value to Cost Ratio	** Effective Cost per kWh Difference From Base Rate + REC	** Effective Cost per kWh Difference From Solar Subscription +REC	On-Site Solar Priority Level
City Hall	30.50			40,230	1,076,811	21.00%	No	$169,327	No	$109,221	1.55	0.020	$0.047	3
Police Department	83.00	83.30		224,500	6,009,051	112.77%	Yes	$861,483	Yes	$480,686	1.79	-0.011	$0.015	2
Wastewater Treatment Plant	161.40			220,000	5,888,602	6.14%	No	$701,490	Yes	$461,071	1.52	0.004	$0.031	2
Water Department Office	15.40			20,980	561,559	9.32%	No	$91,035	No	$59,108	1.54	0.020	$0.047	3
Northfield Community Resource Center	397.30	80.90		568,530	15,217,486	104.26%	Yes	$1,987,027	Yes	$1,364,180	1.46	-0.017	$0.009	1
Outdoor Pool/Old Memorial field		81.30		112,500	3,011,217	106.53%	Yes	$367,544	Yes	$265,371	1.39	-0.026	$0.000	1
Ice Arena	227.20		235.20	605,600	16,209,716	104.05%	Yes	$2,078,084	Yes	$1,703,102	1.22	0.025	$0.051	3
Maintenance Facility	53.60			74,390	1,991,151	113.48%	Yes	$195,505	Yes	$171,589	1.14	0.000	$0.027	2
Liquor Store	17.50			23,860	638,646	19.91%	No	$109,466	No	$66,546	1.64	-0.007	$0.020	2
Northfield Area Fire & Rescue	59.20	69.60		169,780	4,544,395	110.77%	Yes	$632,020	Yes	$393,355	1.61	-0.003	$0.023	2
Grand Total	**1,045**	**315**	**235**	**2,060,370**	**55,148,633**	**35.7%**		**$7,192,981**		**$5,074,228**	1.42			

* Sites with total solar array nameplate capacities below 40KW qualify for enrollment in Xcel Energy's Solar Rewards incentivized solar program. Through the program Xcel Energy compensates the solar array owner with additional payments as purchase of the array's RECs for the first 10 years of operation. Starting in year 11, the additional payments are terminated and the array's RECs revert back to the solar array owner.

** As noted, cost comparisons are based on "apples-to-apples" solutions achieving carbon-free electricity. As such comparisons assume the purchase of RECs for any site receiving grid electricity or Community Solar subscriptions. Prioritization of solar for sites should be re-evaluated if REC purchase is not included for sites without on-site solar generation. Green text indicates sites with on-site solar out-performing alternative approach to achieving carbon zero electricity

Carbon-Free Electricity Implementation Plan - Primary Buildings

Table 5.3 provides an overview of the recommended approach to achieve Carbon-Free electricity for each site included in this study. The options to achieve Carbon-Free electricity for each site include (See "Options For Meeting 100% Carbon Free Goal" in Section 1):

1) Purchase of grid supplied electricity combined with purchase of Renewable Energy Credits (RECs).
2) Allocation of existing Community Solar Subscription and applying a portion of the resulting annual electric cost savings for purchase of RECs
3) Installation of incentivized on-site renewable energy (without green attributes retained for first 10 years of operation) and applying a portion of the resulting annual electric cost savings for purchase of RECs
4) Installation of on-site renewable energy generation (with green attributes retained)

Some site recommendations may include a combination of the above.

Table 5.3: Recommended Carbon-Free Electricity Implementation Plan - Primary City Buildings

General Information	Carbon Free Plan									
Name	On-Site Solar With REC Retained	On-Site Without REC Retained	Recommended Solar Subscription Level (Without REC Retained)	Utility Grid Provided Electricity	RECs Required (MWH)	Estimated Annual REC Cost (25 year ave)	REC Purchase Likely Offset by CSG Subscription or SolarRewards Payment	Achieves Carbon Free	Facility Roof Replacement Year Scheduled	Recommended On-Site Solar Array Installation Timeframe
City Hall			191,574	0	192	$2,525	Yes	Yes		Not Recommended
Police Department	224,500		0	0	0	$0	N/A	Yes		3-6 Years
Wastewater Treatment Plant	220,000		0	3,364,843	3365	$44,348	No	Yes	2021 / 2022	3-6 Years
Water Department Office			225,011	0	225	$2,966	Yes	Yes		Not Recommended
Northfield Community Resource Center	568,530		0	0	0	$0	NA	Yes		0-3 Years
Outdoor Pool/Old Memorial field	112,500		0	0	0	$0	NA	Yes		0-3 Years
Ice Arena			582,055	0	582	$7,671	Yes	Yes	2021	Not Recommended
Maintenance Facility	74,390		0	0	0	$0	NA	Yes		3-6 Years
Liquor Store		23,860	95,952	23,860	120	$1,579	Yes	Yes		3-6 Years
Northfield Area Fire & Rescue	169,780		0	0	0	$0	NA	Yes		3-6 Years
Grand Total	**1,369,700**	**23,860**	**1,094,592**	**3,388,703**	**4,483**	**$59,089**				

Carbon-Free Electricity Implementation Plan - Other Premises

As noted earlier, In addition to the City's primary buildings, other premises receiving electrical service such as street lights and pump station locations, are also eligible for the Community Solar subscriptions and should be included in the City's carbon-free electricity Implementation Plan in order to achieve the City's goals. Table 5.4 provides an overview of the recommended approach to achieve Carbon-Free electricity for these other premises not included in the solar feasibility assessment effort of this study. The options to achieve Carbon-Free electricity for each site include (See "Options For Meeting 100% Carbon Free Goal" in Section 1):

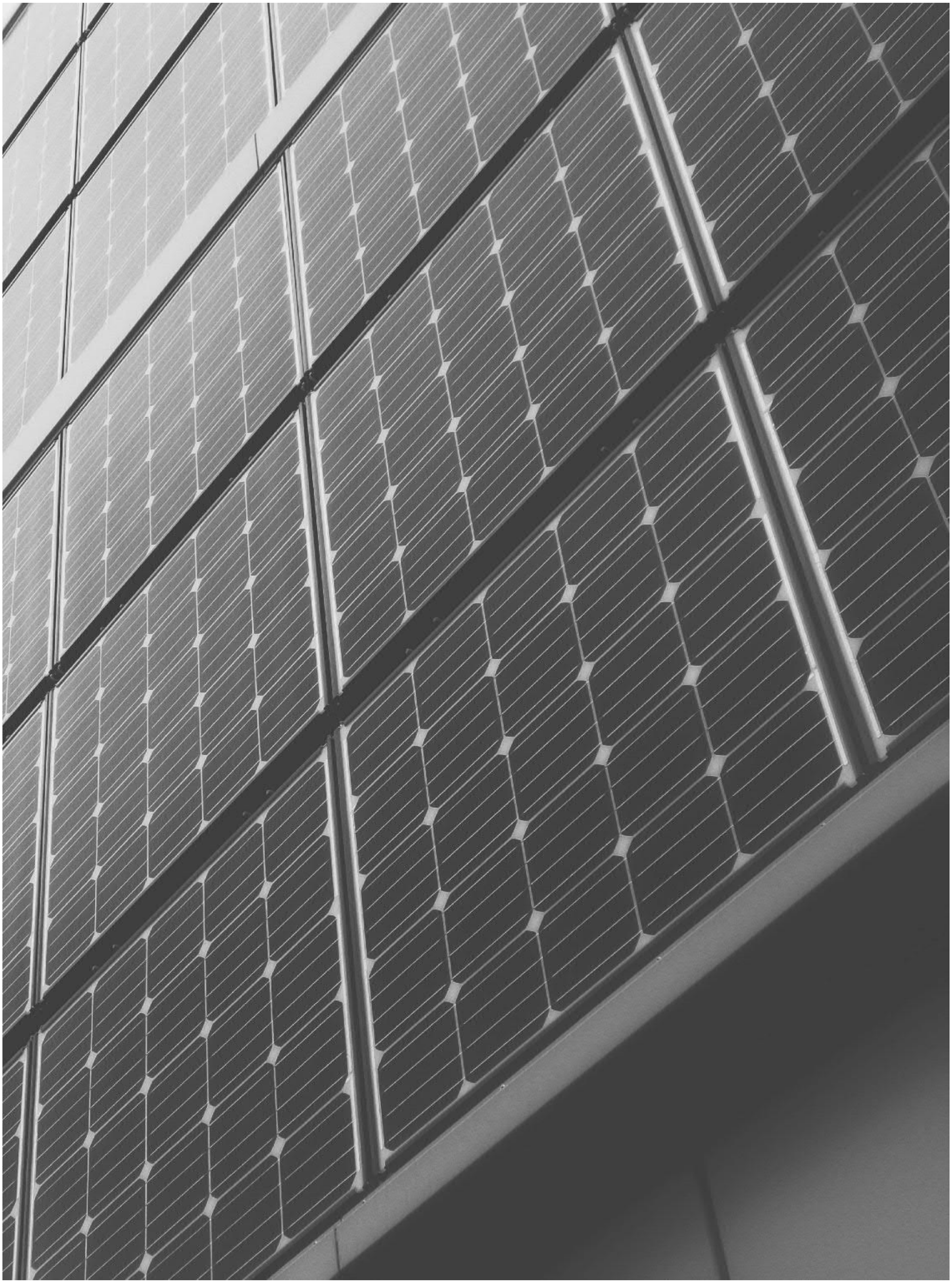
1) Purchase of grid supplied electricity combined with purchase of Renewable Energy Credits (RECs).
2) Allocation of existing Community Solar Subscription and applying a portion of the resulting annual electric cost savings for purchase of RECs.

Some site recommendations may include a combination of the above.

Table 5.4: Recommended Carbon-Free Electricity Implementation Plan - Other Premises

General Information	Carbon Free Plan								
Name	On-Site Solar With REC Retained	On-Site Without REC Retained	Recommended Solar Subscription Level (Without REC Retained)	Utility Grid Provided Electricity	RECs Required (MWH)	Estimated Annual REC Cost (25 year ave)	REC Purchase Likely Offset by CSG Subscription or SolarRewards Payment	Achieves Carbon Free	Recommended On-Site Solar Array Installation Timeframe
Other City Premises									
Street lights			0	0	0	$0	Yes	Yes	0-3 Years
Crosswalk signal			0	0	0	$0	Yes	Yes	0-3 Years
Streetlight and crossing signal			1,239	0	1	$16	Yes	Yes	0-3 Years
Well 6 - Electric			182,000	0	182	$2,399	Yes	Yes	0-3 Years
Sechler Park			13,656	0	14	$180	Yes	Yes	0-3 Years
Riverside Lions Park			3,847	0	4	$51	Yes	Yes	0-3 Years
Well 5			29,552	0	30	$389	Yes	Yes	0-3 Years
Roosevelt Park - warming house			1,214	0	1	$16	Yes	Yes	0-3 Years
Streetlights			1,752	0	2	$23	Yes	Yes	0-3 Years
EV Station and parking lot			6,614	0	7	$87	Yes	Yes	0-3 Years
Streetlight and/or traffic signal			1,160	0	1	$15	Yes	Yes	0-3 Years
SIGNAL LIGHT			10,587	0	11	$140	Yes	Yes	0-3 Years
Streetlight and signal			3,386	0	3	$45	Yes	Yes	0-3 Years
Babcock Rodeo Grounds			10,579	0	11	$139	Yes	Yes	0-3 Years
Well 3			30,066	0	30	$396	Yes	Yes	0-3 Years
Steetlights			4,736	0	5	$62	Yes	Yes	0-3 Years
Street lights, Parking lot lights			16,238	0	16	$214	Yes	Yes	0-3 Years
Bridge Square			0	0	0	$0	Yes	Yes	0-3 Years
Memorial Park			0	0	0	$0	Yes	Yes	0-3 Years
Streetlights			15,250	0	15	$201	Yes	Yes	0-3 Years
Sechler Park			4,840	0	5	$64	Yes	Yes	0-3 Years
Lift Station			16,110	0	16	$212	Yes	Yes	0-3 Years
Riverside Lions Park			6,387	0	6	$84	Yes	Yes	0-3 Years
Sechler Park			1,488	0	1	$20	Yes	Yes	0-3 Years
Babcock Park			4,320	0	4	$57	Yes	Yes	0-3 Years
PUMPING STATION			28,216	0	28	$372	Yes	Yes	0-3 Years
Well 4			29,800	0	30	$393	Yes	Yes	0-3 Years
LIBRARY			41,585	0	42	$548	Yes	Yes	0-3 Years
Riverwalk lights			1,151	0	1	$15	Yes	Yes	0-3 Years
Signal light at Post			3,262	0	3	$43	Yes	Yes	0-3 Years
Garage - Booker Bus, etc.			1,851	0	2	$24	Yes	Yes	0-3 Years
Riverside Lions Park			5,720	0	6	$75	Yes	Yes	0-3 Years
SIGNAL LT/HWY 3 & WO			11,329	0	11	$149	Yes	Yes	0-3 Years
Spring Creek Park - shelter, lights			10,137	0	10	$134	Yes	Yes	0-3 Years
Riverwalk lights			9	0	0	$0	Yes	Yes	0-3 Years
Street lights			2,983	0	3	$39	Yes	Yes	0-3 Years
Water Tower/Archery Range			13,685	0	14	$180	Yes	Yes	0-3 Years
Bridge Square			0	0	0	$0	Yes	Yes	0-3 Years
Central Park			0	0	0	$0	Yes	Yes	0-3 Years
Odd Fellows Park			902	0	1	$12	Yes	Yes	0-3 Years
Streetlights			14,393	0	14	$190	Yes	Yes	0-3 Years
Sechler Park			7,407	0	7	$98	Yes	Yes	0-3 Years
Streetlights			3,016	0	3	$40	Yes	Yes	0-3 Years
WELL 2			28,216	0	28	$372	Yes	Yes	0-3 Years
Compost site			1,514	0	2	$20	Yes	Yes	0-3 Years
Streetlights			29,654	0	30	$391	Yes	Yes	0-3 Years
Way Park			7,343	0	7	$97	Yes	Yes	0-3 Years
Street Light			25,401	0	25	$335	Yes	Yes	0-3 Years
Ped crossing flashing beacon			411	0	0	$5	Yes	Yes	0-3 Years
Ped crossing flashing beacon DQ			412	0	0	$5	Yes	Yes	0-3 Years
Streetlights			4,304	0	4	$57	Yes	Yes	0-3 Years
Grand Total	**0**	**0**	**637,721**	**0**	**638**	**$8,405**			

76,687 Remaining CSG Subscription Capacity (average of 25 years)



Section 06

Environmental Benefits

City of Northfield Buildings Solar Implementation

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Environmental Benefits

Increasing use of Solar PV for electricity generation (on-site solar arrays and/or purchase of RECs) for City of Northfield government facilities will offer additional indirect benefits, namely the reduction of Greenhouse Gas emissions (GHG) and the reduction of fresh water use.

Greenhouse Gas and Electricity

Greenhouse gas emissions form, primarily, from the burning of fossil fuels. The carbon footprint of electricity is the total greenhouse gas emissions throughout the life-cycle from source fuel extraction through to end user electricity. According to the Intergovernmental Panel on Climate Change (IPCC), the median greenhouse gas emission, measured in metric tonnes, for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Metric Tonnes GHG/MWh
Hydroelectric	.004
Wind	.012
Nuclear	.016
Biomass	.018
Geothermal	.045
Solar PV	.046
Natural gas	.469
Coal	1.001

The Water/Energy Nexus

Water and energy are inextricably linked in our current modern infrastructure. Water is used in all phases of energy production. Energy is required to extract, pump and deliver water for use, and to treat waste-water so it can be safely returned to the environment. The cumulative impact of electricity generation on our water sources can be significant, and varies by fuel source. According to The River Network, the average fresh water use for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Gallons/MWh
Hydroelectric	29,920
Wind	1
Nuclear	2,995
Biomass	2
Geothermal	2
Solar PV	2
Natural gas	1,512
Coal	7,143

Environmental Benefits

Current Regional Electric Grid Profile

According to reports on the Electricity Supply by Energy Source for the Upper Midwest grid region, the average greenhouse gas emissions per 1 Mwh of electricity is .365 Metric Tonnes. Using the River Network average fresh water use by fuel type, the average water use per 1 Mwh or electricity in the LLBO region is 5,306.5 gallons.

Based on these numbers, for every Mwh of electricity delivered through solar pv for Northfield government facilities, the City can reduce its annual Greenhouse Gas emissions accounting by .365 metric tonnes (full life-cycle Greenhouse Gas emissions reduction is .319 metric tonnes) and its water footprint by 5,306.5 gallons.

Summary Environmental Potential

Over a 30 year life span for the full project implementation detailed in Section 5 equates to a reduction of 2,130.3 metric tonnes of greenhouse gas (over 41.8 million cubic feet of man made atmosphere) and 31 million gallons of water conserved. See the Table 6.1 for the Environmental Benefit by project priority level and type (on-site solar vs REC purchase).

Table 6.1: Carbon And Water Footprint Reduction Potential - 30 Year Life Span

Priority Level Group	Annual Generation	GHG Emission Reduction	Water Footprint Reduction
1+2 on-site Solar	2,410.5 MWh	**879.8 mTons**	**12.8 Million Gallons**
1+2+3 REC Purchase	3,426 MWh	**1,250.5 mTons**	**18.2 Million Gallons**
Total	5,836.5 MWh	**2,130.3 mTons**	**31 Million Gallons**

Section 07

Conclusions and Next Steps

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Conclusions and Next Steps

Project Ownership and Financing Scenarios

The City has multiple ownership and project financing options available. paleBLUEdot recommends the exploration of the following options:

City Direct Purchase/Owned Solar PV

Under this option, the solar arrays developed are purchased in full from the project contractor at the completion of the array construction and commissioning. The direct purchase can be a cash purchase, or a financed purchase. Should the City desire a direct purchase option on each site, there are several options for structuring the financing, including:

Issue Tax Exempt Bonds.
For most government entities, securing up-front capital through bonds is how public renewable energy projects have traditionally been financed. Prior to issuing a tax exempt bond, research will be required to verify that solar pv projects are qualified for issuance of this bond type.

Apply to the IRS for a Clean Renewable Energy Bonds allocation
CREBs may be issued by electric cooperatives, government entities (states, cities, counties, territories, Indian tribal governments or any political subdivision thereof), and by certain lenders. The bondholder receives federal tax credits in lieu of a portion of the traditional bond interest, resulting in a lower effective interest rate for the borrower. The issuer remains responsible for repaying the principal on the bond. For approved applicants, the federal incentive CREBs can be a valuable source of low-cost financing, if steps are taken to reduce the high transaction costs associated with their issuance.

Bond-PPA Hybred
The hybrid model is a financing option by which a government entity issues a government bond at a low interest rate and transfers that low-cost capital to a developer in exchange for a lower PPA price. Under the model, a government entity (the administrator) issues a request for proposals (RFP) seeking a solar developer to build, operate, and own a solar project or portfolio of projects on public buildings (local hosts). The administrator sells bonds to finance the development costs of the PV installation. The administrator then enters into both a lease-purchase agreement with the winning bidder and a PPA (on behalf of the local hosts) to buy the electricity from the PV system. Careful consideration and definition of the status of renewable energy credits should be made (see Section 1).

Third-Party Engagement Options.

The Federal Tax Incentive program for solar PV, as well as the accelerated depreciation available for solar equipment (MACRS) are very significant opportunities to reduce the up-front costs of solar pv installations through 2021. Third-party engagement options allow mechanisms for Tribal government entities to capture the value of these federal tax incentives. The third party engagement options paleBLUEdot recommends for the City include:

Solar Lease or Power Purchase Agreements
Under this approach, the project development team retains ownership of the solar array and charges a monthly fee to the site owner. The monthly fee is either a set dollar value for the use of the solar equipment ("solar lease"), or a varying monthly fee based on the total electricity produced by the solar array ("Power Purchase Agreements"). In both approaches, the site owner incurs no "up front" costs and typically experiences a reduction in their monthly electricity expenses of perhaps 10%. Both of these options typically include a purchase clause which enables the site owner to purchase the system at fair market value at a future date (year 7, 10, 15, etc).

City Direct Purchase with Reverse ITC Lease
This approach enables a site owner to own the solar array, usually with no up front costs, while empowering the solar project development team to receive the ITC and MACRS tax benefits. This approach is particularly effective for Tribal, Government, or non-profit entities who wish to claim ownership of the array while leveraging the value of the tax benefits through reduced project costs. Under this scenario, the site owner purchases the array at the completion of the project installation and commissioning, usually under a financed purchase whose terms are identical to a typical PPA or Solar Lease, and then executes a reverse lease granting the tax benefit ownership rights to the project development team.

Conclusions and Next Steps

Conclusions

The City of Northfield could leverage both economic and environmental benefits through the further implementation of solar pv at many of the primary City of Northfield facilities. The recommendations of this report are as follows:

1) City to explore proceeding with the procurement of solar pv for all “Priority Level 1 and Level 2” sites as outlined in this report. It is our recommendation that the City explore procurement of Priority Level 1 solar installations prior to the end of the 2023 calendar year and Priority Level 2 installations prior to the end of the 2026 calendar year.

2) City to eExplore executing a joint bulk procurement Request for Proposal process within the 3rd or 4th quarter of 2020 for all “Priority Level 1” solar pv sites (note, City may leverage greater savings if Priority level 2 sites are included as an option). This RFP Process should request comparative proposal options for direct purchase as well as 3rd party project delivery options. The RFP should be configured to promote project cost savings based on the total potential installed capacity, leveraging the “power of bulk purchasing”.

3) Explore the inclusion of local business utilization as well as Northfield resident internship, training, and employment as major selection criteria for the initial and all future tribal solar array procurement processes as a strategy to realize the community economic benefit potential outlined in Section 2 of this report.

4) Additional recommendations in support of community-wide solar potential as outlined in Section 2.

Next Steps

We recommend the following next steps for the City of Northfield in implementation of the development of its Solar PV portfolio:

1) The preliminary prioritizations indicated in this report are based on solar pv performance metrics and EUI data. Further consideration for final prioritization should be made based on the City’s anticipated maintenance, roof replacement, and construction schedules.

2) Projects which anticipate rooftop arrays should have a preliminary structural assessment to confirm solar pv loading can be adequately handled by the existing structure. The weight of a PV system varies based on the panel and racking systems selected, however, preliminary structural assessments should confirm the structure’s ability to support 2-4lbs per square foot for typical flush or tilted racking systems, or 5-9lbs if ballasted racking systems are desired.

3) Develop a detailed implementation plan timeframe. Implementation schedule should identify dates for procurement package development, procurement bidding, installation, and project startup for all project sites.

4) Engage a consultant qualified to support the City in the development of a City bulk purchase competitive bid Request for Proposal (RFP) package for all Priority Level 1 and 2 projects. The RFP should be developed to provide structure to and encourage local participation and City resident training and job placement. The RFP should also be structured to encourage cost discounting based on total aggregate solar array installation. Finally, the RFP should be used to solicit competitive bidding from the national pool of solar developer/contractors to leverage the greatest cost savings for City, recommendations for the RFP include:
   - A To explore the most beneficial project delivery method, the City should consider asking for cost proposals for 1st party ownership (array purchased directly by City) as well as 3rd party ownership (solar power purchase agreement “PPA” or solar lease).
   - B City should consider including all Priority 1 and Priority 2 sites from this report (see Section 5) to explore the potential for leveraging greater cost competitiveness of bulk purchase.
   - C. RFP should be structured to encourage respondents to provide a sliding scale fee based on the total KW installed capacity of projects ultimately engaged.

Section A1

Solar Site Feasibility Reports by Building

City of Northfield Buildings

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Site Solar Feasibility Reports by Building

The goal of the solar feasibility concept development is to explore the general potential for solar pv on each site with the goal of achieving a Zero Net Energy site (a site which generates as much electricity within a year as it consumes within the same timeframe).

Prioritization was given to rooftop solar arrays, with ground mounted and "carport" arrays being included only for sites which required them to achieve Zero Net Energy, or for building sites which can reasonably be assumed to have a structure incapable of supporting a rooftop array. Prior to proceeding further with the planning of any rooftop solar pv array, an assessment of the structure of each building included in this section should be conducted. All sites which have a ground mounted array in this section should have a civil engineering review of the site areas anticipating solar arrays to verify appropriate soil and site conditions.

A preliminary opinion of cost as well as a preliminary 30 year energy generation and value projection have been developed for each site. Costs are intended to illustrate Order of Magnitude and are preliminary in nature. Cost unit prices are based on 2017 national averages provided by the National Renewable Energy Laboratory, modified using local construction cost indicies. The 30 year value projections include estimates of base and solar buy back electric rates based on information available from the subject utility. Electric rates should be validated prior to proceeding further with the planning of any site.

Solar Feasibility Assessment

The detailed Solar Feasibility Assessment for each of the sites can be found in Appendix 1 of this report. The Solar Feasibility Assessment included a review of overall solar feasibility as well as development of solar pv concept designs for each recommended site. These efforts consisted of:

Determining the feasibility of solar energy :

- Conducting remote review of each recommended site using satellite data of each subject building and site.
- Identifying current and planned future building and site conditions which create impediment to solar pv installations.
- Identifying and record solar obstructions impacting potential solar pv performance

Solar PV Concept Design.

- Creating concept design(s) for building and/or site solar PV array at each recommended site. Concept designs include overall array configuration, tilt, azimuth, and preliminary panel and inverter selections.
- Modeling annual solar pv performance based on detailed design components, historic local weather data, and site-specific solar obstructions.
- Creating a solar pv concept design report for each recommended site. Reports (found in Appendix 1 of this report) include:
    - Summary metrics including energy production, performance ratio, and kWh/kWp; Locations of array segments shown on map;
    - Monthly and annual production values;
    - System loss factors and detailed loss tree; records of condition set assumptions;
    - Preliminary bill of materials;
    - Preliminary electrical concept design assumptions;
    - Preliminary Mechanical layout assumptions;
    - Detailed concept plan/layout;
    - Detailed construction cost estimate;
    - 30 year energy production, value, and cost savings projections year-by-year.

Recommended Site Priority

Site prioritization is outlined in greater detail in Section 5 of this report. As reviewed in that section, the prioritization for sites to receive on-site solar installations in this report are based on multiple factors. Site prioritization for on-site solar, as defined in Table 5.3 of Section 5 are:

Priority 1 (0-3 year implementation) Priority 2 (3-6 year implementation) Priority 3 (Not Recommended)

Site Solar Feasibility Reports by Building

To the right are the sites with detailed solar feasibility assessments included in this Appendix (for electronic document viewing, click the name of each site view the report)

Name
City Hall
Police Department
Wastewater Treatment Plant
Water Department Office
Northfield Community Resource Center
Outdoor Pool/Old Memorial field
Ice Arena
Maintenance Facility
Liquor Store
Northfield Area Fire & Rescue

Site Solar Feasibility Reports by Building

City Hall

Concept Design

The roof configuration of the City Hall building is moderately suited for solar PV installation, with good orientation, and configuration, however the building has moderately significant obstructions due to rooftop equipment.

The concept explored in this option is a rooftop solar array meeting the program requirements for the Xcel Energy Solar Rewards program. The Solar Rewards program incentivizes solar installations, first by attributing all energy generated by the solar array to the building's energy consumption on a one-to-one basis (as would occur in a traditional Net Metering interconnection). Secondly, the Solar Rewards program pays the site owner an additional $0.06 per kWh generated for the first 10 years of operation. Under this arrangement, the site owner receives essentially double compensation for electricity generated by the array for the first 10 years. In exchange, Xcel Energy is allowed to retain the Renewable Energy Credits (the "green attributes") for all power generated by the solar array for the 10 year period. Following the 10 year period the array reverts back to a net metered site (with energy generation offsetting energy consumed on a one-to-one basis)

The array is not capable of offsetting all of the electricity used on site. The array's first year generation is estimated to offset approximately 21% of the site's current reported electricity consumption. The site utilization and tree coverage does not readily support ground mounted arrays while carport arrays would not be cost effective for this site and its energy tariff structure. Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.55:1 ratio. As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.02 more than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING		
Total Installed Array Cost (incl. contingency, other owner expenses)	$82,621	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$11,410	
Operational Expense Allowance (insurance, O+M, 30-year)	$15,190	
Total Lifetime Project Costs	$109,221	
SAVINGS		
Total Lifetime Project Savings	$169,327	
OUTCOMES		
Net Lifetime Project Costs or Savings	$60,106	
Total Project Cost Payback (Years)	19.4	Years
Value to Cost Ratio	1.55	to 1.0
Electricity Production (kWh, 30-year)	1,076,811	kWh
Percent of Electricity Usage Covered by Solar (Year	21.00%	

Note, values do not include social cost of carbon avoided by the solar array.

Recommended Site Priority:

Priority 3
(Not Recommended)

Rooftop 1 City of Northfield City Hall, 801 Washington St, Northfield, MN

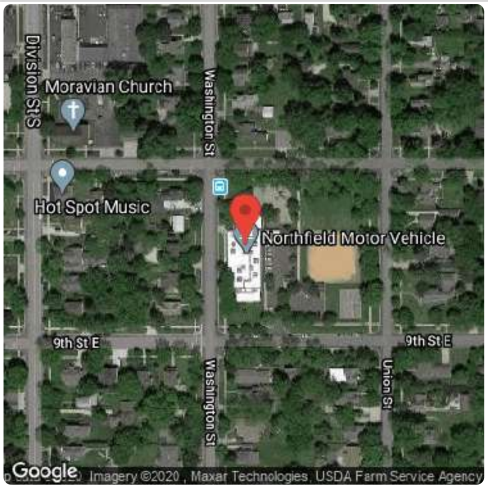
Report

Project Name	City of Northfield City Hall
Project Address	801 Washington St, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

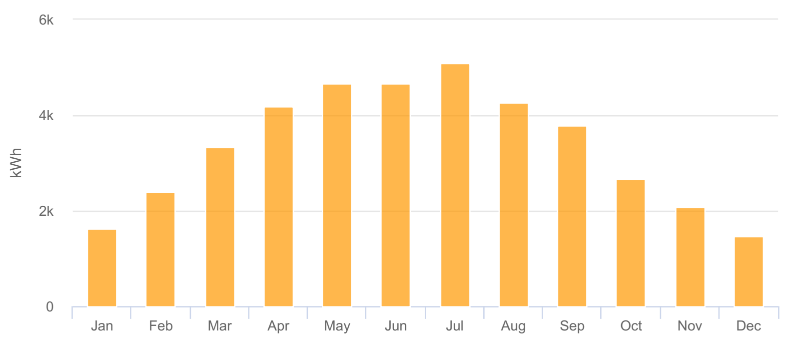
System Metrics

Design	Rooftop 1
Module DC Nameplate	30.5 kW
Inverter AC Nameplate	24.0 kW Load Ratio: 1.27
Annual Production	40.23 MWh
Performance Ratio	81.9%
kWh/kWp	1,321.0
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	70e353687f-301d24fdcb-8f3cf974d4-5e9aee986c

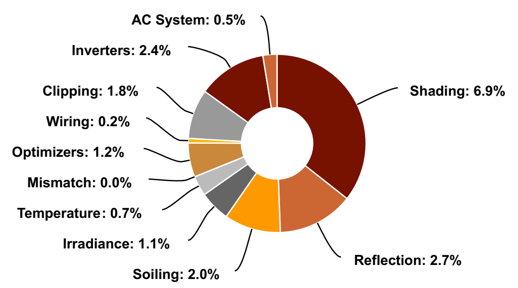
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,613.7	15.7%
	Shaded Irradiance	1,501.7	-6.9%
	Irradiance after Reflection	1,461.3	-2.7%
	Irradiance after Soiling	1,432.1	-2.0%
	Total Collector Irradiance	**1,431.4**	**0.0%**
Energy (kWh)	Nameplate	43,538.9	
	Output at Irradiance Levels	43,066.3	-1.1%
	Output at Cell Temperature Derate	42,762.2	-0.7%
	Output After Mismatch	42,762.1	0.0%
	Optimizer Output	42,246.3	-1.2%
	Optimal DC Output	42,177.5	-0.2%
	Constrained DC Output	41,437.0	-1.8%
	Inverter Output	40,427.4	-2.4%
	Energy to Grid	**40,225.2**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.7 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE8K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE8K (SolarEdge)	3 (24.0 kW)
Strings	10 AWG (Copper)	3 (42.0 ft)
Optimizers	P400 NA (SolarEdge)	87 (34.8 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	87 (30.5 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	16-35	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	69	69	24.2 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	12	12	4.20 kW
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	6	6	2.10 kW

Detailed Layout

Owner Input & Results Worksheet

Project

City Hall
801 Washington St
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array
(from solar bid)

2021	First Year of Operation
30.50	Array Size (kW DC)
350	Watt Rating
87	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
24.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
40,230	First Year Generation (kWh)
$78,901.15	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$3,719.86	Owner Contingency (if any)
$82,621.02	Total Project Budget
$2.71	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance
(from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$5,085	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use
(all meters)

Xcel Energy	Electric Utility
191,574	Total Annual Electric Use (kWh)
516.00	Total Annual Demand (kW)
25,004	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
7.66	Electric Use Intensity (kWh/SF)
77%	EUI as % of National Average
$13,859.63	Annual Energy Charge ($)
$5,412.00	Annual Demand Charge ($)
$19,271.63	Total Annual Electric Cost
$0.0723	Effective Electric Rate ($/kWh)*
$10.49	Effective Demand Charge ($/kW)
43.00	Average Monthly Demand (kW)

Financial Information

$16,524.20	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$66,096.81	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	1,076,811	kWh
Total Electricity Bill Savings	$169,327	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$82,621	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$82,621	
Simple Project Payback	14.64	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$94,031	
Financed Capital Payback	16.66	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$15,190	
Financed Array Lifetime Cost	$109,221	
Financed Array Lifetime Payback	19.35	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1572	
Project Cost Per Solar Per kWh	$0.1014	
Net Electricity Bill Savings Per kWh	$0.0558	
Value to Cost Ratio	1.55	to 1.0

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PROJ: **City Hall**
LOC.: **801 Washington St**
TITLE: **Rooftop**

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**30.5**
Year 1 Generation Projection (MWH)	**40.2**
Annual Site Energy Use (MWH)	**191.6**
Assumed Energy Use During Solar Production Hours	**65%**

Energy Generation Schedule (Based on Predicted Loss) / Potential Revenue Value

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings
1	2021	40,230	kWh	100%	21.00%	$0.0723	$2,910	$5,412	$768	$2,414	$6,092
2	2022	39,908	kWh	99%	20.83%	$0.0742	$2,959	$5,547	$787	$2,394	$6,141
3	2023	39,589	kWh	98%	20.67%	$0.0760	$3,009	$5,686	$807	$2,375	$6,191
4	2024	39,272	kWh	98%	20.50%	$0.0779	$3,060	$5,828	$827	$2,356	$6,243
5	2025	38,958	kWh	97%	20.34%	$0.0799	$3,111	$5,974	$847	$2,337	$6,296
6	2026	38,646	kWh	96%	20.17%	$0.0819	$3,163	$6,123	$869	$2,319	$6,351
7	2027	38,337	kWh	95%	20.01%	$0.0839	$3,216	$6,276	$890	$2,300	$6,407
8	2028	38,030	kWh	95%	19.85%	$0.0860	$3,270	$6,433	$913	$2,282	$6,465
9	2029	37,726	kWh	94%	19.69%	$0.0881	$3,325	$6,594	$935	$2,264	$6,524
10	2030	37,424	kWh	93%	19.54%	$0.0904	$3,381	$6,759	$959	$2,245	$6,586
11	2031	37,125	kWh	92%	19.38%	$0.0926	$3,438	$6,928	$983		$4,421
12	2032	36,828	kWh	92%	19.22%	$0.0949	$3,496	$7,101	$1,007		$4,503
13	2033	36,533	kWh	91%	19.07%	$0.0973	$3,555	$7,279	$1,033		$4,587
14	2034	36,241	kWh	90%	18.92%	$0.0997	$3,614	$7,461	$1,058		$4,673
15	2035	35,951	kWh	89%	18.77%	$0.1022	$3,675	$7,647	$1,085		$4,760
16	2036	35,664	kWh	89%	18.62%	$0.1048	$3,737	$7,838	$1,112		$4,849
17	2037	35,378	kWh	88%	18.47%	$0.1074	$3,800	$8,034	$1,140		$4,939
18	2038	35,095	kWh	87%	18.32%	$0.1101	$3,863	$8,235	$1,168		$5,032
19	2039	34,814	kWh	87%	18.17%	$0.1128	$3,928	$8,441	$1,197		$5,126
20	2040	34,536	kWh	86%	18.03%	$0.1157	$3,994	$8,652	$1,227		$5,222
21	2041	34,260	kWh	85%	17.88%	$0.1185	$4,061	$8,868	$1,258		$5,319
22	2042	33,986	kWh	84%	17.74%	$0.1215	$4,130	$9,090	$1,289		$5,419
23	2043	33,714	kWh	84%	17.60%	$0.1245	$4,199	$9,317	$1,322		$5,521
24	2044	33,444	kWh	83%	17.46%	$0.1277	$4,270	$9,550	$1,355		$5,624
25	2045	33,176	kWh	82%	17.32%	$0.1309	$4,341	$9,789	$1,389		$5,730
26	2046	32,911	kWh	82%	17.18%	$0.1341	$4,414	$10,034	$1,423		$5,838
27	2047	32,648	kWh	81%	17.04%	$0.1375	$4,488	$10,284	$1,459		$5,947
28	2048	32,387	kWh	81%	16.91%	$0.1409	$4,564	$10,541	$1,495		$6,059
29	2049	32,127	kWh	80%	16.77%	$0.1444	$4,640	$10,805	$1,533		$6,173
30	2050	31,870	kWh	79%	16.64%	$0.1480	$4,718	$11,075	$1,571		$6,290

Simplified Cash Flow Projection

Operation Year	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	($24,275)	($122)	($128)	($18,433)	($18,433)
2	($7,751)	($124)	($131)	($1,865)	($20,298)
3	($7,751)	($127)	($133)	($1,820)	($22,118)
4	($7,751)	($129)	($136)	($1,773)	($23,891)
5	($7,751)	($132)	($139)	($1,725)	($25,617)
6	($7,751)	($135)	($141)	($1,676)	($27,293)
7	($7,751)	($137)	($144)	($1,625)	($28,918)
8	($7,751)	($140)	($147)	($1,573)	($30,491)
9	($7,751)	($143)	($150)	($1,519)	($32,010)
10	($7,751)	($146)	($153)	($1,464)	($33,474)
11	$0	($149)	($156)	$4,116	($29,358)
12	$0	($152)	($159)	$4,192	($25,166)
13	$0	($155)	($162)	$4,270	($20,896)
14	$0	($158)	($166)	$4,349	($16,547)
15	$0	($161)	($169)	$4,430	($12,117)
16	$0	($164)	($172)	$4,512	($7,605)
17	$0	($167)	($176)	$4,596	($3,009)
18	$0	($171)	($179)	$4,681	$1,672
19	$0	($174)	($183)	$4,769	$6,441
20	$0	($178)	($5,271)	($227)	$6,214
21	$0	($181)	($187)	$4,952	$11,165
22	$0	($185)	($190)	$5,044	$16,209
23	$0	($189)	($194)	$5,138	$21,347
24	$0	($192)	($198)	$5,234	$26,581
25	$0	($196)	($202)	$5,332	$31,913
26	$0	($200)	($206)	$5,431	$37,344
27	$0	($204)	($210)	$5,533	$42,877
28	$0	($208)	($214)	$5,637	$48,513
29	$0	($212)	($219)	$5,742	$54,256
30	$0	($217)	($223)	$5,850	$60,106

Assumed Percentage of Demand Charge Reduction*: 14.19%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$82,621	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$11,410	
Operational Expense Allowance (insurance, O+M, 30-year)	$15,190	
Total Lifetime Project Costs	$109,221	

SAVINGS

Total Lifetime Project Savings	$169,327	

OUTCOMES

Net Lifetime Project Costs or Savings	$60,106	
Total Project Cost Payback (Years)	19.4	Years
Value to Cost Ratio	1.55	to 1.0
Electricity Production (kWh, 30-year)	1,076,811	kWh
Percent of Electricity Usage Covered by Solar (Year	21.00%	

Site Solar Feasibility Reports by Building

Police Department

Concept Design

The roof configuration of the Police building is moderately well suited for solar PV installation, with good orientation, and overall configuration, and only moderate rooftop equipment obstruction.

The rooftop array is not capable of offsetting all of the electricity used on site. The rooftop array's first year generation is estimated to offset approximately 54% of the site's current reported electricity consumption. To meet the site's full annual use an additional ground mounted array is required. The site area to the west of the facility and parking lot is well suited for a ground mounted solar array meeting 58% or more of the site's annual electric use. The combined arrays included in this concept can provide an estimated 112% of the site's total electric use, making the site Net Zero electricity.

Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Note, values do not include social cost of carbon avoided by the solar array.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.79:1 ratio (1.74 for rooftop, 1.84 for ground). As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.01 less than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING (Rooftop Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$179,228	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$24,752	
Operational Expense Allowance (insurance, O+M, 30-year)	$37,999	
Total Lifetime Project Costs	$241,979	
SAVINGS		
Total Lifetime Project Savings	$420,764	
OUTCOMES		
Net Lifetime Project Costs or Savings	$178,785	
Total Project Cost Payback (Years)	17.3	Years
Value to Cost Ratio	1.74	to 1.0
Electricity Production (kWh, 30-year)	2,917,535	kWh
Percent of Electricity Usage Covered by Solar (Year	54.75%	

COSTS AND FINANCING (Ground Mounted Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$176,232	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$24,338	
Operational Expense Allowance (insurance, O+M, 30-year)	$38,136	
Total Lifetime Project Costs	$238,707	
SAVINGS		
Total Lifetime Project Savings	$440,719	
OUTCOMES		
Net Lifetime Project Costs or Savings	$202,012	
Total Project Cost Payback (Years)	16.2	Years
Value to Cost Ratio	1.85	to 1.0
Electricity Production (kWh, 30-year)	3,091,516	kWh
Percent of Electricity Usage Covered by Solar (Year	58.02%	

Recommended Site Priority:

Priority 2
(3-6 year)

Design 1 City of Northfield Police Department, 1615 Riverview Drive, Northfield, MN

Report

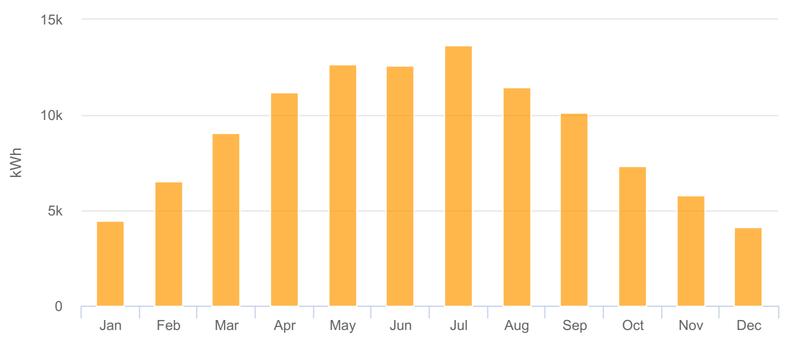
Project Name	City of Northfield Police Department
Project Address	1615 Riverview Drive, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

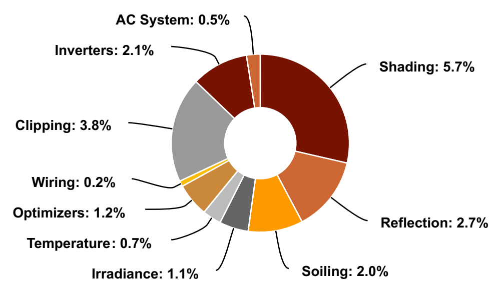
Design	Design 1
Module DC Nameplate	83.0 kW
Inverter AC Nameplate	64.0 kW Load Ratio: 1.30
Annual Production	109.0 MWh
Performance Ratio	81.4%
kWh/kWp	1,314.1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,613.7	15.7%
	Shaded Irradiance	1,521.1	-5.7%
	Irradiance after Reflection	1,479.5	-2.7%
	Irradiance after Soiling	1,449.9	-2.0%
	Total Collector Irradiance	**1,449.4**	**0.0%**
Energy (kWh)	Nameplate	120,112.2	
	Output at Irradiance Levels	118,844.9	-1.1%
	Output at Cell Temperature Derate	118,028.1	-0.7%
	Output After Mismatch	118,027.9	0.0%
	Optimizer Output	116,586.8	-1.2%
	Optimal DC Output	116,350.3	-0.2%
	Constrained DC Output	111,874.0	-3.8%
	Inverter Output	109,551.0	-2.1%
	Energy to Grid	**109,004.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.7 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE27.6K Delta Grid (SolarEdge)	Folsom Labs	Spec Sheet

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Components

Component	Name	Count
Inverters	SE27.6K Delta Grid (SolarEdge)	4 (64.0 kW)
Strings	10 AWG (Copper)	14 (1,621.5 ft)
Optimizers	P400 NA (SolarEdge)	237 (94.8 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	237 (83.0 kW)

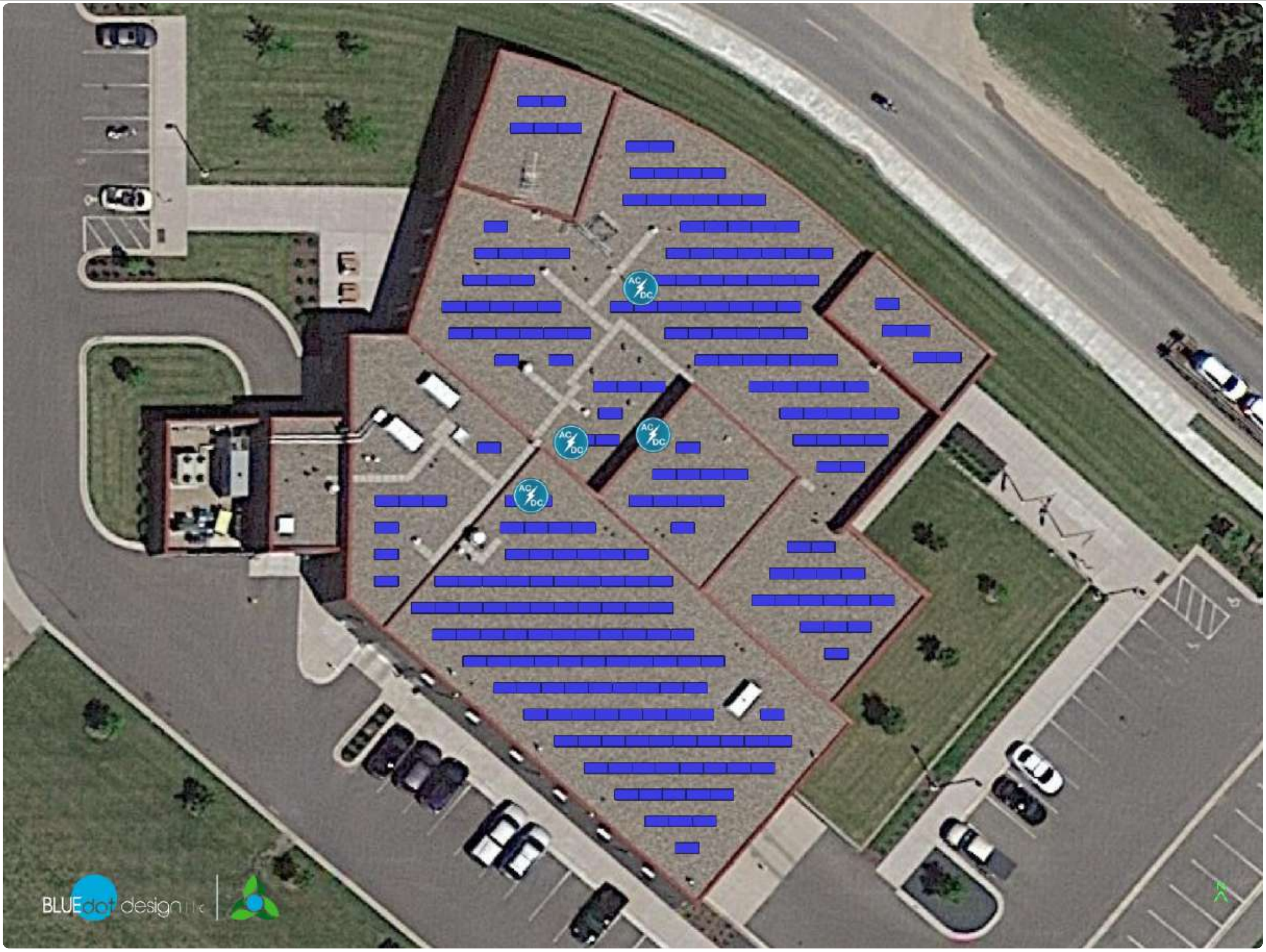
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	9-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	117	117	41.0 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	5	5	1.75 kW
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	5	5	1.75 kW
Field Segment 4	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	110	110	38.5 kW

Detailed Layout



Owner Input & Results Worksheet

paleBLUEdot LLC

Project

Police
1615 Riverview Drive
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
83.00	Array Size (kW DC)
350	Watt Rating
237	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
64.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
109,000	First Year Generation (kWh)
$171,381.96	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$7,846.36	Owner Contingency (if any)
$179,228.32	Total Project Budget
$2.16	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$10,500	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
199,070	Total Annual Electric Use (kWh)
444.00	Total Annual Demand (kW)
20,000	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
9.95	Electric Use Intensity (kWh/SF)
100%	EUI as % of National Average
$15,570.63	Annual Energy Charge ($)
$4,656.00	Annual Demand Charge ($)
$20,226.63	Total Annual Electric Cost
$0.0782	Effective Electric Rate ($/kWh)*
$10.49	Effective Demand Charge ($/kW)
37.00	Average Monthly Demand (kW)

Financial Information

$35,845.66	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$143,382.65	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	2,917,535	kWh
Total Electricity Bill Savings	$420,764	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$179,228	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$179,228	
Simple Project Payback	12.78	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$203,980	
Financed Capital Payback	14.54	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$37,999	
Financed Array Lifetime Cost	$241,979	
Financed Array Lifetime Payback	17.25	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1442	
Project Cost Per Solar Per kWh	$0.0829	
Net Electricity Bill Savings Per kWh	$0.0613	
Value to Cost Ratio	1.74	to 1.0

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PROJ: **Police**
LOC.: **1615 Riverview Drive**
TITLE: **Rooftop**

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**83.0**
Year 1 Generation Projection (MWH)	**109.0**
Annual Site Energy Use (MWH)	**199.1**
Assumed Energy Use During Solar Production Hours	**65%**

Energy Generation Schedule (Based on Predicted Loss)

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use
1	2021	109,000	kWh	100%	54.75%
2	2022	108,128	kWh	99%	54.32%
3	2023	107,263	kWh	98%	53.88%
4	2024	106,405	kWh	98%	53.45%
5	2025	105,554	kWh	97%	53.02%
6	2026	104,709	kWh	96%	52.60%
7	2027	103,872	kWh	95%	52.18%
8	2028	103,041	kWh	95%	51.76%
9	2029	102,216	kWh	94%	51.35%
10	2030	101,399	kWh	93%	50.94%
11	2031	100,587	kWh	92%	50.53%
12	2032	99,783	kWh	92%	50.12%
13	2033	98,984	kWh	91%	49.72%
14	2034	98,192	kWh	90%	49.33%
15	2035	97,407	kWh	89%	48.93%
16	2036	96,628	kWh	89%	48.54%
17	2037	95,855	kWh	88%	48.15%
18	2038	95,088	kWh	87%	47.77%
19	2039	94,327	kWh	87%	47.38%
20	2040	93,573	kWh	86%	47.00%
21	2041	92,824	kWh	85%	46.63%
22	2042	92,081	kWh	84%	46.26%
23	2043	91,345	kWh	84%	45.89%
24	2044	90,614	kWh	83%	45.52%
25	2045	89,889	kWh	82%	45.15%
26	2046	89,170	kWh	82%	44.79%
27	2047	88,457	kWh	81%	44.43%
28	2048	87,749	kWh	81%	44.08%
29	2049	87,047	kWh	80%	43.73%
30	2050	86,351	kWh	79%	43.38%

Potential Revenue Value

Operation Year	Calendar Year	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings
1	2021	$0.0782	$8,526	$4,656	$2,089	$0	$10,615
2	2022	$0.0802	$8,669	$4,772	$2,141	$0	$10,810
3	2023	$0.0822	$8,815	$4,892	$2,195	$0	$11,009
4	2024	$0.0842	$8,963	$5,014	$2,250	$0	$11,212
5	2025	$0.0863	$9,113	$5,139	$2,306	$0	$11,419
6	2026	$0.0885	$9,266	$5,268	$2,363	$0	$11,630
7	2027	$0.0907	$9,422	$5,400	$2,422	$0	$11,844
8	2028	$0.0930	$9,580	$5,535	$2,483	$0	$12,063
9	2029	$0.0953	$9,741	$5,673	$2,545	$0	$12,286
10	2030	$0.0977	$9,905	$5,815	$2,609	$0	$12,514
11	2031	$0.1001	$10,071	$5,960	$2,674		$12,745
12	2032	$0.1026	$10,240	$6,109	$2,741		$12,981
13	2033	$0.1052	$10,412	$6,262	$2,809		$13,222
14	2034	$0.1078	$10,587	$6,418	$2,880		$13,467
15	2035	$0.1105	$10,765	$6,579	$2,952		$13,717
16	2036	$0.1133	$10,946	$6,743	$3,025		$13,971
17	2037	$0.1161	$11,130	$6,912	$3,101		$14,231
18	2038	$0.1190	$11,317	$7,085	$3,179		$14,496
19	2039	$0.1220	$11,507	$7,262	$3,258		$14,765
20	2040	$0.1250	$11,700	$7,443	$3,339		$15,040
21	2041	$0.1282	$11,897	$7,629	$3,423		$15,320
22	2042	$0.1314	$12,097	$7,820	$3,508		$15,605
23	2043	$0.1347	$12,300	$8,016	$3,596		$15,896
24	2044	$0.1380	$12,507	$8,216	$3,686		$16,193
25	2045	$0.1415	$12,717	$8,421	$3,778		$16,495
26	2046	$0.1450	$12,930	$8,632	$3,873		$16,803
27	2047	$0.1486	$13,148	$8,848	$3,970		$17,117
28	2048	$0.1524	$13,369	$9,069	$4,069		$17,437
29	2049	$0.1562	$13,593	$9,296	$4,170		$17,764
30	2050	$0.1601	$13,822	$9,528	$4,275		$18,096

Simplified Cash Flow Projection

Operation Year	Calendar Year	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	($52,659)	($332)	($349)	($42,725)	($42,725)
2	2022	($16,813)	($339)	($356)	($6,698)	($49,423)
3	2023	($16,813)	($345)	($363)	($6,512)	($55,935)
4	2024	($16,813)	($352)	($370)	($6,324)	($62,259)
5	2025	($16,813)	($359)	($377)	($6,131)	($68,390)
6	2026	($16,813)	($367)	($385)	($5,935)	($74,325)
7	2027	($16,813)	($374)	($393)	($5,735)	($80,061)
8	2028	($16,813)	($381)	($400)	($5,532)	($85,593)
9	2029	($16,813)	($389)	($408)	($5,325)	($90,917)
10	2030	($16,813)	($397)	($417)	($5,113)	($96,031)
11	2031	$0	($405)	($425)	$11,916	($84,115)
12	2032	$0	($413)	($433)	$12,135	($71,980)
13	2033	$0	($421)	($442)	$12,359	($59,621)
14	2034	$0	($429)	($451)	$12,587	($47,035)
15	2035	$0	($438)	($460)	$12,819	($34,216)
16	2036	$0	($447)	($469)	$13,055	($21,161)
17	2037	$0	($456)	($479)	$13,297	($7,864)
18	2038	$0	($465)	($488)	$13,543	$5,679
19	2039	$0	($474)	($498)	$13,793	$19,472
20	2040	$0	($484)	($11,007)	$3,549	$23,020
21	2041	$0	($493)	($508)	$14,319	$37,339
22	2042	$0	($503)	($518)	$14,584	$51,923
23	2043	$0	($513)	($528)	$14,855	$66,778
24	2044	$0	($524)	($539)	$15,130	$81,908
25	2045	$0	($534)	($550)	$15,411	$97,320
26	2046	$0	($545)	($561)	$15,698	$113,018
27	2047	$0	($556)	($572)	$15,990	$129,007
28	2048	$0	($567)	($583)	$16,287	$145,295
29	2049	$0	($578)	($595)	$16,591	$161,885
30	2050	$0	($590)	($607)	$16,900	$178,785

Assumed Percentage of Demand
Charge Reduction*: 44.86%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$179,228	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$24,752	
Operational Expense Allowance (insurance, O+M, 30-year)	$37,999	
Total Lifetime Project Costs	$241,979	

SAVINGS

Total Lifetime Project Savings	$420,764	

OUTCOMES

Net Lifetime Project Costs or Savings	$178,785	
Total Project Cost Payback (Years)	17.3	Years
Value to Cost Ratio	1.74	to 1.0
Electricity Production (kWh, 30-year)	2,917,535	kWh
Percent of Electricity Usage Covered by Solar (Year	54.75%	

Ground mounted City of Northfield Police Department, 1615 Riverview Drive, Northfield, MN

Report

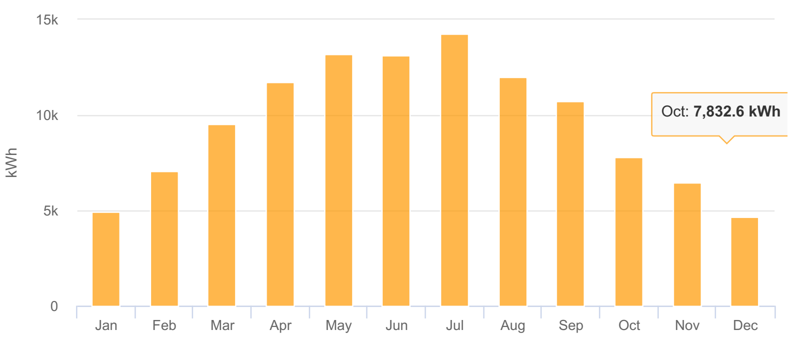
Project Name	City of Northfield Police Department
Project Address	1615 Riverview Drive, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

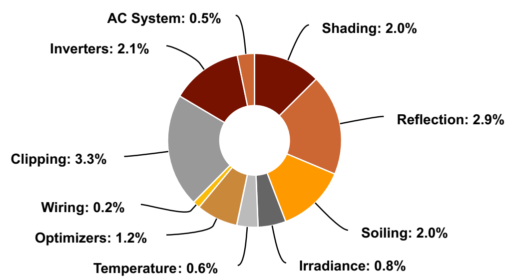
Design	Ground mounted
Module DC Nameplate	83.3 kW
Inverter AC Nameplate	66.6 kW Load Ratio: 1.25
Annual Production	115.5 MWh
Performance Ratio	85.9%
kWh/kWp	1,386.8
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	edef351a35-38368f3ee3-9050205824-c43eec09b7

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,613.7	15.7%
	Shaded Irradiance	1,582.2	-2.0%
	Irradiance after Reflection	1,535.9	-2.9%
	Irradiance after Soiling	1,505.2	-2.0%
	Total Collector Irradiance	**1,505.3**	**0.0%**
Energy (kWh)	Nameplate	126,128.3	
	Output at Irradiance Levels	125,106.9	-0.8%
	Output at Cell Temperature Derate	124,337.1	-0.6%
	Output After Mismatch	124,336.7	0.0%
	Optimizer Output	122,843.0	-1.2%
	Optimal DC Output	122,585.3	-0.2%
	Constrained DC Output	118,550.1	-3.3%
	Inverter Output	116,100.0	-2.1%
	Energy to Grid	**115,520.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		17.0 °C
Simulation Metrics			
		Operating Hours	4673
		Solved Hours	4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
96M 490 (Heliene)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE33.3K (SolarEdge)	Folsom Labs	Spec Sheet

© 2020 Folsom Labs

Components

Component	Name	Count
Inverters	SE33.3K (SolarEdge)	2 (66.6 kW)
Strings	10 AWG (Copper)	7 (755.5 ft)
Optimizers	P400 NA (SolarEdge)	170 (68.0 kW)
Module	Heliene, 96M 490 (490W)	170 (83.3 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	16-25	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	180°	11.4 ft	2x1	85	170	83.3 kW

Detailed Layout

Owner Input & Results Worksheet

Project

Police
1615 Riverview Drive
Groundmounted 1

Date
5/8/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
83.30	Array Size (kW DC)
490	Watt Rating
0	Number of Solar Modules (Roof)
170	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
66.60	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
115,500	First Year Generation (kWh)
$168,452.90	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$7,779.37	Owner Contingency (if any)
$176,232.27	Total Project Budget
$2.12	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$10,537	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
199,070	Total Annual Electric Use (kWh)
444.00	Total Annual Demand (kW)
20,000	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
9.95	Electric Use Intensity (kWh/SF)
100%	EUI as % of National Average
$15,570.63	Annual Energy Charge ($)
$4,656.00	Annual Demand Charge ($)
$20,226.63	Total Annual Electric Cost
$0.0782	Effective Electric Rate ($/kWh)*
$10.49	Effective Demand Charge ($/kW)
37.00	Average Monthly Demand (kW)

Financial Information

$35,246.45	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$140,985.81	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	3,091,516	kWh
Total Electricity Bill Savings	$440,719	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$176,232	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$176,232	
Simple Project Payback	12.00	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$200,570	
Financed Capital Payback	13.65	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$38,136	
Financed Array Lifetime Cost	$238,707	
Financed Array Lifetime Payback	16.25	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1426	
Project Cost Per Solar Per kWh	$0.0772	
Net Electricity Bill Savings Per kWh	$0.0653	
Value to Cost Ratio	1.85	to 1.0

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OWNEF 0

PROJ: **Police**
LOC.: **1615 Riverview Drive**
TITLE: **Groundmounted 1**

08-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**83.3**
Year 1 Generation Projection (MWH)	**115.5**
Annual Site Energy Use (MWH)	**199.1**
Assumed Energy Use During Solar Production Hours	**65%**

Energy Generation Schedule (Based on Predicted Loss) / Potential Revenue Value / Simplified Cash Flow Projection

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	115,500	kWh	100%	58.02%	$0.0782	$9,034	$4,656	$2,096	$0	$11,131	($51,779)	($333)	($350)	($41,331)	($41,331)
2	2022	114,576	kWh	99%	57.56%	$0.0802	$9,186	$4,772	$2,149	$0	$11,335	($16,532)	($340)	($357)	($5,894)	($47,226)
3	2023	113,659	kWh	98%	57.10%	$0.0822	$9,340	$4,892	$2,203	$0	$11,543	($16,532)	($347)	($364)	($5,700)	($52,926)
4	2024	112,750	kWh	98%	56.64%	$0.0842	$9,497	$5,014	$2,258	$0	$11,755	($16,532)	($354)	($371)	($5,503)	($58,429)
5	2025	111,848	kWh	97%	56.19%	$0.0863	$9,657	$5,139	$2,314	$0	$11,971	($16,532)	($361)	($379)	($5,301)	($63,730)
6	2026	110,953	kWh	96%	55.74%	$0.0885	$9,819	$5,268	$2,372	$0	$12,191	($16,532)	($368)	($386)	($5,096)	($68,826)
7	2027	110,066	kWh	95%	55.29%	$0.0907	$9,984	$5,400	$2,431	$0	$12,415	($16,532)	($375)	($394)	($4,887)	($73,712)
8	2028	109,185	kWh	95%	54.85%	$0.0930	$10,152	$5,535	$2,492	$0	$12,644	($16,532)	($383)	($402)	($4,673)	($78,386)
9	2029	108,312	kWh	94%	54.41%	$0.0953	$10,322	$5,673	$2,554	$0	$12,876	($16,532)	($390)	($410)	($4,456)	($82,842)
10	2030	107,445	kWh	93%	53.97%	$0.0977	$10,495	$5,815	$2,618	$0	$13,114	($16,532)	($398)	($418)	($4,235)	($87,077)
11	2031	106,586	kWh	92%	53.54%	$0.1001	$10,672	$5,960	$2,684		$13,355	$0	($406)	($426)	$12,523	($74,554)
12	2032	105,733	kWh	92%	53.11%	$0.1026	$10,851	$6,109	$2,751		$13,602	$0	($414)	($435)	$12,753	($61,802)
13	2033	104,887	kWh	91%	52.69%	$0.1052	$11,033	$6,262	$2,820		$13,853	$0	($423)	($444)	$12,987	($48,815)
14	2034	104,048	kWh	90%	52.27%	$0.1078	$11,219	$6,418	$2,890		$14,109	$0	($431)	($453)	$13,225	($35,590)
15	2035	103,216	kWh	89%	51.85%	$0.1105	$11,407	$6,579	$2,962		$14,369	$0	($440)	($462)	$13,468	($22,122)
16	2036	102,390	kWh	89%	51.43%	$0.1133	$11,599	$6,743	$3,036		$14,635	$0	($448)	($471)	$13,716	($8,406)
17	2037	101,571	kWh	88%	51.02%	$0.1161	$11,794	$6,912	$3,112		$14,906	$0	($457)	($480)	$13,968	$5,562
18	2038	100,758	kWh	87%	50.61%	$0.1190	$11,992	$7,085	$3,190		$15,182	$0	($467)	($490)	$14,225	$19,788
19	2039	99,952	kWh	87%	50.21%	$0.1220	$12,193	$7,262	$3,270		$15,463	$0	($476)	($500)	$14,488	$34,275
20	2040	99,153	kWh	86%	49.81%	$0.1250	$12,398	$7,443	$3,352		$15,750	$0	($485)	($11,047)	$4,217	$38,492
21	2041	98,359	kWh	85%	49.41%	$0.1282	$12,606	$7,629	$3,435		$16,042	$0	($495)	($510)	$15,037	$53,529
22	2042	97,572	kWh	84%	49.01%	$0.1314	$12,818	$7,820	$3,521		$16,339	$0	($505)	($520)	$15,315	$68,844
23	2043	96,792	kWh	84%	48.62%	$0.1347	$13,034	$8,016	$3,609		$16,643	$0	($515)	($530)	$15,597	$84,441
24	2044	96,018	kWh	83%	48.23%	$0.1380	$13,253	$8,216	$3,699		$16,952	$0	($525)	($541)	$15,886	$100,327
25	2045	95,249	kWh	82%	47.85%	$0.1415	$13,475	$8,421	$3,792		$17,267	$0	($536)	($552)	$16,179	$116,506
26	2046	94,487	kWh	82%	47.46%	$0.1450	$13,702	$8,632	$3,887		$17,588	$0	($547)	($563)	$16,479	$132,985
27	2047	93,731	kWh	81%	47.08%	$0.1486	$13,932	$8,848	$3,984		$17,916	$0	($558)	($574)	$16,784	$149,769
28	2048	92,982	kWh	81%	46.71%	$0.1524	$14,166	$9,069	$4,083		$18,249	$0	($569)	($585)	$17,095	$166,865
29	2049	92,238	kWh	80%	46.33%	$0.1562	$14,404	$9,296	$4,186		$18,589	$0	($580)	($597)	$17,412	$184,277
30	2050	91,500	kWh	79%	45.96%	$0.1601	$14,646	$9,528	$4,290		$18,936	$0	($592)	($609)	$17,735	$202,012

Assumed Percentage of Demand
Charge Reduction*: 45.03%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$176,232
Grants, Rebates, No-Obligation Funds	$0
Total Interest Payments	$24,338
Operational Expense Allowance (insurance, O+M, 30-year)	$38,136
Total Lifetime Project Costs	$238,707

SAVINGS

Total Lifetime Project Savings	$440,719

OUTCOMES

Net Lifetime Project Costs or Savings	$202,012	
Total Project Cost Payback (Years)	16.2	Years
Value to Cost Ratio	1.85	to 1.0
Electricity Production (kWh, 30-year)	3,091,516	kWh
Percent of Electricity Usage Covered by Solar (Year	58.02%	

Site Solar Feasibility Reports by Building

Waste Water Treatment Plant

Concept Design

The roof configuration of the primary Waste Water Treatment Plant (WWTP) site are well suited for solar PV installation, with good orientation, overall configuration, and minimal rooftop equipment obstruction.

The rooftop arrays supported by the available roof area are not capable of offsetting all of the electricity used on site. The rooftop array's first year generation is estimated to offset approximately 6% of the site's current reported electricity consumption. On-site renewable energy capacity can be increased through the introduction of a ground mounted array. The primary portion of the site appears inappropriate for significant ground mounted arrays while the Eastern portion of the site is partially wooded, within the flood plain of the river. The Eastern portion of the site is also anticipated for future wastewater treatment locations . With these considerations in mind, a ground mounted array is not currently recommended.

Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.52:1 ratio. As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at the same cost as achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING (Rooftop Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$340,197	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$46,982	
Operational Expense Allowance (insurance, O+M, 30-year)	$73,892	
Total Lifetime Project Costs	$461,071	
SAVINGS		
Total Lifetime Project Savings	$701,490	
OUTCOMES		
Net Lifetime Project Costs or Savings	$240,420	
Total Project Cost Payback (Years)	19.7	Years
Value to Cost Ratio	1.52	to 1.0
Electricity Production (kWh, 30-year)	5,888,602	kWh
Percent of Electricity Usage Covered by Solar (Year	6.14%	

Note, values do not include social cost of carbon avoided by the solar array.

Recommended Site Priority:

Priority 2
(3-6 year)

Design 1 City of Northfiled Wastewater Treatment Plant, 1450 Highway 3 North, Northfield, MN

Report

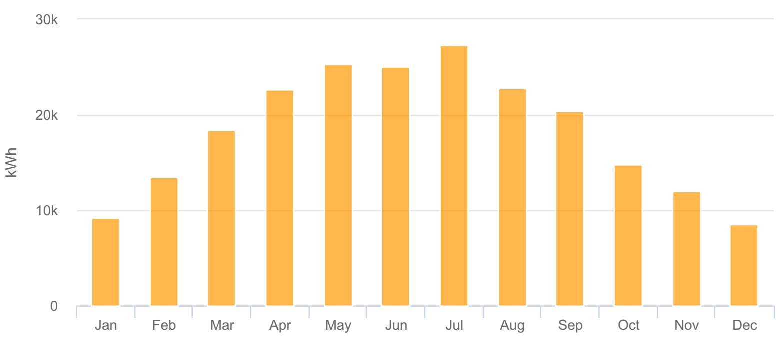
Project Name	City of Northfiled Wastewater Treatment Plant
Project Address	1450 Highway 3 North, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

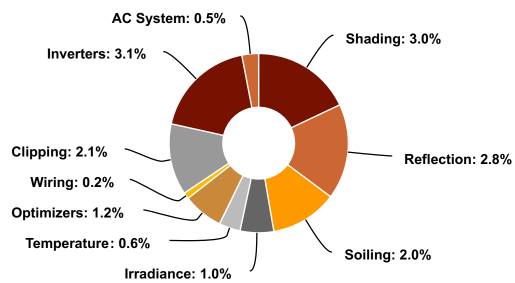
Design	Design 1
Module DC Nameplate	161.4 kW
Inverter AC Nameplate	129.6 kW Load Ratio: 1.24
Annual Production	220.0 MWh
Performance Ratio	84.5%
kWh/kWp	1,363.8
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,613.7	15.7%
	Shaded Irradiance	1,565.7	-3.0%
	Irradiance after Reflection	1,521.2	-2.8%
	Irradiance after Soiling	1,490.7	-2.0%
	Total Collector Irradiance	**1,490.6**	**0.0%**
Energy (kWh)	Nameplate	240,287.4	
	Output at Irradiance Levels	237,879.1	-1.0%
	Output at Cell Temperature Derate	236,369.9	-0.6%
	Output After Mismatch	236,369.6	0.0%
	Optimizer Output	233,530.1	-1.2%
	Optimal DC Output	233,086.7	-0.2%
	Constrained DC Output	228,128.4	-2.1%
	Inverter Output	221,147.0	-3.1%
	Energy to Grid	**220,042.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.9 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model
Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE14.4KUS (SolarEdge)	Folsom Labs	CEC

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Components

Component	Name	Count
Inverters	SE14.4KUS (SolarEdge)	9 (129.6 kW)
Strings	10 AWG (Copper)	28 (2,683.7 ft)
Optimizers	P400 NA (SolarEdge)	461 (184.4 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	461 (161.4 kW)

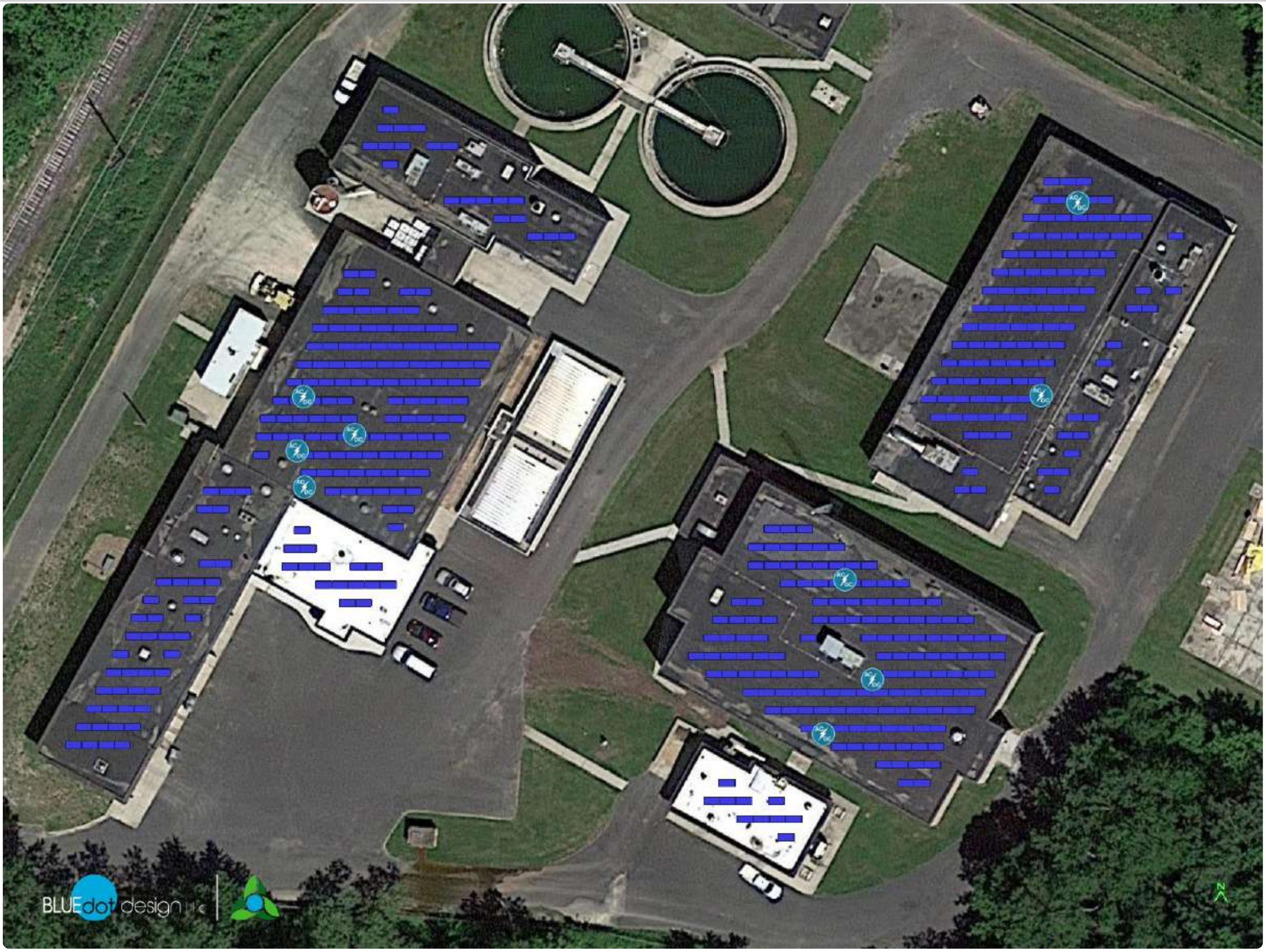
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	9-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	114	114	39.9 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	142	142	49.7 kW
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	10	10	3.50 kW
Field Segment 4	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	15	15	5.25 kW
Field Segment 5	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	160	160	56.0 kW
Field Segment 6	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	20	20	7.00 kW

Detailed Layout



Owner Input & Results Worksheet

Project

Wastewater Treatment
1450 Highway 3 North
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
161.40	Array Size (kW DC)
350	Watt Rating
461	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
129.60	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
220,000	First Year Generation (kWh)
$324,935.97	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$15,260.73	Owner Contingency (if any)
$340,196.70	Total Project Budget
$2.11	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$20,417	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
3,584,843	Total Annual Electric Use (kWh)
6,276.00	Total Annual Demand (kW)
1	Building Area (Square Feet)
50.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
3,584,842.59	Electric Use Intensity (kWh/SF)
35848426%	EUI as % of National Average
$45,696.00	Annual Energy Charge ($)
$218,936.16	Annual Demand Charge ($)
$264,632.16	Total Annual Electric Cost
$0.0127	Effective Electric Rate ($/kWh)*
$34.88	Effective Demand Charge ($/kW)
523.00	Average Monthly Demand (kW)

Financial Information

$68,039.34	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$272,157.36	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	5,888,602	kWh
Total Electricity Bill Savings	$701,490	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$340,197	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$340,197	
Simple Project Payback	14.55	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$387,179	
Financed Capital Payback	16.56	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$73,892	
Financed Array Lifetime Cost	$461,071	
Financed Array Lifetime Payback	19.72	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1191	
Project Cost Per Solar Per kWh	$0.0783	
Net Electricity Bill Savings Per kWh	$0.0408	
Value to Cost Ratio	1.52	to 1.0

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PROJ: **Wastewater Treatment Plant**
LOC.: **1450 Highway 3 North**
TITLE: **Rooftop**

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**161.4**
Year 1 Generation Projection (MWH)	**220.0**
Annual Site Energy Use (MWH)	**3,584.8**
Assumed Energy Use During Solar Production Hours	**50%**

Energy Generation Schedule (Based on Predicted Loss)						Potential Revenue Value						Simplified Cash Flow Projection				
Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	220,000	kWh	100%	6.14%	$0.0127	$2,804	$218,936	$13,513	$0	$16,317	($99,953)	($646)	($678)	($84,959)	($84,959)
2	2022	218,240	kWh	99%	6.09%	$0.0131	$2,851	$224,410	$13,851	$0	$16,702	($31,914)	($659)	($691)	($16,562)	($101,521)
3	2023	216,494	kWh	98%	6.04%	$0.0134	$2,899	$230,020	$14,197	$0	$17,096	($31,914)	($672)	($705)	($16,195)	($117,716)
4	2024	214,762	kWh	98%	5.99%	$0.0137	$2,948	$235,770	$14,552	$0	$17,500	($31,914)	($685)	($719)	($15,818)	($133,534)
5	2025	213,044	kWh	97%	5.94%	$0.0141	$2,998	$241,665	$14,916	$0	$17,913	($31,914)	($699)	($734)	($15,433)	($148,967)
6	2026	211,340	kWh	96%	5.90%	$0.0144	$3,048	$247,706	$15,289	$0	$18,337	($31,914)	($713)	($748)	($15,039)	($164,006)
7	2027	209,649	kWh	95%	5.85%	$0.0148	$3,099	$253,899	$15,671	$0	$18,770	($31,914)	($727)	($763)	($14,634)	($178,640)
8	2028	207,972	kWh	95%	5.80%	$0.0152	$3,151	$260,246	$16,063	$0	$19,214	($31,914)	($742)	($779)	($14,220)	($192,861)
9	2029	206,308	kWh	94%	5.76%	$0.0155	$3,204	$266,752	$16,464	$0	$19,668	($31,914)	($756)	($794)	($13,796)	($206,657)
10	2030	204,658	kWh	93%	5.71%	$0.0159	$3,258	$273,421	$16,876	$0	$20,134	($31,914)	($772)	($810)	($13,362)	($220,019)
11	2031	203,020	kWh	92%	5.66%	$0.0163	$3,313	$280,257	$17,298	$0	$20,610	$0	($787)	($826)	$18,997	($201,022)
12	2032	201,396	kWh	92%	5.62%	$0.0167	$3,368	$287,263	$17,730		$21,099	$0	($803)	($843)	$19,453	($181,569)
13	2033	199,785	kWh	91%	5.57%	$0.0171	$3,425	$294,445	$18,173		$21,598	$0	($819)	($860)	$19,920	($161,649)
14	2034	198,187	kWh	90%	5.53%	$0.0176	$3,483	$301,806	$18,628		$22,110	$0	($835)	($877)	$20,398	($141,251)
15	2035	196,601	kWh	89%	5.48%	$0.0180	$3,541	$309,351	$19,093		$22,634	$0	($852)	($894)	$20,888	($120,363)
16	2036	195,028	kWh	89%	5.44%	$0.0185	$3,601	$317,085	$19,571		$23,171	$0	($869)	($912)	$21,390	($98,973)
17	2037	193,468	kWh	88%	5.40%	$0.0189	$3,661	$325,012	$20,060		$23,721	$0	($886)	($931)	$21,904	($77,068)
18	2038	191,920	kWh	87%	5.35%	$0.0194	$3,723	$333,137	$20,562		$24,284	$0	($904)	($949)	$22,431	($54,638)
19	2039	190,385	kWh	87%	5.31%	$0.0199	$3,785	$341,466	$21,076		$24,861	$0	($922)	($968)	$22,970	($31,667)
20	2040	188,862	kWh	86%	5.27%	$0.0204	$3,849	$350,002	$21,602		$25,451	$0	($941)	($21,405)	$3,106	($28,561)
21	2041	187,351	kWh	85%	5.23%	$0.0209	$3,913	$358,752	$22,142		$26,056	$0	($959)	($988)	$24,109	($4,452)
22	2042	185,852	kWh	84%	5.18%	$0.0214	$3,979	$367,721	$22,696		$26,675	$0	($979)	($1,007)	$24,689	$20,237
23	2043	184,365	kWh	84%	5.14%	$0.0219	$4,046	$376,914	$23,263		$27,309	$0	($998)	($1,027)	$25,284	$45,521
24	2044	182,890	kWh	83%	5.10%	$0.0225	$4,114	$386,337	$23,845		$27,959	$0	($1,018)	($1,048)	$25,893	$71,414
25	2045	181,427	kWh	82%	5.06%	$0.0231	$4,183	$395,996	$24,441		$28,624	$0	($1,038)	($1,069)	$26,517	$97,930
26	2046	179,976	kWh	82%	5.02%	$0.0236	$4,253	$405,895	$25,052		$29,305	$0	($1,059)	($1,090)	$27,156	$125,086
27	2047	178,536	kWh	81%	4.98%	$0.0242	$4,325	$416,043	$25,679		$30,003	$0	($1,080)	($1,112)	$27,811	$152,897
28	2048	177,108	kWh	81%	4.94%	$0.0248	$4,397	$426,444	$26,320		$30,718	$0	($1,102)	($1,134)	$28,481	$181,378
29	2049	175,691	kWh	80%	4.90%	$0.0254	$4,471	$437,105	$26,978		$31,450	$0	($1,124)	($1,157)	$29,169	$210,547
30	2050	174,285	kWh	79%	4.86%	$0.0261	$4,546	$448,033	$27,653		$32,199	$0	($1,146)	($1,180)	$29,873	$240,420

Assumed Percentage of Demand Charge Reduction*: 6.17%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$340,197	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$46,982	
Operational Expense Allowance (insurance, O+M, 30-year)	$73,892	
Total Lifetime Project Costs	$461,071	

SAVINGS

Total Lifetime Project Savings	$701,490	

OUTCOMES

Net Lifetime Project Costs or Savings	$240,420	
Total Project Cost Payback (Years)	19.7	Years
Value to Cost Ratio	1.52	to 1.0
Electricity Production (kWh, 30-year)	5,888,602	kWh
Percent of Electricity Usage Covered by Solar (Year	6.14%	

Site Solar Feasibility Reports by Building

Water Department Office

Concept Design

The roof configuration of the Water Department Office building is moderately suited for solar PV installation, with good orientation, configuration, and limited rooftop equipment. However the building has moderately significant solar obstructions due to mature trees immediately adjacent to the building.

The concept explored in this option is a rooftop solar array meeting the program requirements for the Xcel Energy Solar Rewards program. The Solar Rewards program incentivizes solar installations, first by attributing all energy generated by the solar array to the building's energy consumption on a one-to-one basis (as would occur in a traditional Net Metering interconnection). Secondly, the Solar Rewards program pays the site owner an additional $0.06 per kWh generated for the first 10 years of operation. Under this arrangement, the site owner receives essentially double compensation for electricity generated by the array for the first 10 years. In exchange, Xcel Energy is allowed to retain the Renewable Energy Credits (the "green attributes") for all power generated by the solar array for the 10 year period. Following the 10 year period the array reverts back to a net metered site (with energy generation offsetting energy consumed on a one-to-one basis)

The array is not capable of offsetting all of the electricity used on site. The array's first year generation is estimated to offset approximately 9% of the site's current reported electricity consumption. The site utilization and tree coverage does not readily support ground mounted arrays while carport arrays would not be cost effective for this site and its energy tariff structure. Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.54:1 ratio. As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.02 more than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

COSTS AND FINANCING		
Total Installed Array Cost (incl. contingency, other owner expenses)	$45,012	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$6,216	
Operational Expense Allowance (insurance, O+M, 30-year)	$7,880	
Total Lifetime Project Costs	$59,108	
SAVINGS		
Total Lifetime Project Savings	$91,035	
OUTCOMES		
Net Lifetime Project Costs or Savings	$31,927	
Total Project Cost Payback (Years)	19.5	Years
Value to Cost Ratio	1.54	to 1.0
Electricity Production (kWh, 30-year)	561,559	kWh
Percent of Electricity Usage Covered by Solar (Year	9.32%	

Note, values do not include social cost of carbon avoided by the solar array.

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

Recommended Site Priority:

Priority 3
(Not Recommended)

paleBLUEdot LLC

Rooftop City of Northfield Water Department Office, 1101 College St, Northfield, MN

Report

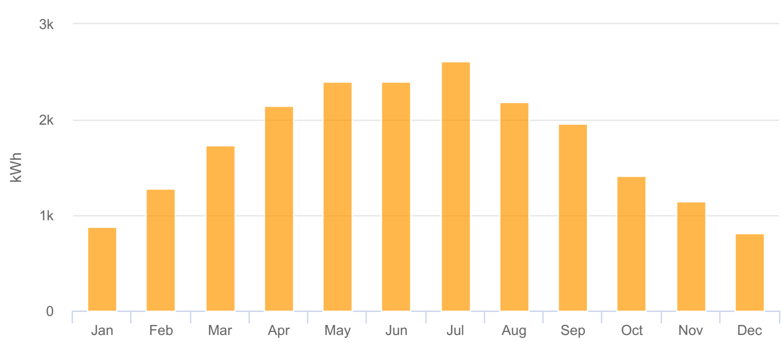
Project Name	City of Northfield Water Department Office
Project Address	1101 College St, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

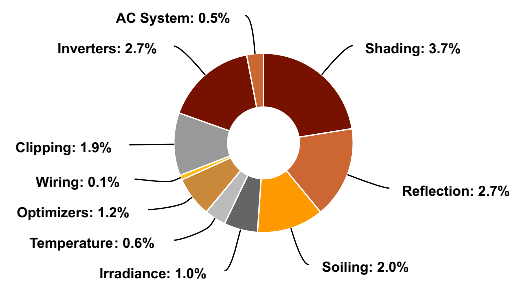
Design	Rooftop
Module DC Nameplate	15.4 kW
Inverter AC Nameplate	12.0 kW Load Ratio: 1.28
Annual Production	20.98 MWh
Performance Ratio	84.4%
kWh/kWp	1,362.6
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,613.7	15.7%
	Shaded Irradiance	1,553.5	-3.7%
	Irradiance after Reflection	1,510.8	-2.7%
	Irradiance after Soiling	1,480.6	-2.0%
	Total Collector Irradiance	**1,480.3**	**0.0%**
Energy (kWh)	Nameplate	22,775.9	
	Output at Irradiance Levels	22,545.9	-1.0%
	Output at Cell Temperature Derate	22,401.5	-0.6%
	Output After Mismatch	22,401.5	0.0%
	Optimizer Output	22,131.9	-1.2%
	Optimal DC Output	22,101.3	-0.1%
	Constrained DC Output	21,685.5	-1.9%
	Inverter Output	21,089.3	-2.7%
	Energy to Grid	**20,983.8**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.9 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE6K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE6K (SolarEdge)	2 (12.0 kW)
Strings	10 AWG (Copper)	2 (71.5 ft)
Optimizers	P400 NA (SolarEdge)	44 (17.6 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	44 (15.4 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	16-35	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	27	27	9.45 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	17	17	5.95 kW

Detailed Layout

paleBLUEdot LLC

Owner Input & Results Worksheet

Project

Water Department
1101 College St
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
15.40	Array Size (kW DC)
350	Watt Rating
44	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
64.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
20,980	First Year Generation (kWh)
$42,983.52	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$2,028.52	Owner Contingency (if any)
$45,012.03	Total Project Budget
$2.92	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$2,777	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
225,011	Total Annual Electric Use (kWh)
1,080.00	Total Annual Demand (kW)
7,500	Building Area (Square Feet)
50.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
30.00	Electric Use Intensity (kWh/SF)
300%	EUI as % of National Average
$17,192.71	Annual Energy Charge ($)
$11,328.00	Annual Demand Charge ($)
$28,520.71	Total Annual Electric Cost
$0.0764	Effective Electric Rate ($/kWh)*
$10.49	Effective Demand Charge ($/kW)
90.00	Average Monthly Demand (kW)

Financial Information

$9,002.41	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$36,009.63	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	561,559	kWh
Total Electricity Bill Savings	$91,035	
Cash Purchase Payback		
Allowance for annual expenses and financing costs excluded		
Capital Cost	$45,012	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$45,012	
Simple Project Payback	14.83	Years
Financed Purchase Payback		
Allowance for annual expenses excluded. Financing costs included		
Financed Capital Cost	$51,228	
Financed Capital Payback	16.88	Years
Financed Array Lifetime Payback		
30 year allowance for annual expenses and financing costs included.		
30 year Operational Expense Allowance (ins/O+M)	$7,880	
Financed Array Lifetime Cost	$59,108	
Financed Array Lifetime Payback	19.48	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1621	
Project Cost Per Solar Per kWh	$0.1053	
Net Electricity Bill Savings Per kWh	$0.0569	
Value to Cost Ratio	1.54	to 1.0

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PROJ: Water Department
LOC.: 1101 College St
TITLE: Rooftop

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**15.4**
Year 1 Generation Projection (MWH)	**21.0**
Annual Site Energy Use (MWH)	**225.0**
Assumed Energy Use During Solar Production Hours	**50%**

Energy Generation Schedule (Based on Predicted Loss) / Potential Revenue Value / Simplified Cash Flow Projection

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	20,980	kWh	100%	9.32%	$0.0764	$1,603	$11,328	$388	$1,259	$3,250	($13,225)	($62)	($65)	($10,102)	($10,102)
2	2022	20,812	kWh	99%	9.25%	$0.0783	$1,630	$11,611	$397	$1,249	$3,276	($4,223)	($63)	($66)	($1,075)	($11,177)
3	2023	20,646	kWh	98%	9.18%	$0.0803	$1,657	$11,901	$407	$1,239	$3,303	($4,223)	($64)	($67)	($1,051)	($12,228)
4	2024	20,480	kWh	98%	9.10%	$0.0823	$1,685	$12,199	$417	$1,229	$3,332	($4,223)	($65)	($69)	($1,025)	($13,253)
5	2025	20,317	kWh	97%	9.03%	$0.0843	$1,714	$12,504	$428	$1,219	$3,360	($4,223)	($67)	($70)	($999)	($14,252)
6	2026	20,154	kWh	96%	8.96%	$0.0864	$1,742	$12,817	$439	$1,209	$3,390	($4,223)	($68)	($71)	($972)	($15,223)
7	2027	19,993	kWh	95%	8.89%	$0.0886	$1,772	$13,137	$450	$1,200	$3,421	($4,223)	($69)	($73)	($944)	($16,168)
8	2028	19,833	kWh	95%	8.81%	$0.0908	$1,801	$13,465	$461	$1,190	$3,452	($4,223)	($71)	($74)	($916)	($17,083)
9	2029	19,674	kWh	94%	8.74%	$0.0931	$1,832	$13,802	$472	$1,180	$3,484	($4,223)	($72)	($76)	($886)	($17,969)
10	2030	19,517	kWh	93%	8.67%	$0.0954	$1,862	$14,147	$484	$1,171	$3,518	($4,223)	($74)	($77)	($856)	($18,825)
11	2031	19,361	kWh	92%	8.60%	$0.0978	$1,894	$14,501	$496		$2,390	$0	($75)	($79)	$2,236	($16,589)
12	2032	19,206	kWh	92%	8.54%	$0.1003	$1,925	$14,863	$509		$2,434	$0	($77)	($80)	$2,277	($14,312)
13	2033	19,052	kWh	91%	8.47%	$0.1028	$1,958	$15,235	$521		$2,479	$0	($78)	($82)	$2,319	($11,993)
14	2034	18,900	kWh	90%	8.40%	$0.1053	$1,991	$15,616	$534		$2,525	$0	($80)	($84)	$2,362	($9,631)
15	2035	18,749	kWh	89%	8.33%	$0.1080	$2,024	$16,006	$548		$2,572	$0	($81)	($85)	$2,405	($7,226)
16	2036	18,599	kWh	89%	8.27%	$0.1107	$2,058	$16,406	$561		$2,620	$0	($83)	($87)	$2,450	($4,776)
17	2037	18,450	kWh	88%	8.20%	$0.1134	$2,093	$16,816	$575		$2,668	$0	($85)	($89)	$2,495	($2,281)
18	2038	18,302	kWh	87%	8.13%	$0.1163	$2,128	$17,237	$590		$2,718	$0	($86)	($91)	$2,541	$259
19	2039	18,156	kWh	87%	8.07%	$0.1192	$2,164	$17,668	$605		$2,768	$0	($88)	($92)	$2,588	$2,847
20	2040	18,011	kWh	86%	8.00%	$0.1222	$2,200	$18,110	$620		$2,820	$0	($90)	($2,872)	($142)	$2,706
21	2041	17,866	kWh	85%	7.94%	$0.1252	$2,237	$18,562	$635		$2,872	$0	($92)	($94)	$2,686	$5,392
22	2042	17,724	kWh	84%	7.88%	$0.1283	$2,275	$19,026	$651		$2,926	$0	($93)	($96)	$2,736	$8,128
23	2043	17,582	kWh	84%	7.81%	$0.1315	$2,313	$19,502	$667		$2,980	$0	($95)	($98)	$2,787	$10,915
24	2044	17,441	kWh	83%	7.75%	$0.1348	$2,352	$19,990	$684		$3,036	$0	($97)	($100)	$2,839	$13,754
25	2045	17,302	kWh	82%	7.69%	$0.1382	$2,391	$20,489	$701		$3,092	$0	($99)	($102)	$2,891	$16,645
26	2046	17,163	kWh	82%	7.63%	$0.1417	$2,431	$21,001	$719		$3,150	$0	($101)	($104)	$2,945	$19,590
27	2047	17,026	kWh	81%	7.57%	$0.1452	$2,472	$21,527	$737		$3,209	$0	($103)	($106)	$3,000	$22,590
28	2048	16,890	kWh	81%	7.51%	$0.1488	$2,514	$22,065	$755		$3,269	$0	($105)	($108)	$3,055	$25,645
29	2049	16,755	kWh	80%	7.45%	$0.1525	$2,556	$22,616	$774		$3,330	$0	($107)	($110)	$3,112	$28,757
30	2050	16,620	kWh	79%	7.39%	$0.1564	$2,599	$23,182	$793		$3,392	$0	($109)	($113)	$3,170	$31,927

Assumed Percentage of Demand Charge Reduction*: 3.42%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$45,012	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$6,216	
Operational Expense Allowance (insurance, O+M, 30-year)	$7,880	
Total Lifetime Project Costs	$59,108	

SAVINGS

Total Lifetime Project Savings	$91,035	

OUTCOMES

Net Lifetime Project Costs or Savings	$31,927	
Total Project Cost Payback (Years)	19.5	Years
Value to Cost Ratio	1.54	to 1.0
Electricity Production (kWh, 30-year)	561,559	kWh
Percent of Electricity Usage Covered by Solar (Year	9.32%	

Site Solar Feasibility Reports by Building

Northfield Resource Center

Concept Design

The roof configuration of the Resource Center building is well suited for solar PV installation, with good orientation, and overall configuration, and only moderate rooftop equipment obstruction. Though much of the slopped roof configuration requires an easterly or westerly orientation for portions of the array, modeling indicates an overall well performing array.

The rooftop array is not capable of offsetting all of the electricity used on site. The rooftop array's first year generation is estimated to offset approximately 86% of the site's current reported electricity consumption. To meet the site's full annual use an additional ground mounted array is required. The site area to the SouthEast of the facility and parking lot is moderately well suited for a ground mounted solar array meeting 18% or more of the site's annual electric use. The combined arrays included in this concept can provide an estimated 104% of the site's total electric use, making the site Net Zero electricity.

Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Note, values do not include social cost of carbon avoided by the solar array.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.46:1 ratio (1.41 for rooftop, 1.71 for ground). As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.017 less than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING (Rooftop Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$840,024	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$116,010	
Operational Expense Allowance (insurance, O+M, 30-year)	$181,891	
Total Lifetime Project Costs	$1,137,925	
SAVINGS		
Total Lifetime Project Savings	$1,599,615	
OUTCOMES		
Net Lifetime Project Costs or Savings	$461,690	
Total Project Cost Payback (Years)	21.3	Years
Value to Cost Ratio	1.41	to 1.0
Electricity Production (kWh, 30-year)	12,564,136	kWh
Percent of Electricity Usage Covered by Solar (Year	86.08%	

COSTS AND FINANCING (Ground Mounted Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$166,257	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$22,961	
Operational Expense Allowance (insurance, O+M, 30-year)	$37,038	
Total Lifetime Project Costs	$226,255	
SAVINGS		
Total Lifetime Project Savings	$387,412	
OUTCOMES		
Net Lifetime Project Costs or Savings	$161,156	
Total Project Cost Payback (Years)	17.5	Years
Value to Cost Ratio	1.71	to 1.0
Electricity Production (kWh, 30-year)	2,653,351	kWh
Percent of Electricity Usage Covered by Solar (Year	18.18%	

Recommended Site Priority:

Priority 1
(0-3 year)

Design 1 City of Northfield Northfield Community Resource Center, 1651 Jefferson Parkway, Northfield, MN

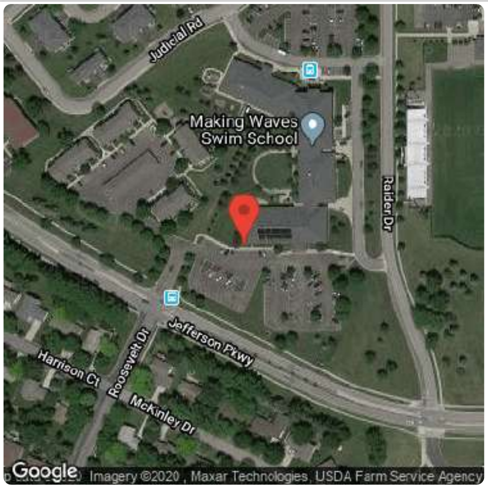
Report

Project Name	City of Northfield Northfield Community Resource Center
Project Address	1651 Jefferson Parkway, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

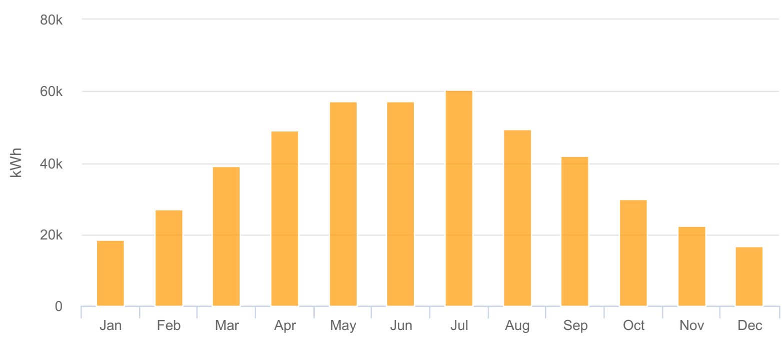
System Metrics

Design	Design 1
Module DC Nameplate	397.3 kW
Inverter AC Nameplate	306.0 kW Load Ratio: 1.30
Annual Production	469.4 MWh
Performance Ratio	81.9%
kWh/kWp	1,181.6
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

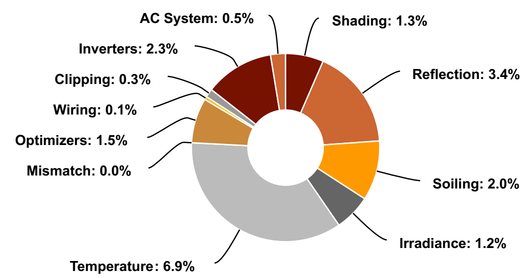
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,442.1	3.4%
	Shaded Irradiance	1,423.8	-1.3%
	Irradiance after Reflection	1,375.8	-3.4%
	Irradiance after Soiling	1,348.2	-2.0%
	Total Collector Irradiance	**1,348.3**	**0.0%**
Energy (kWh)	Nameplate	535,091.6	
	Output at Irradiance Levels	528,565.0	-1.2%
	Output at Cell Temperature Derate	492,177.1	-6.9%
	Output After Mismatch	492,175.3	0.0%
	Optimizer Output	484,764.5	-1.5%
	Optimal DC Output	484,262.3	-0.1%
	Constrained DC Output	482,871.3	-0.3%
	Inverter Output	471,745.0	-2.3%
	Energy to Grid	**469,386.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		23.4 °C
Simulation Metrics			
		Operating Hours	4673
		Solved Hours	4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE17K (SolarEdge)	Folsom Labs	Spec Sheet

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Components

Component	Name	Count
Inverters	SE17K (SolarEdge)	18 (306.0 kW)
Strings	10 AWG (Copper)	36 (3,289.2 ft)
Optimizers	P400 NA (SolarEdge)	1,135 (454.0 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	1,135 (397.3 kW)

Wiring Zones

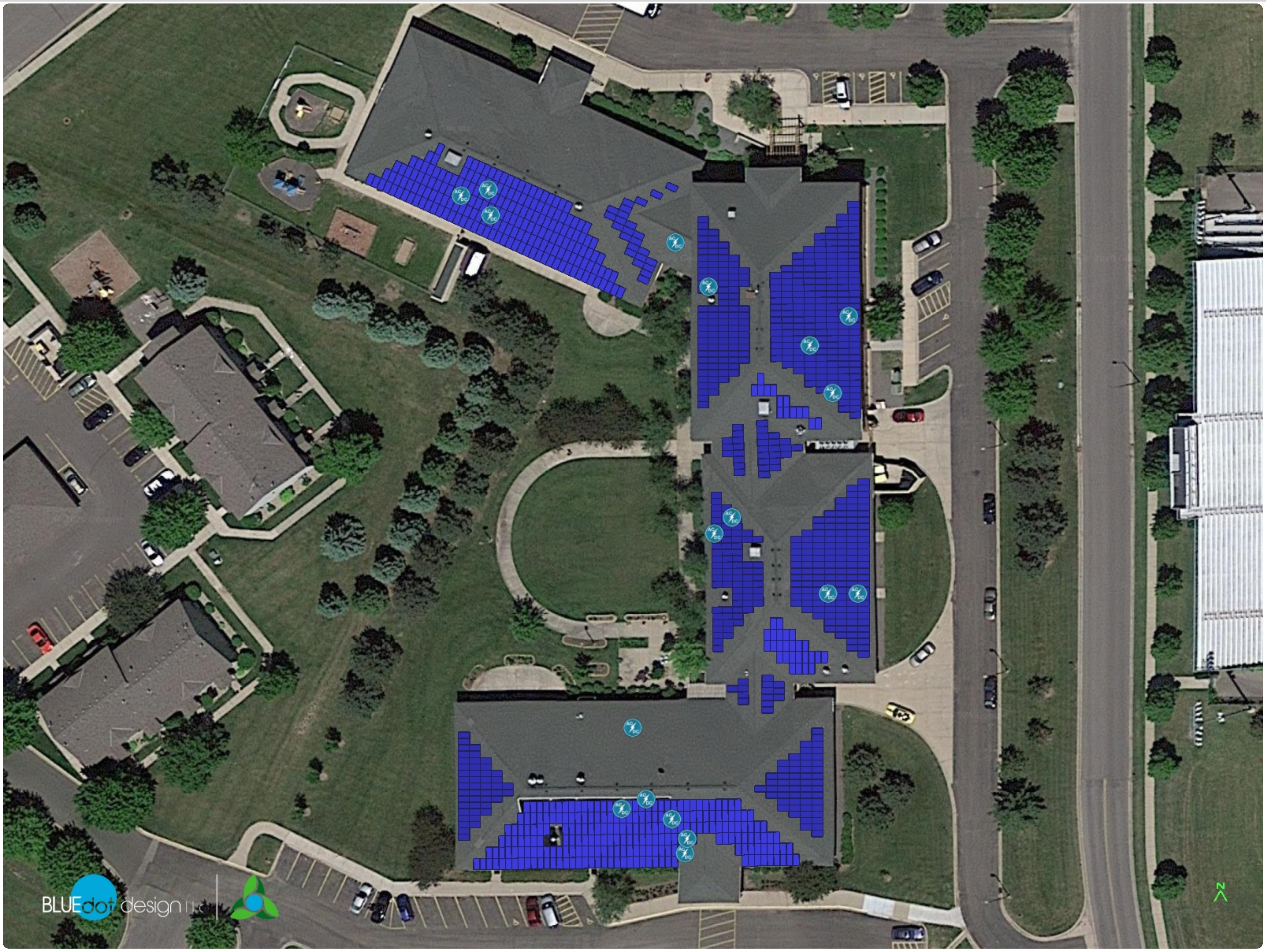
Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	15-32	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	26°	179.2068183697172°	0.0 ft	1x1	229	229	80.2 kW
Field Segment 2	Flush Mount	Portrait (Vertical)	24°	90°	0.0 ft	1x1	54	54	18.9 kW
Field Segment 3	Flush Mount	Portrait (Vertical)	29°	270°	0.0 ft	1x1	46	46	16.1 kW
Field Segment 4	Flush Mount	Portrait (Vertical)	26°	180°	0.0 ft	1x1	26	26	9.10 kW
Field Segment 5	Flush Mount	Portrait (Vertical)	26°	90.29382193465074°	0.0 ft	1x1	9	9	3.15 kW
Field Segment 6	Flush Mount	Portrait (Vertical)	33°	269.35985033047643°	0.0 ft	1x1	5	5	1.75 kW
Field Segment 7	Flush Mount	Portrait (Vertical)	26°	90°	0.0 ft	1x1	135	135	47.3 kW
Field Segment 8	Flush Mount	Portrait (Vertical)	35°	269.3489396197705°	0.0 ft	1x1	75	75	26.3 kW
Field Segment 9	Flush Mount	Portrait (Vertical)	26°	87.78025820866333°	0.0 ft	1x1	19	19	6.65 kW
Field Segment 10	Flush Mount	Portrait (Vertical)	30°	267.78179005850154°	0.0 ft	1x1	11	11	3.85 kW
Field Segment 11	Flush Mount	Portrait (Vertical)	26°	179.6086287353371°	0.0 ft	1x1	14	14	4.90 kW
Field Segment 12	Flush Mount	Portrait (Vertical)	26°	89.46135463620249°	0.0 ft	1x1	188	188	65.8 kW
Field Segment 13	Flush Mount	Portrait (Vertical)	35°	269.9768539732487°	0.0 ft	1x1	105	105	36.8 kW
Field Segment 14	Flush Mount	Portrait (Vertical)	26°	113.77269670116834°	0.0 ft	1x1	24	24	8.40 kW
Field Segment 15	Flush Mount	Portrait (Vertical)	26°	204.3138368874404°	0.0 ft	1x1	195	195	68.3 kW

Detailed Layout

Detailed Layout



Owner Input & Results Worksheet

Project

Community Resource
1651 Jefferson Parkway
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
397.30	Array Size (kW DC)
350	Watt Rating
1,135	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
306.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
469,400	First Year Generation (kWh)
$799,954.03	Total Contractor Bid
$2,500.00	Other Owner Expenses (legal, etc.)
$37,570.05	Owner Contingency (if any)
$840,024.08	Total Project Budget
$2.11	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$50,258	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
545,280	Total Annual Electric Use (kWh)
1,716.00	Total Annual Demand (kW)
0	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
N/A	Electric Use Intensity (kWh/SF)
N/A	EUI as % of National Average
$51,160.00	Annual Energy Charge ($)
$11,451.00	Annual Demand Charge ($)
$62,611.00	Total Annual Electric Cost
$0.0938	Effective Electric Rate ($/kWh)*
$6.67	Effective Demand Charge ($/kW)
143.00	Average Monthly Demand (kW)

Financial Information

$168,004.82	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$672,019.26	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	12,564,136	kWh
Total Electricity Bill Savings	$1,599,615	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$840,024	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$840,024	
Simple Project Payback	15.75	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$956,034	
Financed Capital Payback	17.93	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$181,891	
Financed Array Lifetime Cost	$1,137,925	
Financed Array Lifetime Payback	21.34	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1273	
Project Cost Per Solar Per kWh	$0.0906	
Net Electricity Bill Savings Per kWh	$0.0367	
Value to Cost Ratio	1.41	to 1.0

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PROJ: **Community Resource Center**
LOC.: **1651 Jefferson Parkway**
TITLE: **Rooftop**

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**397.3**
Year 1 Generation Projection (MWH)	**469.4**
Annual Site Energy Use (MWH)	**545.3**
Assumed Energy Use During Solar Production Hours	**65%**

Energy Generation Schedule (Based on Predicted Loss) | **Potential Revenue Value** | **Simplified Cash Flow Projection**

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	469,400	kWh	100%	86.08%	$0.0938	$33,254	$11,451	$3,181	$0	$36,435	($246,808)	($1,589)	($1,669)	($213,630)	($213,630)
2	2022	465,645	kWh	99%	85.40%	$0.0962	$34,085	$11,737	$3,261	$0	$37,346	($78,803)	($1,621)	($1,702)	($44,780)	($258,410)
3	2023	461,920	kWh	98%	84.71%	$0.0986	$34,937	$12,031	$3,343	$0	$38,280	($78,803)	($1,653)	($1,736)	($43,912)	($302,322)
4	2024	458,224	kWh	98%	84.03%	$0.1010	$35,811	$12,331	$3,426	$0	$39,237	($78,803)	($1,686)	($1,771)	($43,023)	($345,345)
5	2025	454,558	kWh	97%	83.36%	$0.1036	$36,706	$12,640	$3,512	$0	$40,218	($78,803)	($1,720)	($1,806)	($42,111)	($387,457)
6	2026	450,922	kWh	96%	82.70%	$0.1062	$37,624	$12,956	$3,600	$0	$41,223	($78,803)	($1,755)	($1,842)	($41,176)	($428,633)
7	2027	447,315	kWh	95%	82.03%	$0.1088	$38,564	$13,280	$3,690	$0	$42,254	($78,803)	($1,790)	($1,879)	($40,218)	($468,851)
8	2028	443,736	kWh	95%	81.38%	$0.1115	$39,529	$13,612	$3,782	$0	$43,310	($78,803)	($1,825)	($1,917)	($39,235)	($508,086)
9	2029	440,186	kWh	94%	80.73%	$0.1143	$40,517	$13,952	$3,876	$0	$44,393	($78,803)	($1,862)	($1,955)	($38,227)	($546,313)
10	2030	436,665	kWh	93%	80.08%	$0.1172	$41,530	$14,301	$3,973	$0	$45,503	($78,803)	($1,899)	($1,994)	($37,193)	($583,506)
11	2031	433,171	kWh	92%	79.44%	$0.1201	$42,568	$14,658	$4,073		$46,640	$0	($1,937)	($2,034)	$42,669	($540,837)
12	2032	429,706	kWh	92%	78.80%	$0.1231	$43,632	$15,025	$4,174		$47,806	$0	($1,976)	($2,075)	$43,756	($497,081)
13	2033	426,268	kWh	91%	78.17%	$0.1262	$44,723	$15,400	$4,279		$49,002	$0	($2,015)	($2,116)	$44,870	($452,211)
14	2034	422,858	kWh	90%	77.55%	$0.1293	$45,841	$15,785	$4,386		$50,227	$0	($2,056)	($2,159)	$46,012	($406,199)
15	2035	419,475	kWh	89%	76.93%	$0.1326	$46,987	$16,180	$4,495		$51,482	$0	($2,097)	($2,202)	$47,184	($359,015)
16	2036	416,120	kWh	89%	76.31%	$0.1359	$48,162	$16,584	$4,608		$52,769	$0	($2,139)	($2,246)	$48,385	($310,631)
17	2037	412,791	kWh	88%	75.70%	$0.1393	$49,366	$16,999	$4,723		$54,089	$0	($2,182)	($2,291)	$49,616	($261,014)
18	2038	409,488	kWh	87%	75.10%	$0.1428	$50,600	$17,424	$4,841		$55,441	$0	($2,225)	($2,337)	$50,879	($210,135)
19	2039	406,212	kWh	87%	74.50%	$0.1463	$51,865	$17,860	$4,962		$56,827	$0	($2,270)	($2,383)	$52,174	($157,961)
20	2040	402,963	kWh	86%	73.90%	$0.1500	$53,162	$18,306	$5,086		$58,248	$0	($2,315)	($52,689)	$3,243	($154,718)
21	2041	399,739	kWh	85%	73.31%	$0.1537	$54,491	$18,764	$5,213		$59,704	$0	($2,361)	($2,431)	$54,911	($99,807)
22	2042	396,541	kWh	84%	72.72%	$0.1576	$55,853	$19,233	$5,344		$61,196	$0	($2,409)	($2,480)	$56,308	($43,499)
23	2043	393,369	kWh	84%	72.14%	$0.1615	$57,249	$19,714	$5,477		$62,726	$0	($2,457)	($2,529)	$57,740	$14,241
24	2044	390,222	kWh	83%	71.56%	$0.1656	$58,680	$20,207	$5,614		$64,294	$0	($2,506)	($2,580)	$59,209	$73,450
25	2045	387,100	kWh	82%	70.99%	$0.1697	$60,147	$20,712	$5,754		$65,902	$0	($2,556)	($2,631)	$60,714	$134,164
26	2046	384,003	kWh	82%	70.42%	$0.1739	$61,651	$21,230	$5,898		$67,549	$0	($2,607)	($2,684)	$62,258	$196,422
27	2047	380,931	kWh	81%	69.86%	$0.1783	$63,192	$21,760	$6,046		$69,238	$0	($2,659)	($2,738)	$63,841	$260,264
28	2048	377,884	kWh	81%	69.30%	$0.1827	$64,772	$22,304	$6,197		$70,969	$0	($2,713)	($2,792)	$65,464	$325,728
29	2049	374,861	kWh	80%	68.75%	$0.1873	$66,391	$22,862	$6,352		$72,743	$0	($2,767)	($2,848)	$67,128	$392,856
30	2050	371,862	kWh	79%	68.20%	$0.1920	$68,051	$23,433	$6,511		$74,562	$0	($2,822)	($2,905)	$68,834	$461,690

Assumed Percentage of Demand
Charge Reduction*: 27.78%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/
Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$840,024	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$116,010	
Operational Expense Allowance (insurance, O+M, 30-year)	$181,891	
Total Lifetime Project Costs	$1,137,925	

SAVINGS

Total Lifetime Project Savings	$1,599,615	

OUTCOMES

Net Lifetime Project Costs or Savings	$461,690	
Total Project Cost Payback (Years)	21.3	Years
Value to Cost Ratio	1.41	to 1.0
Electricity Production (kWh, 30-year)	12,564,136	kWh
Percent of Electricity Usage Covered by Solar (Year	86.08%	

Groundmounted City of Northfield Northfield Community Resource Center, 1651 Jefferson Parkway, Northfield, MN

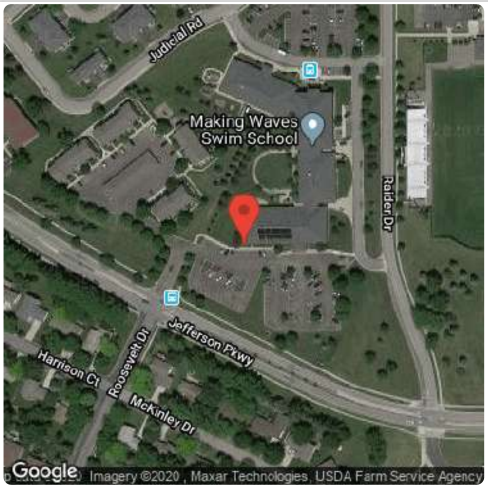
Report

Project Name	City of Northfield Northfield Community Resource Center
Project Address	1651 Jefferson Parkway, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

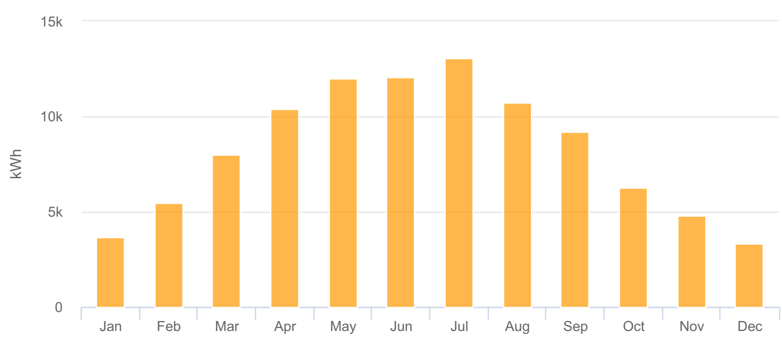
System Metrics

Design	Groundmounted
Module DC Nameplate	80.9 kW
Inverter AC Nameplate	66.6 kW Load Ratio: 1.21
Annual Production	99.13 MWh
Performance Ratio	76.8%
kWh/kWp	1,226.1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	edef351a35-38368f3ee3-9050205824-c43eec09b7

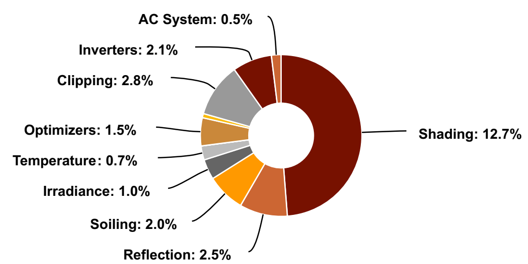
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,595.7	14.4%
	Shaded Irradiance	1,393.7	-12.7%
	Irradiance after Reflection	1,358.9	-2.5%
	Irradiance after Soiling	1,331.8	-2.0%
	Total Collector Irradiance	**1,332.2**	**0.0%**
Energy (kWh)	Nameplate	108,339.5	
	Output at Irradiance Levels	107,204.7	-1.0%
	Output at Cell Temperature Derate	106,419.8	-0.7%
	Output After Mismatch	106,419.6	0.0%
	Optimizer Output	104,867.1	-1.5%
	Optimal DC Output	104,642.7	-0.2%
	Constrained DC Output	101,712.1	-2.8%
	Inverter Output	99,626.7	-2.1%
	Energy to Grid	**99,128.5**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.2 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

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Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model
Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Module Characterizations

Module	Uploaded By	Characterization
96M 490 (Heliene)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE33.3K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE33.3K (SolarEdge)	2 (66.6 kW)
Strings	10 AWG (Copper)	7 (565.1 ft)
Optimizers	P400 NA (SolarEdge)	165 (66.0 kW)
Module	Heliene, 96M 490 (490W)	165 (80.9 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	16-25	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	22°	180°	14.6 ft	3x1	55	165	80.9 kW

Detailed Layout

Owner Input & Results Worksheet

Project

Community Resource
1651 Jefferson Parkway
Groundmounted

Date
5/8/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
80.90	Array Size (kW DC)
490	Watt Rating
0	Number of Solar Modules (Roof)
165	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
66.60	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
99,130	First Year Generation (kWh)
$156,178.98	Total Contractor Bid
$2,500.00	Other Owner Expenses (legal, etc.)
$7,578.30	Owner Contingency (if any)
$166,257.28	Total Project Budget
$2.06	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$10,234	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
545,280	Total Annual Electric Use (kWh)
1,716.00	Total Annual Demand (kW)
0	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
N/A	Electric Use Intensity (kWh/SF)
N/A	EUI as % of National Average
$51,160.00	Annual Energy Charge ($)
$11,451.00	Annual Demand Charge ($)
$62,611.00	Total Annual Electric Cost
$0.0938	Effective Electric Rate ($/kWh)*
$6.67	Effective Demand Charge ($/kW)
143.00	Average Monthly Demand (kW)

Financial Information

$33,251.46	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$133,005.82	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	2,653,351	kWh
Total Electricity Bill Savings	$387,412	
Cash Purchase Payback		
Allowance for annual expenses and financing costs excluded		
Capital Cost	$166,257	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$166,257	
Simple Project Payback	12.87	Years
Financed Purchase Payback		
Allowance for annual expenses excluded. Financing costs included		
Financed Capital Cost	$189,218	
Financed Capital Payback	14.65	Years
Financed Array Lifetime Payback		
30 year allowance for annual expenses and financing costs included.		
30 year Operational Expense Allowance (ins/O+M)	$37,038	
Financed Array Lifetime Cost	$226,255	
Financed Array Lifetime Payback	17.52	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1460	
Project Cost Per Solar Per kWh	$0.0853	
Net Electricity Bill Savings Per kWh	$0.0607	
Value to Cost Ratio	1.71	to 1.0

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PROJ: Community Resource Center
LOC.: 1651 Jefferson Parkway
TITLE: Groundmounted

08-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**80.9**
Year 1 Generation Projection (MWH)	**99.1**
Annual Site Energy Use (MWH)	**545.3**
Assumed Energy Use During Solar Production Hours	**65%**

Energy Generation Schedule (Based on Predicted Loss) | **Potential Revenue Value** | **Simplified Cash Flow Projection**

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	99,130	kWh	100%	18.18%	$0.0938	$9,301	$11,451	$648	$0	$9,949	($48,848)	($324)	($340)	($39,563)	($39,563)
2	2022	98,337	kWh	99%	18.03%	$0.0962	$9,457	$11,737	$664	$0	$10,121	($15,597)	($330)	($347)	($6,152)	($45,715)
3	2023	97,550	kWh	98%	17.89%	$0.0986	$9,616	$12,031	$681	$0	$10,296	($15,597)	($337)	($354)	($5,990)	($51,706)
4	2024	96,770	kWh	98%	17.75%	$0.1010	$9,777	$12,331	$698	$0	$10,475	($15,597)	($343)	($361)	($5,826)	($57,531)
5	2025	95,996	kWh	97%	17.60%	$0.1036	$9,942	$12,640	$715	$0	$10,657	($15,597)	($350)	($368)	($5,658)	($63,189)
6	2026	95,228	kWh	96%	17.46%	$0.1062	$10,109	$12,956	$733	$0	$10,842	($15,597)	($357)	($375)	($5,487)	($68,677)
7	2027	94,466	kWh	95%	17.32%	$0.1088	$10,278	$13,280	$751	$0	$11,030	($15,597)	($364)	($383)	($5,314)	($73,991)
8	2028	93,710	kWh	95%	17.19%	$0.1115	$10,451	$13,612	$770	$0	$11,221	($15,597)	($372)	($390)	($5,137)	($79,128)
9	2029	92,961	kWh	94%	17.05%	$0.1143	$10,627	$13,952	$789	$0	$11,416	($15,597)	($379)	($398)	($4,958)	($84,086)
10	2030	92,217	kWh	93%	16.91%	$0.1172	$10,805	$14,301	$809	$0	$11,614	($15,597)	($387)	($406)	($4,775)	($88,861)
11	2031	91,479	kWh	92%	16.78%	$0.1201	$10,987	$14,658	$829		$11,816	$0	($394)	($414)	$11,007	($77,854)
12	2032	90,747	kWh	92%	16.64%	$0.1231	$11,171	$15,025	$850		$12,021	$0	($402)	($422)	$11,197	($66,657)
13	2033	90,021	kWh	91%	16.51%	$0.1262	$11,359	$15,400	$871		$12,230	$0	($410)	($431)	$11,389	($55,268)
14	2034	89,301	kWh	90%	16.38%	$0.1293	$11,550	$15,785	$893		$12,443	$0	($419)	($440)	$11,585	($43,683)
15	2035	88,587	kWh	89%	16.25%	$0.1326	$11,744	$16,180	$915		$12,659	$0	($427)	($448)	$11,784	($31,899)
16	2036	87,878	kWh	89%	16.12%	$0.1359	$11,941	$16,584	$938		$12,879	$0	($436)	($457)	$11,987	($19,913)
17	2037	87,175	kWh	88%	15.99%	$0.1393	$12,142	$16,999	$962		$13,104	$0	($444)	($466)	$12,193	($7,720)
18	2038	86,478	kWh	87%	15.86%	$0.1428	$12,346	$17,424	$986		$13,332	$0	($453)	($476)	$12,403	$4,683
19	2039	85,786	kWh	87%	15.73%	$0.1463	$12,553	$17,860	$1,010		$13,564	$0	($462)	($485)	$12,616	$17,299
20	2040	85,099	kWh	86%	15.61%	$0.1500	$12,764	$18,306	$1,036		$13,800	$0	($471)	($10,729)	$2,600	$19,899
21	2041	84,419	kWh	85%	15.48%	$0.1537	$12,979	$18,764	$1,062		$14,040	$0	($481)	($495)	$13,064	$32,963
22	2042	83,743	kWh	84%	15.36%	$0.1576	$13,197	$19,233	$1,088		$14,285	$0	($490)	($505)	$13,289	$46,252
23	2043	83,073	kWh	84%	15.23%	$0.1615	$13,418	$19,714	$1,115		$14,534	$0	($500)	($515)	$13,518	$59,770
24	2044	82,409	kWh	83%	15.11%	$0.1656	$13,644	$20,207	$1,143		$14,787	$0	($510)	($525)	$13,751	$73,522
25	2045	81,750	kWh	82%	14.99%	$0.1697	$13,873	$20,712	$1,172		$15,045	$0	($520)	($536)	$13,988	$87,510
26	2046	81,096	kWh	82%	14.87%	$0.1739	$14,106	$21,230	$1,201		$15,307	$0	($531)	($547)	$14,230	$101,740
27	2047	80,447	kWh	81%	14.75%	$0.1783	$14,343	$21,760	$1,231		$15,574	$0	($542)	($557)	$14,475	$116,215
28	2048	79,803	kWh	81%	14.64%	$0.1827	$14,584	$22,304	$1,262		$15,846	$0	($552)	($569)	$14,725	$130,940
29	2049	79,165	kWh	80%	14.52%	$0.1873	$14,829	$22,862	$1,293		$16,122	$0	($563)	($580)	$14,979	$145,919
30	2050	78,531	kWh	79%	14.40%	$0.1920	$15,078	$23,433	$1,326		$16,404	$0	($575)	($592)	$15,238	$161,156

Assumed Percentage of Demand Charge Reduction*: 5.66%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/
Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$166,257
Grants, Rebates, No-Obligation Funds	$0
Total Interest Payments	$22,961
Operational Expense Allowance (insurance, O+M, 30-year)	$37,038
Total Lifetime Project Costs	$226,255

SAVINGS

Total Lifetime Project Savings	$387,412

OUTCOMES

Net Lifetime Project Costs or Savings	$161,156	
Total Project Cost Payback (Years)	17.5	Years
Value to Cost Ratio	1.71	to 1.0
Electricity Production (kWh, 30-year)	2,653,351	kWh
Percent of Electricity Usage Covered by Solar (Year	18.18%	

Site Solar Feasibility Reports by Building

Memorial Field Pool

Concept Design

The roof configuration of the Pool Building is moderately well suited for a solar array, however, the total capacity available for a rooftop array is approximately 15% of the site's annual electrical consumption.

To meet the site's full annual use an additional ground mounted array is required. The site area to the Northwest of the pool area contains two thermal solar fields reported to paleBLUEdot as being non-functioning. The area occupied by these thermal fields and the site area between is sufficient for a ground mounted pv array meeting 106% of the site's annual electric use, making the site Net Zero electricity.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.39:1 ratio. As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.026 less than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING		
Total Installed Array Cost (incl. contingency, other owner expenses)	$200,466	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$27,685	
Operational Expense Allowance (insurance, O+M, 30-year)	$37,221	
Total Lifetime Project Costs	$265,371	
SAVINGS		
Total Lifetime Project Savings	$367,544	
OUTCOMES		
Net Lifetime Project Costs or Savings	$102,173	
Total Project Cost Payback (Years)	21.7	Years
Value to Cost Ratio	1.39	to 1.0
Electricity Production (kWh, 30-year)	3,011,217	kWh
Percent of Electricity Usage Covered by Solar (Year	106.53%	

Note, values do not include social cost of carbon avoided by the solar array.

Recommended Site Priority:

Priority 1
(0-3 year)

Groundmounted City of Northfield, Memorial Field Pool, 801 7th St E, Northfield, MN

Report

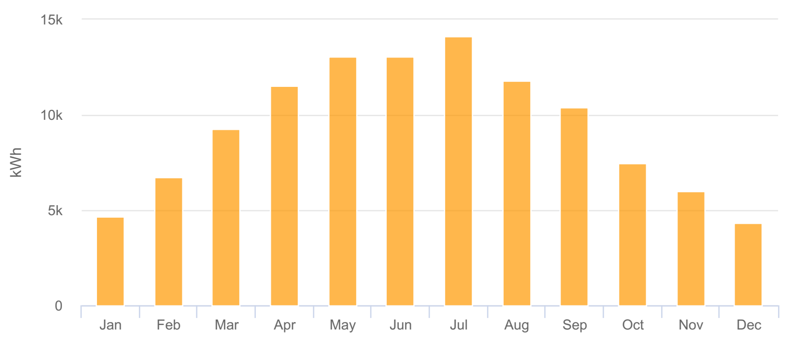
Project Name	City of Northfield, Memorial Field Pool
Project Address	801 7th St E, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

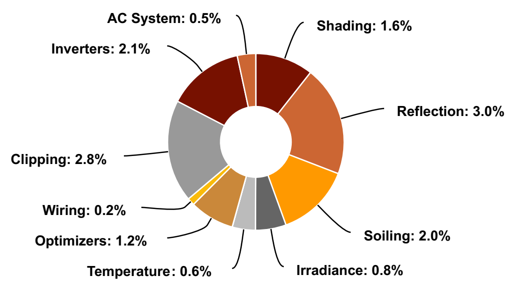
Design	Groundmounted
Module DC Nameplate	81.3 kW
Inverter AC Nameplate	66.6 kW Load Ratio: 1.22
Annual Production	112.5 MWh
Performance Ratio	86.7%
kWh/kWp	1,383.4
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	edef351a35-38368f3ee3-9050205824-c43eec09b7

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,595.7	14.4%
	Shaded Irradiance	1,570.8	-1.6%
	Irradiance after Reflection	1,524.1	-3.0%
	Irradiance after Soiling	1,493.6	-2.0%
	Total Collector Irradiance	**1,493.5**	**0.0%**
Energy (kWh)	Nameplate	122,184.1	
	Output at Irradiance Levels	121,177.7	-0.8%
	Output at Cell Temperature Derate	120,420.8	-0.6%
	Output After Mismatch	120,420.6	0.0%
	Optimizer Output	118,974.7	-1.2%
	Optimal DC Output	118,737.3	-0.2%
	Constrained DC Output	115,464.6	-2.8%
	Inverter Output	113,091.6	-2.1%
	Energy to Grid	**112,526.1**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.9 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
96M 490 (Heliene)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE33.3K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE33.3K (SolarEdge)	2 (66.6 kW)
Strings	10 AWG (Copper)	7 (596.9 ft)
Optimizers	P400 NA (SolarEdge)	166 (66.4 kW)
Module	Heliene, 96M 490 (490W)	166 (81.3 kW)

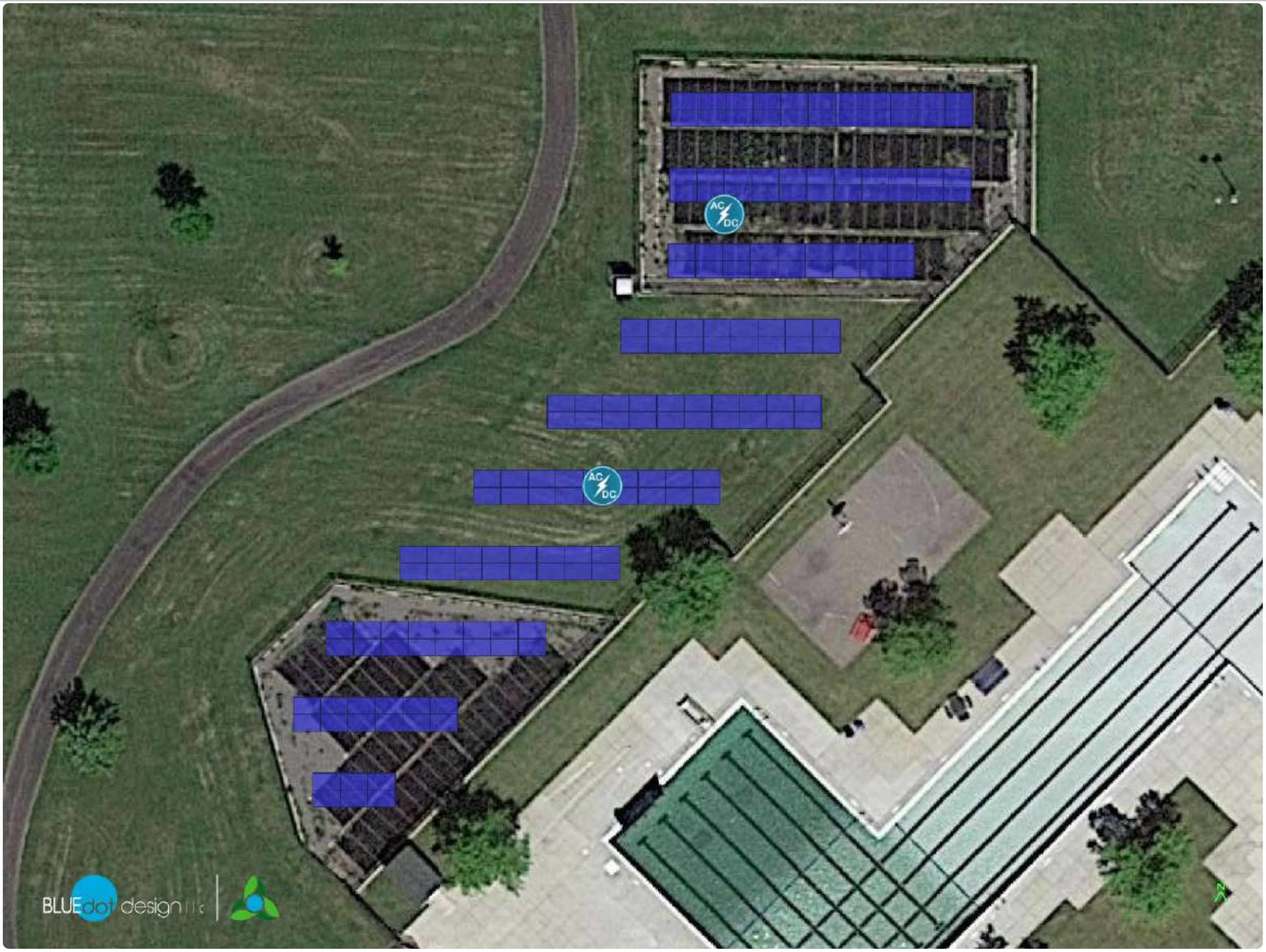
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	16-25	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	22°	180°	9.8 ft	2x1	83	166	81.3 kW

Detailed Layout



paleBLUEdot LLC

Owner Input & Results Worksheet

Project

Memorial Field Pool
801 7th St E
Groundmounted

Date
5/8/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
81.30	Array Size (kW DC)
490	Watt Rating
0	Number of Solar Modules (Roof)
166	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
66.60	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
112,500	First Year Generation (kWh)
$191,362.81	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$9,102.95	Owner Contingency (if any)
$200,465.76	Total Project Budget
$2.47	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$10,284	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
105,600	Total Annual Electric Use (kWh)
252.00	Total Annual Demand (kW)
0	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
N/A	Electric Use Intensity (kWh/SF)
N/A	EUI as % of National Average
$10,695.00	Annual Energy Charge ($)
$1,834.00	Annual Demand Charge ($)
$12,529.00	Total Annual Electric Cost
$0.1013	Effective Electric Rate ($/kWh)*
$7.28	Effective Demand Charge ($/kW)
21.00	Average Monthly Demand (kW)

Financial Information

$40,093.15	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$160,372.61	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	3,011,217	kWh
Total Electricity Bill Savings	$367,544	
Cash Purchase Payback		
Allowance for annual expenses and financing costs excluded		
Capital Cost	$200,466	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$200,466	
Simple Project Payback	16.36	Years
Financed Purchase Payback		
Allowance for annual expenses excluded. Financing costs included		
Financed Capital Cost	$228,151	
Financed Capital Payback	18.62	Years
Financed Array Lifetime Payback		
30 year allowance for annual expenses and financing costs included.		
30 year Operational Expense Allowance (ins/O+M)	$37,221	
Financed Array Lifetime Cost	$265,371	
Financed Array Lifetime Payback	21.66	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1221	
Project Cost Per Solar Per kWh	$0.0881	
Net Electricity Bill Savings Per kWh	$0.0339	
Value to Cost Ratio	1.39	to 1.0

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PROJ: Memorial Field Pool
LOC.: 801 7th St E
TITLE: Groundmounted

08-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**81.3**
Year 1 Generation Projection (MWH)	**112.5**
Annual Site Energy Use (MWH)	**105.6**
Assumed Energy Use During Solar Production Hours	**65%**

Energy Generation Schedule (Based on Predicted Loss)						**Potential Revenue Value**						**Simplified Cash Flow Projection**				
Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	112,500	kWh	100%	106.53%	$0.1013	$6,952	$1,834	$1,420	$0	$8,372	($58,899)	($325)	($341)	($51,194)	($51,194)
2	2022	111,600	kWh	99%	105.68%	$0.1038	$7,126	$1,880	$1,456	$0	$8,581	($18,806)	($332)	($348)	($10,905)	($62,098)
3	2023	110,707	kWh	98%	104.84%	$0.1064	$7,304	$1,927	$1,492	$0	$8,796	($18,806)	($338)	($355)	($10,704)	($72,802)
4	2024	109,822	kWh	98%	104.00%	$0.1091	$7,486	$1,975	$1,529	$0	$9,016	($18,806)	($345)	($362)	($10,498)	($83,300)
5	2025	108,943	kWh	97%	103.17%	$0.1118	$7,673	$2,024	$1,567	$0	$9,241	($18,806)	($352)	($370)	($10,286)	($93,586)
6	2026	108,071	kWh	96%	102.34%	$0.1146	$7,865	$2,075	$1,607	$0	$9,472	($18,806)	($359)	($377)	($10,070)	($103,656)
7	2027	107,207	kWh	95%	101.52%	$0.1175	$8,062	$2,127	$1,647	$0	$9,709	($18,806)	($366)	($385)	($9,848)	($113,504)
8	2028	106,349	kWh	95%	100.71%	$0.1204	$8,263	$2,180	$1,688	$0	$9,951	($18,806)	($374)	($392)	($9,620)	($123,124)
9	2029	105,498	kWh	94%	99.90%	$0.1234	$8,470	$2,235	$1,730	$0	$10,200	($18,806)	($381)	($400)	($9,387)	($132,511)
10	2030	104,654	kWh	93%	99.10%	$0.1265	$8,682	$2,290	$1,773	$0	$10,455	($18,806)	($389)	($408)	($9,147)	($141,658)
11	2031	103,817	kWh	92%	98.31%	$0.1296	$8,899	$2,348	$1,818		$10,717	$0	($396)	($416)	$9,904	($131,754)
12	2032	102,987	kWh	92%	97.53%	$0.1329	$9,121	$2,406	$1,863		$10,985	$0	($404)	($425)	$10,156	($121,598)
13	2033	102,163	kWh	91%	96.75%	$0.1362	$9,349	$2,467	$1,910		$11,259	$0	($412)	($433)	$10,414	($111,185)
14	2034	101,345	kWh	90%	95.97%	$0.1396	$9,583	$2,528	$1,958		$11,541	$0	($421)	($442)	$10,678	($100,507)
15	2035	100,535	kWh	89%	95.20%	$0.1431	$9,823	$2,591	$2,006		$11,829	$0	($429)	($451)	$10,949	($89,557)
16	2036	99,730	kWh	89%	94.44%	$0.1467	$10,068	$2,656	$2,057		$12,125	$0	($438)	($460)	$11,228	($78,330)
17	2037	98,933	kWh	88%	93.69%	$0.1503	$10,320	$2,723	$2,108		$12,428	$0	($446)	($469)	$11,513	($66,817)
18	2038	98,141	kWh	87%	92.94%	$0.1541	$10,578	$2,791	$2,161		$12,739	$0	($455)	($478)	$11,805	($55,012)
19	2039	97,356	kWh	87%	92.19%	$0.1580	$10,842	$2,860	$2,215		$13,057	$0	($464)	($488)	$12,105	($42,907)
20	2040	96,577	kWh	86%	91.46%	$0.1619	$11,113	$2,932	$2,270		$13,384	$0	($474)	($10,782)	$2,128	($40,779)
21	2041	95,805	kWh	85%	90.72%	$0.1660	$11,391	$3,005	$2,327		$13,718	$0	($483)	($497)	$12,737	($28,041)
22	2042	95,038	kWh	84%	90.00%	$0.1701	$11,676	$3,080	$2,385		$14,061	$0	($493)	($507)	$13,061	($14,980)
23	2043	94,278	kWh	84%	89.28%	$0.1744	$11,968	$3,157	$2,445		$14,413	$0	($503)	($518)	$13,392	($1,588)
24	2044	93,524	kWh	83%	88.56%	$0.1787	$12,267	$3,236	$2,506		$14,773	$0	($513)	($528)	$13,732	$12,144
25	2045	92,775	kWh	82%	87.86%	$0.1832	$12,574	$3,317	$2,568		$15,142	$0	($523)	($538)	$14,081	$26,225
26	2046	92,033	kWh	82%	87.15%	$0.1878	$12,888	$3,400	$2,633		$15,521	$0	($534)	($549)	$14,438	$40,663
27	2047	91,297	kWh	81%	86.46%	$0.1925	$13,210	$3,485	$2,698		$15,909	$0	($544)	($560)	$14,804	$55,468
28	2048	90,567	kWh	81%	85.76%	$0.1973	$13,541	$3,572	$2,766		$16,307	$0	($555)	($571)	$15,180	$70,648
29	2049	89,842	kWh	80%	85.08%	$0.2022	$13,879	$3,662	$2,835		$16,714	$0	($566)	($583)	$15,565	$86,213
30	2050	89,123	kWh	79%	84.40%	$0.2073	$14,226	$3,753	$2,906		$17,132	$0	($578)	($594)	$15,960	$102,173

Assumed Percentage of Demand Charge Reduction*: 77.43%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/
Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$200,466	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$27,685	
Operational Expense Allowance (insurance, O+M, 30-year)	$37,221	
Total Lifetime Project Costs	$265,371	

SAVINGS

Total Lifetime Project Savings	$367,544	

OUTCOMES

Net Lifetime Project Costs or Savings	$102,173	
Total Project Cost Payback (Years)	21.7	Years
Value to Cost Ratio	1.39	to 1.0
Electricity Production (kWh, 30-year)	3,011,217	kWh
Percent of Electricity Usage Covered by Solar (Year	106.53%	

Site Solar Feasibility Reports by Building

Ice Arena

Concept Design

The roof configuration of the Ice Arena building is moderately well suited for solar, with the west/southwest portion of the roof having good solar exposure and little roof obstructions.

The rooftop array is not capable of offsetting all of the electricity used on site. The rooftop array's first year generation is estimated to offset approximately 50% of the site's current reported electricity consumption. To meet the site's full annual use an additional array is required. The site area has insufficient space for an effective ground mounted array, however, "Carport" arrays (array structured over parking lot sections) are possible and capable of meeting 53% more of the site's annual electric use. The combined arrays included in this concept can provide an estimated 103% of the site's total electric use, making the site Net Zero electricity.

Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Note, values do not include social cost of carbon avoided by the solar array.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.22:1 ratio (1.56 for rooftop, 1.01 for ground). As such, this array may provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.025 more than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING (Rooftop Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$481,417	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$66,485	
Operational Expense Allowance (insurance, O+M, 30-year)	$104,016	
Total Lifetime Project Costs	$651,918	
SAVINGS		
Total Lifetime Project Savings	$1,016,434	
OUTCOMES		
Net Lifetime Project Costs or Savings	$364,516	
Total Project Cost Payback (Years)	19.2	Years
Value to Cost Ratio	1.56	to 1.0
Electricity Production (kWh, 30-year)	7,885,374	kWh
Percent of Electricity Usage Covered by Solar (Year	50.61%	

COSTS AND FINANCING (Ground Mounted Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$829,015	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$114,489	
Operational Expense Allowance (insurance, O+M, 30-year)	$107,679	
Total Lifetime Project Costs	$1,051,183	
SAVINGS		
Total Lifetime Project Savings	$1,061,650	
OUTCOMES		
Net Lifetime Project Costs or Savings	$10,467	
Total Project Cost Payback (Years)	29.7	Years
Value to Cost Ratio	1.01	to 1.0
Electricity Production (kWh, 30-year)	8,324,342	kWh
Percent of Electricity Usage Covered by Solar (Year	53.43%	

Recommended Site Priority:

Priority 3
(Not Recommended)

Design 1 City of Northfield, Ice Arena, 1280 Bollenbacher Drive, Northfield, MN

Report

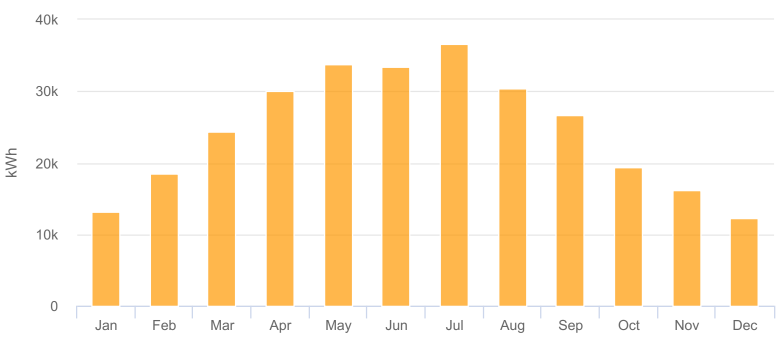
Project Name	City of Northfield, Ice Arena
Project Address	1280 Bollenbacher Drive, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

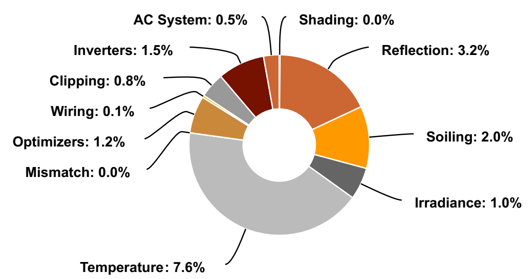
Design	Design 1
Module DC Nameplate	227.2 kW
Inverter AC Nameplate	180.0 kW Load Ratio: 1.26
Annual Production	294.6 MWh
Performance Ratio	83.2%
kWh/kWp	1,297.2
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,559.5	11.8%
	Shaded Irradiance	1,559.0	0.0%
	Irradiance after Reflection	1,509.1	-3.2%
	Irradiance after Soiling	1,478.9	-2.0%
	Total Collector Irradiance	**1,478.9**	**0.0%**
Energy (kWh)	Nameplate	335,632.0	
	Output at Irradiance Levels	332,187.7	-1.0%
	Output at Cell Temperature Derate	307,019.0	-7.6%
	Output After Mismatch	307,018.7	0.0%
	Optimizer Output	303,334.2	-1.2%
	Optimal DC Output	303,109.0	-0.1%
	Constrained DC Output	300,665.3	-0.8%
	Inverter Output	296,129.0	-1.5%
	Energy to Grid	**294,648.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		24.7 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE30KUS (SolarEdge)	Folsom Labs	Spec Sheet

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Components

Component	Name	Count
Inverters	SE30KUS (SolarEdge)	6 (180.0 kW)
Strings	10 AWG (Copper)	17 (2,440.9 ft)
Optimizers	P400 NA (SolarEdge)	649 (259.6 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	649 (227.2 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	18-39	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	28°	220.878°	0.0 ft	1x1	649	649	227.2 kW

Detailed Layout

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Owner Input & Results Worksheet

Project

Ice Arena
1280 Bollenbacher Drive
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array
(from solar bid)

2021	First Year of Operation
227.20	Array Size (kW DC)
350	Watt Rating
649	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
180.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
294,600	First Year Generation (kWh)
$457,433.59	Total Contractor Bid
$2,500.00	Other Owner Expenses (legal, etc.)
$21,483.51	Owner Contingency (if any)
$481,417.10	Total Project Budget
$2.12	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance
(from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$28,741	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use
(all meters)

Xcel Energy	Electric Utility
582,055	Total Annual Electric Use (kWh)
1,908.00	Total Annual Demand (kW)
30,000	Building Area (Square Feet)
50.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
19.40	Electric Use Intensity (kWh/SF)
194%	EUI as % of National Average
$39,192.53	Annual Energy Charge ($)
$20,016.00	Annual Demand Charge ($)
$59,208.53	Total Annual Electric Cost
$0.0673	Effective Electric Rate ($/kWh)*
$10.49	Effective Demand Charge ($/kW)
159.00	Average Monthly Demand (kW)

Financial Information

$96,283.42	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$385,133.68	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	7,885,374	kWh
Total Electricity Bill Savings	$1,016,434	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$481,417	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$481,417	
Simple Project Payback	14.21	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$547,902	
Financed Capital Payback	16.17	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$104,016	
Financed Array Lifetime Cost	$651,918	
Financed Array Lifetime Payback	19.24	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1289	
Project Cost Per Solar Per kWh	$0.0827	
Net Electricity Bill Savings Per kWh	$0.0462	
Value to Cost Ratio	1.56	to 1.0

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PROJ: **Ice Arena**
LOC.: **1280 Bollenbacher Drive**
TITLE: **Rooftop**

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**227.2**
Year 1 Generation Projection (MWH)	**294.6**
Annual Site Energy Use (MWH)	**582.1**
Assumed Energy Use During Solar Production Hours	**50%**

Energy Generation Schedule (Based on Predicted Loss) | **Potential Revenue Value** | **Simplified Cash Flow Projection**

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	294,600	kWh	100%	50.61%	$0.0673	$19,596	$20,016	$5,720	$0	$25,317	($141,445)	($909)	($954)	($117,992)	($117,992)
2	2022	292,243	kWh	99%	50.21%	$0.0690	$20,086	$20,516	$5,863	$0	$25,949	($45,162)	($927)	($973)	($21,113)	($139,104)
3	2023	289,905	kWh	98%	49.81%	$0.0707	$20,509	$21,029	$6,010	$0	$26,519	($45,162)	($946)	($993)	($20,581)	($159,686)
4	2024	287,586	kWh	98%	49.41%	$0.0725	$20,853	$21,555	$6,160	$0	$27,014	($45,162)	($964)	($1,013)	($20,125)	($179,811)
5	2025	285,285	kWh	97%	49.01%	$0.0743	$21,204	$22,094	$6,314	$0	$27,518	($45,162)	($984)	($1,033)	($19,661)	($199,472)
6	2026	283,003	kWh	96%	48.62%	$0.0762	$21,560	$22,646	$6,472	$0	$28,032	($45,162)	($1,003)	($1,054)	($19,187)	($218,658)
7	2027	280,739	kWh	95%	48.23%	$0.0781	$21,922	$23,212	$6,634	$0	$28,556	($45,162)	($1,023)	($1,075)	($18,704)	($237,362)
8	2028	278,493	kWh	95%	47.85%	$0.0800	$22,291	$23,793	$6,800	$0	$29,090	($45,162)	($1,044)	($1,096)	($18,212)	($255,574)
9	2029	276,265	kWh	94%	47.46%	$0.0820	$22,665	$24,388	$6,970	$0	$29,635	($45,162)	($1,065)	($1,118)	($17,710)	($273,284)
10	2030	274,055	kWh	93%	47.08%	$0.0841	$23,046	$24,997	$7,144	$0	$30,190	($45,162)	($1,086)	($1,140)	($17,199)	($290,483)
11	2031	271,863	kWh	92%	46.71%	$0.0862	$23,433	$25,622	$7,322		$30,755	$0	($1,108)	($1,163)	$28,484	($261,998)
12	2032	269,688	kWh	92%	46.33%	$0.0883	$23,827	$26,263	$7,506		$31,332	$0	($1,130)	($1,186)	$29,016	($232,983)
13	2033	267,530	kWh	91%	45.96%	$0.0906	$24,227	$26,919	$7,693		$31,920	$0	($1,153)	($1,210)	$29,557	($203,425)
14	2034	265,390	kWh	90%	45.60%	$0.0928	$24,634	$27,592	$7,885		$32,519	$0	($1,176)	($1,234)	$30,109	($173,316)
15	2035	263,267	kWh	89%	45.23%	$0.0951	$25,048	$28,282	$8,083		$33,130	$0	($1,199)	($1,259)	$30,672	($142,644)
16	2036	261,161	kWh	89%	44.87%	$0.0975	$25,469	$28,989	$8,285		$33,753	$0	($1,223)	($1,284)	$31,246	($111,398)
17	2037	259,071	kWh	88%	44.51%	$0.1000	$25,896	$29,714	$8,492		$34,388	$0	($1,248)	($1,310)	$31,831	($79,567)
18	2038	256,999	kWh	87%	44.15%	$0.1025	$26,332	$30,457	$8,704		$35,036	$0	($1,273)	($1,336)	$32,427	($47,140)
19	2039	254,943	kWh	87%	43.80%	$0.1050	$26,774	$31,218	$8,922		$35,696	$0	($1,298)	($1,363)	$33,035	($14,106)
20	2040	252,903	kWh	86%	43.45%	$0.1076	$27,224	$31,999	$9,145		$36,368	$0	($1,324)	($30,131)	$4,914	($9,192)
21	2041	250,880	kWh	85%	43.10%	$0.1103	$27,681	$32,799	$9,373		$37,054	$0	($1,350)	($1,390)	$34,314	$25,122
22	2042	248,873	kWh	84%	42.76%	$0.1131	$28,146	$33,619	$9,608		$37,754	$0	($1,377)	($1,418)	$34,958	$60,080
23	2043	246,882	kWh	84%	42.42%	$0.1159	$28,619	$34,459	$9,848		$38,467	$0	($1,405)	($1,446)	$35,616	$95,696
24	2044	244,907	kWh	83%	42.08%	$0.1188	$29,100	$35,320	$10,094		$39,194	$0	($1,433)	($1,475)	$36,286	$131,981
25	2045	242,948	kWh	82%	41.74%	$0.1218	$29,589	$36,203	$10,346		$39,935	$0	($1,462)	($1,505)	$36,969	$168,950
26	2046	241,004	kWh	82%	41.41%	$0.1248	$30,086	$37,109	$10,605		$40,691	$0	($1,491)	($1,535)	$37,665	$206,615
27	2047	239,076	kWh	81%	41.07%	$0.1280	$30,591	$38,036	$10,870		$41,461	$0	($1,521)	($1,566)	$38,375	$244,990
28	2048	237,164	kWh	81%	40.75%	$0.1312	$31,105	$38,987	$11,142		$42,247	$0	($1,551)	($1,597)	$39,099	$284,089
29	2049	235,266	kWh	80%	40.42%	$0.1344	$31,628	$39,962	$11,421		$43,048	$0	($1,582)	($1,629)	$39,837	$323,926
30	2050	233,384	kWh	79%	40.10%	$0.1378	$32,159	$40,961	$11,706		$43,865	$0	($1,614)	($1,661)	$40,590	$364,516

Assumed Percentage of Demand
Charge Reduction*: 28.58%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$481,417	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$66,485	
Operational Expense Allowance (insurance, O+M, 30-year)	$104,016	
Total Lifetime Project Costs	$651,918	

SAVINGS

Total Lifetime Project Savings	$1,016,434	

OUTCOMES

Net Lifetime Project Costs or Savings	$364,516	
Total Project Cost Payback (Years)	19.2	Years
Value to Cost Ratio	1.56	to 1.0
Electricity Production (kWh, 30-year)	7,885,374	kWh
Percent of Electricity Usage Covered by Solar (Year	50.61%	

Carport City of Northfield, Ice Arena, 1280 Bollenbacher Drive, Northfield, MN

Report

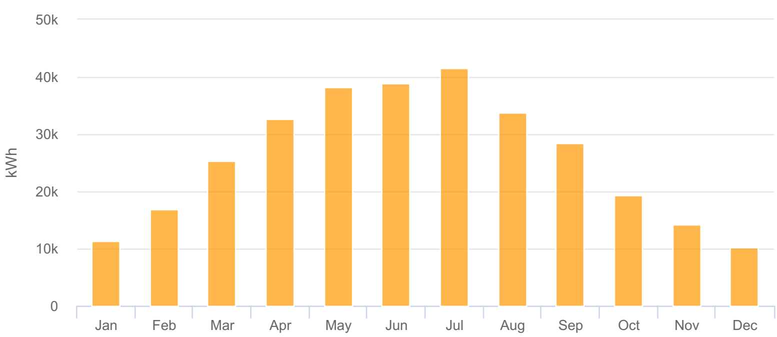
Project Name	City of Northfield, Ice Arena
Project Address	1280 Bollenbacher Drive, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

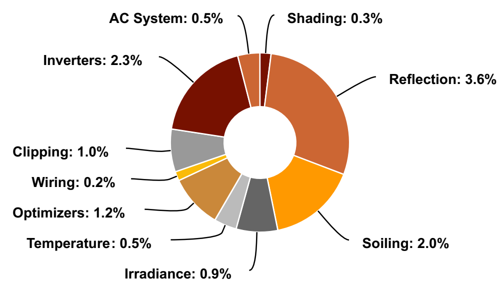
Design	Carport
Module DC Nameplate	235.2 kW
Inverter AC Nameplate	187.0 kW Load Ratio: 1.26
Annual Production	311.0 MWh
Performance Ratio	88.7%
kWh/kWp	1,322.2
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	edef351a35-38368f3ee3-9050205824-c43eec09b7

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,491.4	7.0%
	Shaded Irradiance	1,487.7	-0.3%
	Irradiance after Reflection	1,434.2	-3.6%
	Irradiance after Soiling	1,405.5	-2.0%
	Total Collector Irradiance	**1,405.5**	**0.0%**
Energy (kWh)	Nameplate	332,505.3	
	Output at Irradiance Levels	329,392.8	-0.9%
	Output at Cell Temperature Derate	327,708.0	-0.5%
	Output After Mismatch	327,707.9	0.0%
	Optimizer Output	323,759.1	-1.2%
	Optimal DC Output	323,077.9	-0.2%
	Constrained DC Output	319,964.6	-1.0%
	Inverter Output	312,537.0	-2.3%
	Energy to Grid	**310,975.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.6 °C
Simulation Metrics			
		Operating Hours	4673
		Solved Hours	4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
96M 490 (Heliene)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE17K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE17K (SolarEdge)	11 (187.0 kW)
Strings	10 AWG (Copper)	22 (2,789.3 ft)
Optimizers	P400 NA (SolarEdge)	480 (192.0 kW)
Module	Heliene, 96M 490 (490W)	480 (235.2 kW)

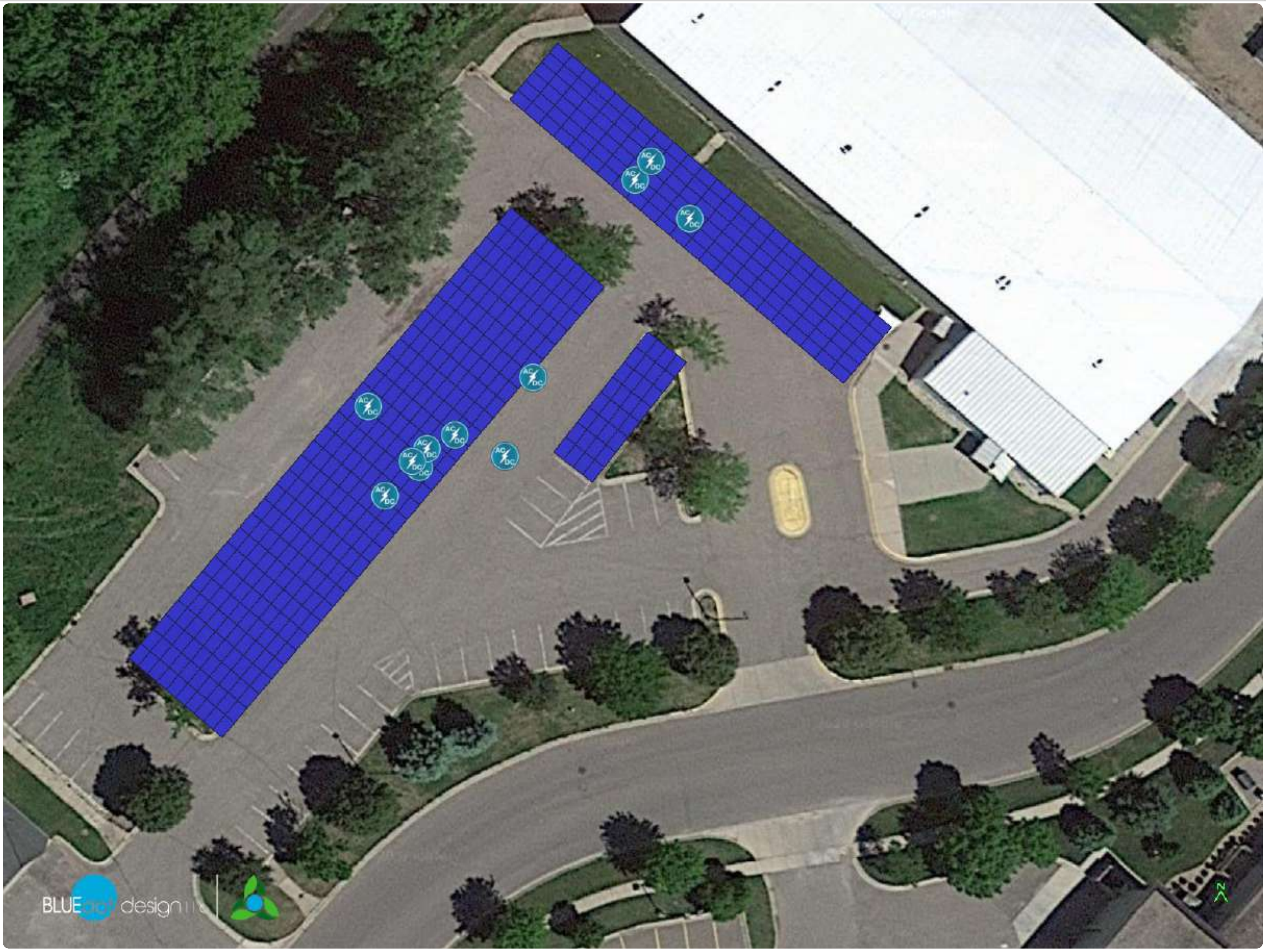
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	15-22	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Carport	Landscape (Horizontal)	15°	220.396°	0.0 ft	1x1	138	138	67.6 kW
Field Segment 2	Carport	Landscape (Horizontal)	15°	130.327°	0.0 ft	1x1	310	310	151.9 kW
Field Segment 3	Carport	Landscape (Horizontal)	15°	128.032°	0.0 ft	1x1	32	32	15.7 kW

Detailed Layout



paleBLUEdot LLC

Owner Input & Results Worksheet

Project

Ice Arena
1280 Bollenbacher Drive
Carport

Date
5/8/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
235.20	Array Size (kW DC)
490	Watt Rating
0	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
480	Number of Solar Modules (Carport)
187.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
311,000	First Year Generation (kWh)
$788,221.84	Total Contractor Bid
$2,500.00	Other Owner Expenses (legal, etc.)
$38,293.34	Owner Contingency (if any)
$829,015.18	Total Project Budget
$3.52	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$29,753	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
582,055	Total Annual Electric Use (kWh)
1,908.00	Total Annual Demand (kW)
30,000	Building Area (Square Feet)
50.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
19.40	Electric Use Intensity (kWh/SF)
194%	EUI as % of National Average
$39,192.53	Annual Energy Charge ($)
$20,016.00	Annual Demand Charge ($)
$59,208.53	Total Annual Electric Cost
$0.0673	Effective Electric Rate ($/kWh)*
$10.49	Effective Demand Charge ($/kW)
159.00	Average Monthly Demand (kW)

Financial Information

$165,803.04	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$663,212.15	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	8,324,342	kWh
Total Electricity Bill Savings	$1,061,650	
Cash Purchase Payback		
Allowance for annual expenses and financing costs excluded		
Capital Cost	$829,015	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$829,015	
Simple Project Payback	23.43	Years
Financed Purchase Payback		
Allowance for annual expenses excluded. Financing costs included		
Financed Capital Cost	$943,504	
Financed Capital Payback	26.66	Years
Financed Array Lifetime Payback		
30 year allowance for annual expenses and financing costs included.		
30 year Operational Expense Allowance (ins/O+M)	$107,679	
Financed Array Lifetime Cost	$1,051,183	
Financed Array Lifetime Payback	29.70	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1275	
Project Cost Per Solar Per kWh	$0.1263	
Net Electricity Bill Savings Per kWh	$0.0013	
Value to Cost Ratio	1.01	to 1.0

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PROJ: Ice Arena
LOC.: 1280 Bollenbacher Drive
TITLE: Carport

08-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**235.2**
Year 1 Generation Projection (MWH)	**311.0**
Annual Site Energy Use (MWH)	**582.1**
Assumed Energy Use During Solar Production Hours	**50%**

Energy Generation Schedule (Based on Predicted Loss) / Potential Revenue Value / Simplified Cash Flow Projection

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	311,000	kWh	100%	53.43%	$0.0673	$19,596	$20,016	$5,922	$0	$25,518	($243,573)	($941)	($988)	($219,984)	($219,984)
2	2022	308,512	kWh	99%	53.00%	$0.0690	$20,086	$20,516	$6,070	$0	$26,156	($77,770)	($960)	($1,008)	($53,581)	($273,565)
3	2023	306,044	kWh	98%	52.58%	$0.0707	$20,588	$21,029	$6,222	$0	$26,810	($77,770)	($979)	($1,028)	($52,967)	($326,532)
4	2024	303,596	kWh	98%	52.16%	$0.0725	$21,103	$21,555	$6,377	$0	$27,480	($77,770)	($998)	($1,048)	($52,337)	($378,869)
5	2025	301,167	kWh	97%	51.74%	$0.0743	$21,631	$22,094	$6,536	$0	$28,167	($77,770)	($1,018)	($1,069)	($51,691)	($430,560)
6	2026	298,757	kWh	96%	51.33%	$0.0762	$22,171	$22,646	$6,700	$0	$28,871	($77,770)	($1,039)	($1,091)	($51,028)	($481,588)
7	2027	296,367	kWh	95%	50.92%	$0.0781	$22,726	$23,212	$6,867	$0	$29,593	($77,770)	($1,059)	($1,112)	($50,349)	($531,937)
8	2028	293,996	kWh	95%	50.51%	$0.0800	$23,294	$23,793	$7,039	$0	$30,333	($77,770)	($1,081)	($1,135)	($49,653)	($581,590)
9	2029	291,644	kWh	94%	50.11%	$0.0820	$23,876	$24,388	$7,215	$0	$31,091	($77,770)	($1,102)	($1,157)	($48,939)	($630,528)
10	2030	289,311	kWh	93%	49.71%	$0.0841	$24,329	$24,997	$7,395	$0	$31,724	($77,770)	($1,124)	($1,181)	($48,351)	($678,879)
11	2031	286,997	kWh	92%	49.31%	$0.0862	$24,737	$25,622	$7,580		$32,318	$0	($1,147)	($1,204)	$29,967	($648,912)
12	2032	284,701	kWh	92%	48.91%	$0.0883	$25,153	$26,263	$7,770		$32,923	$0	($1,170)	($1,228)	$30,525	($618,388)
13	2033	282,423	kWh	91%	48.52%	$0.0906	$25,576	$26,919	$7,964		$33,540	$0	($1,193)	($1,253)	$31,094	($587,294)
14	2034	280,164	kWh	90%	48.13%	$0.0928	$26,005	$27,592	$8,163		$34,168	$0	($1,217)	($1,278)	$31,674	($555,620)
15	2035	277,923	kWh	89%	47.75%	$0.0951	$26,442	$28,282	$8,367		$34,809	$0	($1,241)	($1,303)	$32,265	($523,356)
16	2036	275,699	kWh	89%	47.37%	$0.0975	$26,886	$28,989	$8,576		$35,463	$0	($1,266)	($1,330)	$32,867	($490,489)
17	2037	273,494	kWh	88%	46.99%	$0.1000	$27,338	$29,714	$8,791		$36,129	$0	($1,292)	($1,356)	$33,481	($457,007)
18	2038	271,306	kWh	87%	46.61%	$0.1025	$27,797	$30,457	$9,011		$36,808	$0	($1,317)	($1,383)	$34,107	($422,900)
19	2039	269,135	kWh	87%	46.24%	$0.1050	$28,264	$31,218	$9,236		$37,500	$0	($1,344)	($1,411)	$34,746	($388,154)
20	2040	266,982	kWh	86%	45.87%	$0.1076	$28,739	$31,999	$9,467		$38,206	$0	($1,371)	($31,192)	$5,643	($382,511)
21	2041	264,846	kWh	85%	45.50%	$0.1103	$29,222	$32,799	$9,703		$38,925	$0	($1,398)	($1,439)	$36,088	($346,422)
22	2042	262,727	kWh	84%	45.14%	$0.1131	$29,713	$33,619	$9,946		$39,659	$0	($1,426)	($1,468)	$36,765	($309,657)
23	2043	260,626	kWh	84%	44.78%	$0.1159	$30,212	$34,459	$10,195		$40,407	$0	($1,454)	($1,497)	$37,455	($272,202)
24	2044	258,541	kWh	83%	44.42%	$0.1188	$30,720	$35,320	$10,450		$41,169	$0	($1,484)	($1,527)	$38,158	($234,044)
25	2045	256,472	kWh	82%	44.06%	$0.1218	$31,236	$36,203	$10,711		$41,947	$0	($1,513)	($1,558)	$38,876	($195,168)
26	2046	254,421	kWh	82%	43.71%	$0.1248	$31,761	$37,109	$10,979		$42,739	$0	($1,543)	($1,589)	$39,607	($155,561)
27	2047	252,385	kWh	81%	43.36%	$0.1280	$32,294	$38,036	$11,253		$43,547	$0	($1,574)	($1,621)	$40,352	($115,209)
28	2048	250,366	kWh	81%	43.01%	$0.1312	$32,837	$38,987	$11,534		$44,371	$0	($1,606)	($1,653)	$41,112	($74,097)
29	2049	248,363	kWh	80%	42.67%	$0.1344	$33,388	$39,962	$11,823		$45,211	$0	($1,638)	($1,686)	$41,887	($32,210)
30	2050	246,376	kWh	79%	42.33%	$0.1378	$33,949	$40,961	$12,118		$46,067	$0	($1,671)	($1,720)	$42,677	$10,467

Assumed Percentage of Demand
Charge Reduction*: 29.58%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$829,015	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$114,489	
Operational Expense Allowance (insurance, O+M, 30-year)	$107,679	
Total Lifetime Project Costs	$1,051,183	

SAVINGS

Total Lifetime Project Savings	$1,061,650	

OUTCOMES

Net Lifetime Project Costs or Savings	$10,467	
Total Project Cost Payback (Years)	29.7	Years
Value to Cost Ratio	1.01	to 1.0
Electricity Production (kWh, 30-year)	8,324,342	kWh
Percent of Electricity Usage Covered by Solar (Year	53.43%	

Site Solar Feasibility Reports by Building

Maintenance building

Concept Design

The roof configuration of the primary Maintenance building site is well suited for solar PV installation, with good orientation, overall configuration, and moderate rooftop equipment obstruction.

The rooftop arrays supported by the available roof area is capable of offsetting all of the electricity used on site, with a first year generation of over 113% of the site's annual electric use making the site a Net Zero electricity site.

Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.14:1 ratio. As such, this array may provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at the same cost as achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING		
Total Installed Array Cost (incl. contingency, other owner expenses)	$128,295	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$17,718	
Operational Expense Allowance (insurance, O+M, 30-year)	$25,575	
Total Lifetime Project Costs	$171,589	
SAVINGS		
Total Lifetime Project Savings	$195,505	
OUTCOMES		
Net Lifetime Project Costs or Savings	$23,917	
Total Project Cost Payback (Years)	26.3	Years
Value to Cost Ratio	1.14	to 1.0
Electricity Production (kWh, 30-year)	1,991,151	kWh
Percent of Electricity Usage Covered by Solar (Year	113.48%	

Note, values do not include social cost of carbon avoided by the solar array.

Recommended Site Priority:

Priority 2
(3-6 year)

Design 1 City of Northfield Maintenance Facility, 1710 Riverview Dr, Northfield, MN

Report

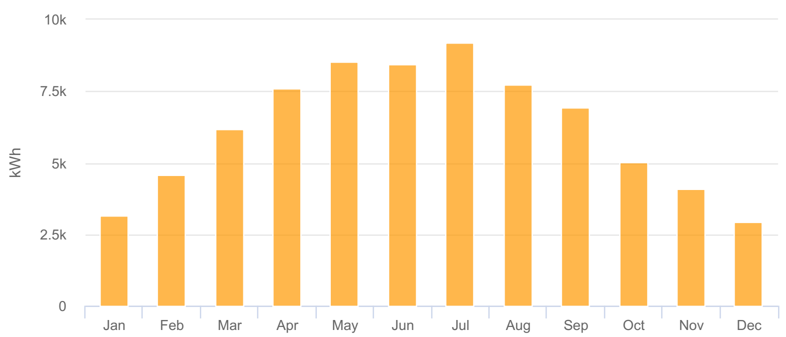
Project Name	City of Northfield Maintenance Facility
Project Address	1710 Riverview Dr, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

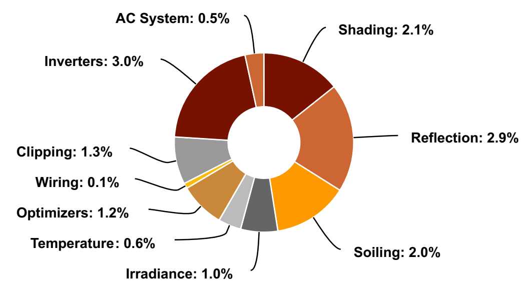
Design	Design 1
Module DC Nameplate	53.6 kW
Inverter AC Nameplate	43.2 kW Load Ratio: 1.24
Annual Production	74.39 MWh
Performance Ratio	86.1%
kWh/kWp	1,389.2
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,613.7	15.7%
	Shaded Irradiance	1,579.7	-2.1%
	Irradiance after Reflection	1,534.0	-2.9%
	Irradiance after Soiling	1,503.3	-2.0%
	Total Collector Irradiance	**1,503.3**	**0.0%**
Energy (kWh)	Nameplate	80,425.9	
	Output at Irradiance Levels	79,633.3	-1.0%
	Output at Cell Temperature Derate	79,149.6	-0.6%
	Output After Mismatch	79,149.5	0.0%
	Optimizer Output	78,199.2	-1.2%
	Optimal DC Output	78,089.4	-0.1%
	Constrained DC Output	77,103.9	-1.3%
	Inverter Output	74,764.8	-3.0%
	Energy to Grid	**74,390.9**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		17.0 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model
Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE14.4KUS (SolarEdge)	Folsom Labs	CEC

Components

Component	Name	Count
Inverters	SE14.4KUS (SolarEdge)	3 (43.2 kW)
Strings	10 AWG (Copper)	9 (591.6 ft)
Optimizers	P400 NA (SolarEdge)	153 (61.2 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	153 (53.6 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	9-17	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	180°	4.3 ft	1x1	153	153	53.6 kW

Detailed Layout

Owner Input & Results Worksheet

Project

Maintenance Facility
1710 Riverview Dr
Rooftop

Date
5/8/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
53.60	Array Size (kW DC)
350	Watt Rating
153	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
43.20	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
74,390	First Year Generation (kWh)
$122,528.95	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$5,766.36	Owner Contingency (if any)
$128,295.31	Total Project Budget
$2.39	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$7,817	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
65,553	Total Annual Electric Use (kWh)
252.00	Total Annual Demand (kW)
24,960	Building Area (Square Feet)
65.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
2.63	Electric Use Intensity (kWh/SF)
26%	EUI as % of National Average
$4,768.26	Annual Energy Charge ($)
$2,652.00	Annual Demand Charge ($)
$7,420.26	Total Annual Electric Cost
$0.0727	Effective Electric Rate ($/kWh)*
$10.52	Effective Demand Charge ($/kW)
21.00	Average Monthly Demand (kW)

Financial Information

$25,659.06	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$102,636.25	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	1,991,151	kWh
Total Electricity Bill Savings	$195,505	

Cash Purchase Payback

Allowance for annual expenses and financing costs excluded

Capital Cost	$128,295	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$128,295	
Simple Project Payback	19.69	Years

Financed Purchase Payback

Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$146,013	
Financed Capital Payback	22.41	Years

Financed Array Lifetime Payback

30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$25,575	
Financed Array Lifetime Cost	$171,589	
Financed Array Lifetime Payback	26.33	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.0982	
Project Cost Per Solar Per kWh	$0.0862	
Net Electricity Bill Savings Per kWh	$0.0120	
Value to Cost Ratio	1.14	to 1.0

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PROJ: Maintenance Facility
LOC.: 1710 Riverview Dr
TITLE: Rooftop

08-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	53.6
Year 1 Generation Projection (MWH)	74.4
Annual Site Energy Use (MWH)	65.6
Assumed Energy Use During Solar Production Hours	65%

Energy Generation Schedule (Based on Predicted Loss)						Potential Revenue Value						Simplified Cash Flow Projection				
Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	74,390	kWh	100%	113.48%	$0.0727	$3,099	$2,652	$1,354	$0	$4,453	($37,694)	($214)	($225)	($33,681)	($33,681)
2	2022	73,795	kWh	99%	112.57%	$0.0746	$3,177	$2,718	$1,388	$0	$4,564	($12,035)	($219)	($230)	($7,919)	($41,600)
3	2023	73,205	kWh	98%	111.67%	$0.0764	$3,256	$2,786	$1,422	$0	$4,679	($12,035)	($223)	($234)	($7,814)	($49,414)
4	2024	72,619	kWh	98%	110.78%	$0.0783	$3,338	$2,856	$1,458	$0	$4,796	($12,035)	($228)	($239)	($7,706)	($57,120)
5	2025	72,038	kWh	97%	109.89%	$0.0803	$3,421	$2,927	$1,494	$0	$4,915	($12,035)	($232)	($244)	($7,596)	($64,716)
6	2026	71,462	kWh	96%	109.01%	$0.0823	$3,507	$3,000	$1,532	$0	$5,038	($12,035)	($237)	($249)	($7,482)	($72,199)
7	2027	70,890	kWh	95%	108.14%	$0.0844	$3,594	$3,076	$1,570	$0	$5,164	($12,035)	($241)	($254)	($7,366)	($79,565)
8	2028	70,323	kWh	95%	107.28%	$0.0865	$3,684	$3,152	$1,609	$0	$5,293	($12,035)	($246)	($259)	($7,247)	($86,812)
9	2029	69,760	kWh	94%	106.42%	$0.0886	$3,776	$3,231	$1,649	$0	$5,426	($12,035)	($251)	($264)	($7,125)	($93,936)
10	2030	69,202	kWh	93%	105.57%	$0.0908	$3,871	$3,312	$1,691	$0	$5,561	($12,035)	($256)	($269)	($6,999)	($100,935)
11	2031	68,649	kWh	92%	104.72%	$0.0931	$3,967	$3,395	$1,733		$5,700	$0	($261)	($274)	$5,165	($95,771)
12	2032	68,099	kWh	92%	103.88%	$0.0954	$4,067	$3,480	$1,776		$5,843	$0	($267)	($280)	$5,296	($90,474)
13	2033	67,555	kWh	91%	103.05%	$0.0978	$4,168	$3,567	$1,821		$5,989	$0	($272)	($286)	$5,432	($85,043)
14	2034	67,014	kWh	90%	102.23%	$0.1003	$4,273	$3,656	$1,866		$6,139	$0	($277)	($291)	$5,570	($79,473)
15	2035	66,478	kWh	89%	101.41%	$0.1028	$4,379	$3,747	$1,913		$6,292	$0	($283)	($297)	$5,712	($73,760)
16	2036	65,946	kWh	89%	100.60%	$0.1053	$4,489	$3,841	$1,961		$6,449	$0	($289)	($303)	$5,858	($67,902)
17	2037	65,419	kWh	88%	99.79%	$0.1080	$4,601	$3,937	$2,010		$6,611	$0	($294)	($309)	$6,007	($61,895)
18	2038	64,895	kWh	87%	99.00%	$0.1107	$4,716	$4,035	$2,060		$6,776	$0	($300)	($315)	$6,161	($55,735)
19	2039	64,376	kWh	87%	98.20%	$0.1134	$4,834	$4,136	$2,111		$6,945	$0	($306)	($322)	$6,318	($49,417)
20	2040	63,861	kWh	86%	97.42%	$0.1163	$4,955	$4,240	$2,164		$7,119	$0	($312)	($8,145)	($1,338)	($50,755)
21	2041	63,350	kWh	85%	96.64%	$0.1192	$5,079	$4,346	$2,218		$7,297	$0	($319)	($328)	$6,650	($44,104)
22	2042	62,843	kWh	84%	95.87%	$0.1222	$5,206	$4,454	$2,274		$7,479	$0	($325)	($335)	$6,820	($37,285)
23	2043	62,341	kWh	84%	95.10%	$0.1252	$5,336	$4,566	$2,331		$7,666	$0	($331)	($341)	$6,994	($30,291)
24	2044	61,842	kWh	83%	94.34%	$0.1284	$5,469	$4,680	$2,389		$7,858	$0	($338)	($348)	$7,172	($23,119)
25	2045	61,347	kWh	82%	93.58%	$0.1316	$5,606	$4,797	$2,449		$8,055	$0	($345)	($355)	$7,355	($15,764)
26	2046	60,856	kWh	82%	92.84%	$0.1349	$5,746	$4,917	$2,510		$8,256	$0	($352)	($362)	$7,542	($8,222)
27	2047	60,370	kWh	81%	92.09%	$0.1382	$5,890	$5,040	$2,573		$8,462	$0	($359)	($369)	$7,734	($488)
28	2048	59,887	kWh	81%	91.36%	$0.1417	$6,037	$5,166	$2,637		$8,674	$0	($366)	($377)	$7,931	$7,443
29	2049	59,408	kWh	80%	90.63%	$0.1452	$6,188	$5,295	$2,703		$8,891	$0	($373)	($384)	$8,133	$15,576
30	2050	58,932	kWh	79%	89.90%	$0.1489	$6,343	$5,427	$2,770		$9,113	$0	($381)	($392)	$8,340	$23,917

Assumed Percentage of Demand
Charge Reduction*: 51.05%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$128,295
Grants, Rebates, No-Obligation Funds	$0
Total Interest Payments	$17,718
Operational Expense Allowance (insurance, O+M, 30-year)	$25,575
Total Lifetime Project Costs	$171,589

SAVINGS

Total Lifetime Project Savings	$195,505

OUTCOMES

Net Lifetime Project Costs or Savings	$23,917	
Total Project Cost Payback (Years)	26.3	Years
Value to Cost Ratio	1.14	to 1.0
Electricity Production (kWh, 30-year)	1,991,151	kWh
Percent of Electricity Usage Covered by Solar (Year	113.48%	

Site Solar Feasibility Reports by Building

Liquor Store

Concept Design

The roof configuration of the City Hall building is moderately suited for solar PV installation, with good orientation, and configuration, however the building has moderately significant obstructions due to rooftop equipment.

The concept explored in this option is a rooftop solar array meeting the program requirements for the Xcel Energy Solar Rewards program. The Solar Rewards program incentivizes solar installations, first by attributing all energy generated by the solar array to the building's energy consumption on a one-to-one basis (as would occur in a traditional Net Metering interconnection). Secondly, the Solar Rewards program pays the site owner an additional $0.06 per kWh generated for the first 10 years of operation. Under this arrangement, the site owner receives essentially double compensation for electricity generated by the array for the first 10 years. In exchange, Xcel Energy is allowed to retain the Renewable Energy Credits (the "green attributes") for all power generated by the solar array for the 10 year period. Following the 10 year period the array reverts back to a net metered site (with energy generation offsetting energy consumed on a one-to-one basis)

The array is not capable of offsetting all of the electricity used on site. The array's first year generation is estimated to offset approximately 20% of the site's current reported electricity consumption. The site utilization and tree coverage does not readily support ground mounted arrays while carport arrays would not be cost effective for this site and its energy tariff structure. **Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.**

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.64:1 ratio. As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.007 less than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING		
Total Installed Array Cost (incl. contingency, other owner expenses)	$50,633	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$6,993	
Operational Expense Allowance (insurance, O+M, 30-year)	$8,921	
Total Lifetime Project Costs	$66,546	
SAVINGS		
Total Lifetime Project Savings	$109,466	
OUTCOMES		
Net Lifetime Project Costs or Savings	$42,919	
Total Project Cost Payback (Years)	18.2	Years
Value to Cost Ratio	1.64	to 1.0
Electricity Production (kWh, 30-year)	638,646	kWh
Percent of Electricity Usage Covered by Solar (Year	19.91%	

Note, values do not include social cost of carbon avoided by the solar array.

Recommended Site Priority:

Priority 2
(3-6 year)

Design 1 City of Northfield Liquor Store, 116 Fifth Street West, Northfield, MN

Report

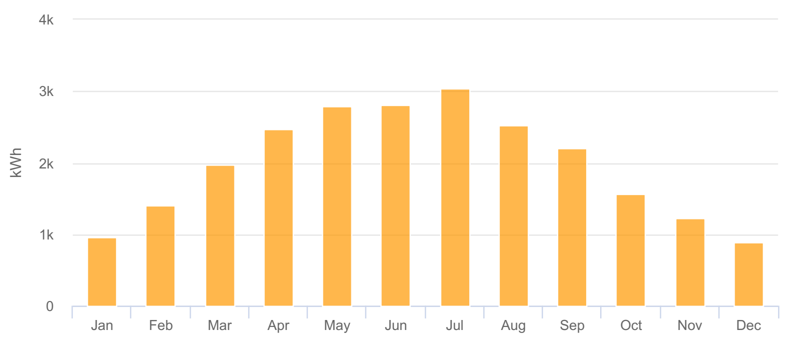
Project Name	City of Northfield Liquor Store
Project Address	116 Fifth Street West, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

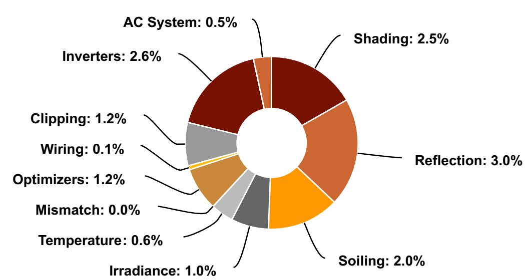
Design	Design 1
Module DC Nameplate	17.5 kW
Inverter AC Nameplate	14.0 kW Load Ratio: 1.25
Annual Production	23.86 MWh
Performance Ratio	86.1%
kWh/kWp	1,363.5
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	82059887e2-94bbd10f05-3ed91e0153-ff78756751

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,584.5	13.6%
	Shaded Irradiance	1,545.3	-2.5%
	Irradiance after Reflection	1,498.8	-3.0%
	Irradiance after Soiling	1,468.8	-2.0%
	Total Collector Irradiance	**1,469.0**	**0.0%**
Energy (kWh)	Nameplate	25,683.5	
	Output at Irradiance Levels	25,417.8	-1.0%
	Output at Cell Temperature Derate	25,258.3	-0.6%
	Output After Mismatch	25,258.3	0.0%
	Optimizer Output	24,955.1	-1.2%
	Optimal DC Output	24,926.5	-0.1%
	Constrained DC Output	24,627.8	-1.2%
	Inverter Output	23,980.5	-2.6%
	Energy to Grid	**23,860.6**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.8 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE7K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE7K (SolarEdge)	2 (14.0 kW)
Strings	10 AWG (Copper)	2 (21.8 ft)
Optimizers	P400 NA (SolarEdge)	50 (20.0 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	50 (17.5 kW)

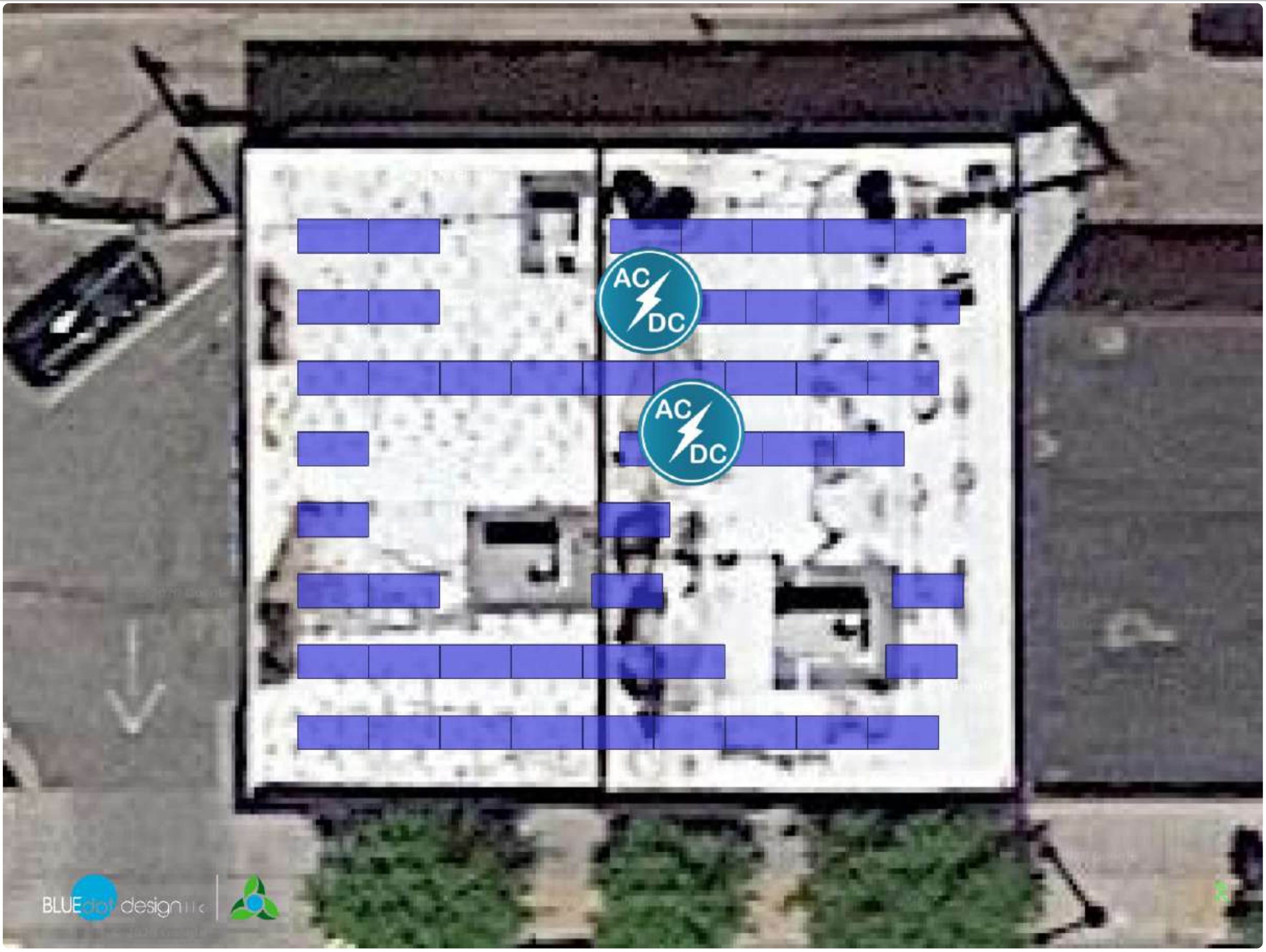
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	16-35	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	20°	180°	3.4 ft	1x1	50	50	17.5 kW

Detailed Layout



Owner Input & Results Worksheet

Project

Liquor Store
116 Fifth Street West
Rooftop

Date
5/9/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
17.50	Array Size (kW DC)
350	Watt Rating
50	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
14.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
23,860	First Year Generation (kWh)
$48,351.27	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$2,281.53	Owner Contingency (if any)
$50,632.80	Total Project Budget
$2.89	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$3,123	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
119,812	Total Annual Electric Use (kWh)
252.00	Total Annual Demand (kW)
4,400	Building Area (Square Feet)
60.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
27.23	Electric Use Intensity (kWh/SF)
272%	EUI as % of National Average
$12,234.46	Annual Energy Charge ($)
$221.00	Annual Demand Charge ($)
$12,455.46	Total Annual Electric Cost
$0.1021	Effective Electric Rate ($/kWh)*
$0.88	Effective Demand Charge ($/kW)
21.00	Average Monthly Demand (kW)

Financial Information

$10,126.56	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$40,506.24	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	638,646	kWh
Total Electricity Bill Savings	$109,466	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$50,633	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$50,633	
Simple Project Payback	13.88	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$57,625	
Financed Capital Payback	15.79	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$8,921	
Financed Array Lifetime Cost	$66,546	
Financed Array Lifetime Payback	18.24	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1714	
Project Cost Per Solar Per kWh	$0.1042	
Net Electricity Bill Savings Per kWh	$0.0672	
Value to Cost Ratio	1.64	to 1.0

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PROJ: **Liquor Store**
LOC.: **116 Fifth Street West**
TITLE: **Rooftop**

09-May-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	**17.5**
Year 1 Generation Projection (MWH)	**23.9**
Annual Site Energy Use (MWH)	**119.8**
Assumed Energy Use During Solar Production Hours	**60%**

Energy Generation Schedule (Based on Predicted Loss) / Potential Revenue Value / Simplified Cash Flow Projection

Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	23,860	kWh	100%	19.91%	$0.1021	$2,436	$221	$37	$1,432	$3,905	($14,876)	($70)	($74)	($11,115)	($11,115)
2	2022	23,669	kWh	99%	19.76%	$0.1047	$2,477	$227	$38	$1,420	$3,935	($4,750)	($71)	($75)	($961)	($12,076)
3	2023	23,480	kWh	98%	19.60%	$0.1073	$2,519	$232	$39	$1,409	$3,966	($4,750)	($73)	($76)	($933)	($13,009)
4	2024	23,292	kWh	98%	19.44%	$0.1100	$2,561	$238	$40	$1,398	$3,998	($4,750)	($74)	($78)	($904)	($13,912)
5	2025	23,106	kWh	97%	19.28%	$0.1127	$2,604	$244	$41	$1,386	$4,031	($4,750)	($76)	($80)	($874)	($14,786)
6	2026	22,921	kWh	96%	19.13%	$0.1155	$2,648	$250	$42	$1,375	$4,065	($4,750)	($77)	($81)	($843)	($15,630)
7	2027	22,737	kWh	95%	18.98%	$0.1184	$2,693	$256	$43	$1,364	$4,100	($4,750)	($79)	($83)	($812)	($16,441)
8	2028	22,555	kWh	95%	18.83%	$0.1214	$2,738	$263	$44	$1,353	$4,135	($4,750)	($80)	($84)	($780)	($17,221)
9	2029	22,375	kWh	94%	18.68%	$0.1244	$2,784	$269	$45	$1,343	$4,171	($4,750)	($82)	($86)	($747)	($17,968)
10	2030	22,196	kWh	93%	18.53%	$0.1275	$2,831	$276	$46	$1,332	$4,208	($4,750)	($84)	($88)	($713)	($18,681)
11	2031	22,018	kWh	92%	18.38%	$0.1307	$2,878	$283	$47		$2,925	$0	($85)	($90)	$2,750	($15,931)
12	2032	21,842	kWh	92%	18.23%	$0.1340	$2,926	$290	$48		$2,975	$0	($87)	($91)	$2,796	($13,134)
13	2033	21,668	kWh	91%	18.08%	$0.1373	$2,976	$297	$50		$3,025	$0	($89)	($93)	$2,843	($10,291)
14	2034	21,494	kWh	90%	17.94%	$0.1408	$3,026	$305	$51		$3,076	$0	($91)	($95)	$2,891	($7,400)
15	2035	21,322	kWh	89%	17.80%	$0.1443	$3,076	$312	$52		$3,129	$0	($92)	($97)	$2,939	($4,461)
16	2036	21,152	kWh	89%	17.65%	$0.1479	$3,128	$320	$53		$3,182	$0	($94)	($99)	$2,988	($1,473)
17	2037	20,982	kWh	88%	17.51%	$0.1516	$3,181	$328	$55		$3,235	$0	($96)	($101)	$3,038	$1,566
18	2038	20,815	kWh	87%	17.37%	$0.1554	$3,234	$336	$56		$3,290	$0	($98)	($103)	$3,089	$4,655
19	2039	20,648	kWh	87%	17.23%	$0.1593	$3,288	$345	$57		$3,346	$0	($100)	($105)	$3,141	$7,796
20	2040	20,483	kWh	86%	17.10%	$0.1632	$3,344	$353	$59		$3,403	$0	($102)	($3,230)	$71	$7,866
21	2041	20,319	kWh	85%	16.96%	$0.1673	$3,400	$362	$60		$3,460	$0	($104)	($107)	$3,249	$11,116
22	2042	20,157	kWh	84%	16.82%	$0.1715	$3,457	$371	$62		$3,519	$0	($106)	($109)	$3,304	$14,419
23	2043	19,995	kWh	84%	16.69%	$0.1758	$3,515	$380	$63		$3,579	$0	($108)	($111)	$3,359	$17,778
24	2044	19,835	kWh	83%	16.56%	$0.1802	$3,574	$390	$65		$3,639	$0	($110)	($114)	$3,415	$21,193
25	2045	19,677	kWh	82%	16.42%	$0.1847	$3,634	$400	$67		$3,701	$0	($113)	($116)	$3,472	$24,666
26	2046	19,519	kWh	82%	16.29%	$0.1893	$3,695	$410	$68		$3,764	$0	($115)	($118)	$3,530	$28,196
27	2047	19,363	kWh	81%	16.16%	$0.1940	$3,757	$420	$70		$3,827	$0	($117)	($121)	$3,590	$31,786
28	2048	19,208	kWh	81%	16.03%	$0.1989	$3,820	$430	$72		$3,892	$0	($119)	($123)	$3,650	$35,435
29	2049	19,054	kWh	80%	15.90%	$0.2039	$3,885	$441	$74		$3,958	$0	($122)	($125)	$3,711	$39,146
30	2050	18,902	kWh	79%	15.78%	$0.2090	$3,950	$452	$75		$4,025	$0	($124)	($128)	$3,773	$42,919

Assumed Percentage of Demand
Charge Reduction*: 16.67%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/
Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$50,633	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$6,993	
Operational Expense Allowance (insurance, O+M, 30-year)	$8,921	
Total Lifetime Project Costs	$66,546	

SAVINGS

Total Lifetime Project Savings	$109,466	

OUTCOMES

Net Lifetime Project Costs or Savings	$42,919	
Total Project Cost Payback (Years)	18.2	Years
Value to Cost Ratio	1.64	to 1.0
Electricity Production (kWh, 30-year)	638,646	kWh
Percent of Electricity Usage Covered by Solar (Year	19.91%	

Site Solar Feasibility Reports by Building

Fire and Rescue

Concept Design

The roof configuration of the Fire and Rescue building is well suited for solar PV installation, with good orientation, overall configuration, and minimal rooftop equipment obstruction.

The rooftop array is not capable of offsetting all of the electricity used on site. The rooftop array's first year generation is estimated to offset approximately 51% of the site's current reported electricity consumption. To meet the site's full annual use an additional ground mounted array is required. The site area to the south of the facility and parking lot is well suited for a ground mounted solar array meeting 59% or more of the site's annual electric use. The combined arrays included in this concept can provide an estimated 110.8% of the site's total electric use, making the site Net Zero electricity.

Note: A structural assessment should be conducted to assure the building's ability to support the structural demands of a rooftop array prior to proceeding with project implementation.

Note, values do not include social cost of carbon avoided by the solar array.

Potential Financial Performance

The estimated total value of solar PV (potential total economic benefit to the building owner) exceeds the total project cost at a 1.61:1 ratio (1.59 for rooftop, 1.62 for ground). As such, this array should provide payback over its anticipated life span.

Over a 30 year lifespan, the cost per kWh produced by this array is estimated at $0.003 less than achieving renewable energy for the site through purchase of grid electricity combined with Renewable Energy Credits (RECs).

Improving Financial Performance

This array may provide improved cost savings if the City can execute additional energy consumption savings, demand reduction strategies, and explore the addition of energy storage.

Utilization of additional funding sources such as grants, or no/low interest loans could significantly improve the project's financial payback for the building.

In addition, utilization of a 3rd party ownership structure (solar lease or solar PPA) may also increase long-term payback of the solar array and enable the City to leverage a portion of the value of the Investment Tax Credit and Depreciation. NOTE: if pursued 3rd party structure agreement must allow City to retain RECs.

COSTS AND FINANCING (Rooftop Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$137,231	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$18,952	
Operational Expense Allowance (insurance, O+M, 30-year)	$27,948	
Total Lifetime Project Costs	$184,131	
SAVINGS		
Total Lifetime Project Savings	$293,587	
OUTCOMES		
Net Lifetime Project Costs or Savings	$109,457	
Total Project Cost Payback (Years)	18.8	Years
Value to Cost Ratio	1.59	to 1.0
Electricity Production (kWh, 30-year)	2,116,685	kWh
Percent of Electricity Usage Covered by Solar (Year	51.60%	

COSTS AND FINANCING (Ground Mounted Array)		
Total Installed Array Cost (incl. contingency, other owner expenses)	$155,540	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$21,480	
Operational Expense Allowance (insurance, O+M, 30-year)	$32,204	
Total Lifetime Project Costs	$209,224	
SAVINGS		
Total Lifetime Project Savings	$338,432	
OUTCOMES		
Net Lifetime Project Costs or Savings	$129,208	
Total Project Cost Payback (Years)	18.5	Years
Value to Cost Ratio	1.62	to 1.0
Electricity Production (kWh, 30-year)	2,427,710	kWh
Percent of Electricity Usage Covered by Solar (Year	59.18%	

Recommended Site Priority:

Priority 1
(0-3 year)

Design 2 City of Northfield Fire and Rescue, 301 5th St W, Northfield, MN

Report

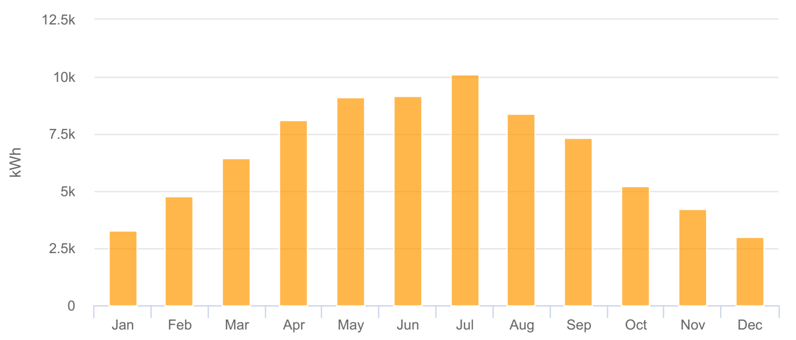
Project Name	City of Northfield Fire and Rescue
Project Address	301 5th St W, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

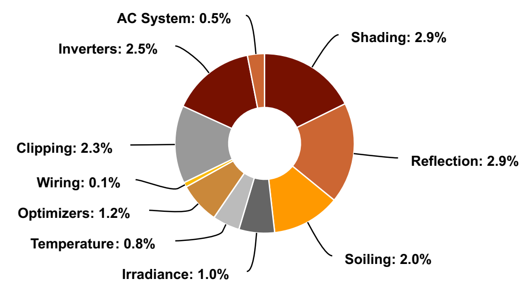
Design	Design 2
Module DC Nameplate	59.2 kW
Inverter AC Nameplate	45.0 kW Load Ratio: 1.31
Annual Production	79.08 MWh
Performance Ratio	84.8%
kWh/kWp	1,336.9
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	f899f52eda-b47c748d08-a4b7c942ee-9a23df64f4

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,576.9	13.1%
	Shaded Irradiance	1,531.5	-2.9%
	Irradiance after Reflection	1,486.4	-2.9%
	Irradiance after Soiling	1,456.6	-2.0%
	Total Collector Irradiance	**1,456.6**	**0.0%**
Energy (kWh)	Nameplate	86,077.8	
	Output at Irradiance Levels	85,179.1	-1.0%
	Output at Cell Temperature Derate	84,499.6	-0.8%
	Output After Mismatch	84,499.5	0.0%
	Optimizer Output	83,484.2	-1.2%
	Optimal DC Output	83,371.6	-0.1%
	Constrained DC Output	81,473.6	-2.3%
	Inverter Output	79,476.8	-2.5%
	Energy to Grid	**79,079.4**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.8 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
72M-350 (Mar18) (Heliene Inc)	Folsom Labs	Heliene_72M-350_Mar2018.pan, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE15K (SolarEdge)	Folsom Labs	Spec Sheet Efficiency

Components

Component	Name	Count
Inverters	SE15K (SolarEdge)	3 (45.0 kW)
Strings	10 AWG (Copper)	6 (387.6 ft)
Optimizers	P400 NA (SolarEdge)	169 (67.6 kW)
Module	Heliene Inc, 72M-350 (Mar18) (350W)	169 (59.2 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	15-32	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	26°	213.227°	4.4 ft	1x1	112	112	39.2 kW
Field Segment 2	Fixed Tilt	Landscape (Horizontal)	26°	212.34218024578126°	4.4 ft	1x1	57	57	20.0 kW

Detailed Layout

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Owner Input & Results Worksheet

Project

Fire and Rescue
301 5th St W
Rooftop

Date
6/25/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
59.20	Array Size (kW DC)
350	Watt Rating
169	Number of Solar Modules (Roof)
0	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
45.00	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
79,080	First Year Generation (kWh)
$131,065.54	Total Contractor Bid
$0.00	Other Owner Expenses (legal, etc.)
$6,165.07	Owner Contingency (if any)
$137,230.61	Total Project Budget
$2.32	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$8,334	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
153,270	Total Annual Electric Use (kWh)
444.00	Total Annual Demand (kW)
13,536	Building Area (Square Feet)
60.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
11.32	Electric Use Intensity (kWh/SF)
113%	EUI as % of National Average
$11,763.00	Annual Energy Charge ($)
$4,224.00	Annual Demand Charge ($)
$15,987.00	Total Annual Electric Cost
$0.0767	Effective Electric Rate ($/kWh)*
$9.51	Effective Demand Charge ($/kW)
37.00	Average Monthly Demand (kW)

Financial Information

$27,446.12	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$109,784.49	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	2,116,685	kWh
Total Electricity Bill Savings	$293,587	
Cash Purchase Payback — Allowance for annual expenses and financing costs excluded		
Capital Cost	$137,231	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$137,231	
Simple Project Payback	14.02	Years
Financed Purchase Payback — Allowance for annual expenses excluded. Financing costs included		
Financed Capital Cost	$156,183	
Financed Capital Payback	15.96	Years
Financed Array Lifetime Payback — 30 year allowance for annual expenses and financing costs included.		
30 year Operational Expense Allowance (ins/O+M)	$27,948	
Financed Array Lifetime Cost	$184,131	
Financed Array Lifetime Payback	18.82	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1387	
Project Cost Per Solar Per kWh	$0.0870	
Net Electricity Bill Savings Per kWh	$0.0517	
Value to Cost Ratio	1.59	to 1.0

OWNER: 0

PROJ: Fire and Rescue
LOC.: 301 5th St W
TITLE: Rooftop

25-Jun-20

Order of Magnitude Budget - Solar PV Project Public Sector

DC Nameplate Capacity 59.2
Year 1 Generation Projection 79.1

Note: Costs are intended to illustrate Order of Magnitude and are preliminary in nature. Cost unit prices are based on 2017 national averages provided by the National Renewable Energy Laboratory, modified using local construction cost indices and escalated to 2020 dollars. All information is preliminary

Acres: 0

	Material	Labor	Combined
Cost Indices	1.10	1.10	1.10

DESCRIPTION	Watt Rating	Quantity	Unit Allow	Project Cost	SUB TOTAL	PERCENT TOTAL	Cost per watt
ADMINISTRATION COSTS					**$0**	**0.00%**	$0.00
LEGAL, FISCAL & ADMINISTRATIVE		0	2500	$0			
LAND AQCUISITION		0	0	$0			
LAND SALE - EXISTING STRUCTURES		0	0	$0			
SOIL BORINGS		0	4200	$0			
SURVEY		0	3500	$0			
INSTALLATION COSTS	Watt Rating				**$123,301**	**89.85%**	$2.08
PV Modules - Rooftop (Heliene 350W)	350	169	213	$35,994		29.19%	
PV Modules - Ground Mount (Heliene 350W)	350	0	213	$0		0.00%	
PV Modules - Carport/Parking (Heliene 350W)	350	0	213	$0		0.00%	
Inverters		1	7247	$7,247		5.88%	
Optimizers		169	60	$10,140		8.22%	
Structural BOS		1	0	$0		0.00%	
Electrical BOS		1	9999	$9,999		8.11%	
Racking - Roof		1	10494	$10,494		8.51%	
Racking - Ground Mount		1	0	$0		0.00%	
Racking - Carport		1	0	$0		0.00%	
Sales Tax		1	0	$0		0.00%	
Installation Labor		1	9935	$9,935		8.06%	
Site Fencing		0	15	$0		0.00%	
Site Grading		0	21780	$0		0.00%	
Roof Patch/Repair		1	3479	$3,479		2.82%	
Building Renovation - Not Included		0	0	$0		0.00%	
Haz Mat Removal - Not Included		0	0	$0		0.00%	
Permitting, Inspection, Interconnection		1	6512	$6,512		5.28%	
Bid Contingency		1	7605	$7,605		6.17%	
Overhead		1	10948	$10,948		8.88%	
Profit		1	10948	$10,948		8.88%	
DEVELOPER OVERHEAD AND PROFESSIONAL FEES					**$7,764**	**5.66%**	$0.13
PROCUREMENT MANAGEMENT - Owner's Representative / Procurement Management				$0			
PROCUREMENT MANAGEMENT - Design/Build Package				$3,083			
PROCUREMENT MANGEMENT - Utility Project Terms Determination (interconnection, process, and tariff)				$496			
ENGINEERING - Structural Assessment				$3,479			
ENGINEERING - Structural Modifications (not included)				$0			
ENGINEERING - Civil				$0			
Reimbursable Expenses				$706			
CONTINGENCY					**$6,165**	**4.49%**	$0.10
OWNER"S PROJECT CONTINGENCY				$6,165			
Project Total - FY 2020					**$137,231**	**100.00%**	$2.32

OWNER 0

PROJ: Fire and Rescue
LOC.: 301 5th St W
TITLE: Rooftop

25-Jun-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	59.2
Year 1 Generation Projection (MWH)	79.1
Annual Site Energy Use (MWH)	153.3
Assumed Energy Use During Solar Production Hours	60%

Energy Generation Schedule (Based on Predicted Loss)						Potential Revenue Value						Simplified Cash Flow Projection				
Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	79,080	kWh	100%	51.60%	$0.0767	$6,069	$4,224	$1,352	$0	$7,421	($40,320)	($237)	($249)	($33,384)	($33,384)
2	2022	78,447	kWh	99%	51.18%	$0.0787	$6,171	$4,330	$1,385	$0	$7,557	($12,874)	($242)	($254)	($5,812)	($39,197)
3	2023	77,820	kWh	98%	50.77%	$0.0806	$6,275	$4,438	$1,420	$0	$7,695	($12,874)	($246)	($259)	($5,684)	($44,880)
4	2024	77,197	kWh	98%	50.37%	$0.0826	$6,380	$4,549	$1,456	$0	$7,836	($12,874)	($251)	($264)	($5,553)	($50,433)
5	2025	76,580	kWh	97%	49.96%	$0.0847	$6,487	$4,663	$1,492	$0	$7,979	($12,874)	($256)	($269)	($5,420)	($55,853)
6	2026	75,967	kWh	96%	49.56%	$0.0868	$6,596	$4,779	$1,529	$0	$8,126	($12,874)	($261)	($275)	($5,284)	($61,137)
7	2027	75,359	kWh	95%	49.17%	$0.0890	$6,707	$4,899	$1,568	$0	$8,275	($12,874)	($267)	($280)	($5,146)	($66,283)
8	2028	74,756	kWh	95%	48.77%	$0.0912	$6,820	$5,021	$1,607	$0	$8,427	($12,874)	($272)	($286)	($5,005)	($71,287)
9	2029	74,158	kWh	94%	48.38%	$0.0935	$6,934	$5,147	$1,647	$0	$8,581	($12,874)	($277)	($291)	($4,861)	($76,148)
10	2030	73,565	kWh	93%	48.00%	$0.0958	$7,051	$5,275	$1,688	$0	$8,739	($12,874)	($283)	($297)	($4,715)	($80,863)
11	2031	72,977	kWh	92%	47.61%	$0.0982	$7,169	$5,407	$1,730		$8,900	$0	($289)	($303)	$8,308	($72,555)
12	2032	72,393	kWh	92%	47.23%	$0.1007	$7,290	$5,542	$1,774		$9,063	$0	($294)	($309)	$8,460	($64,095)
13	2033	71,814	kWh	91%	46.85%	$0.1032	$7,412	$5,681	$1,818		$9,230	$0	($300)	($315)	$8,615	($55,481)
14	2034	71,239	kWh	90%	46.48%	$0.1058	$7,537	$5,823	$1,863		$9,400	$0	($306)	($322)	$8,772	($46,709)
15	2035	70,669	kWh	89%	46.11%	$0.1084	$7,663	$5,968	$1,910		$9,573	$0	($312)	($328)	$8,933	($37,776)
16	2036	70,104	kWh	89%	45.74%	$0.1112	$7,792	$6,118	$1,958		$9,750	$0	($319)	($335)	$9,097	($28,679)
17	2037	69,543	kWh	88%	45.37%	$0.1139	$7,923	$6,271	$2,007		$9,930	$0	($325)	($341)	$9,263	($19,416)
18	2038	68,987	kWh	87%	45.01%	$0.1168	$8,056	$6,427	$2,057		$10,113	$0	($332)	($348)	$9,433	($9,983)
19	2039	68,435	kWh	87%	44.65%	$0.1197	$8,192	$6,588	$2,108		$10,300	$0	($338)	($355)	$9,606	($376)
20	2040	67,887	kWh	86%	44.29%	$0.1227	$8,329	$6,753	$2,161		$10,490	$0	($345)	($8,696)	$1,449	$1,072
21	2041	67,344	kWh	85%	43.94%	$0.1258	$8,469	$6,922	$2,215		$10,684	$0	($352)	($362)	$9,970	$11,042
22	2042	66,805	kWh	84%	43.59%	$0.1289	$8,611	$7,095	$2,270		$10,882	$0	($359)	($369)	$10,153	$21,196
23	2043	66,271	kWh	84%	43.24%	$0.1321	$8,756	$7,272	$2,327		$11,083	$0	($366)	($377)	$10,340	$31,536
24	2044	65,741	kWh	83%	42.89%	$0.1354	$8,903	$7,454	$2,385		$11,288	$0	($373)	($384)	$10,531	$42,066
25	2045	65,215	kWh	82%	42.55%	$0.1388	$9,053	$7,640	$2,445		$11,498	$0	($381)	($392)	$10,725	$52,791
26	2046	64,693	kWh	82%	42.21%	$0.1423	$9,205	$7,831	$2,506		$11,711	$0	($388)	($400)	$10,922	$63,713
27	2047	64,176	kWh	81%	41.87%	$0.1458	$9,359	$8,027	$2,569		$11,928	$0	($396)	($408)	$11,124	$74,837
28	2048	63,662	kWh	81%	41.54%	$0.1495	$9,517	$8,228	$2,633		$12,150	$0	($404)	($416)	$11,329	$86,166
29	2049	63,153	kWh	80%	41.20%	$0.1532	$9,677	$8,433	$2,699		$12,375	$0	($412)	($424)	$11,539	$97,705
30	2050	62,648	kWh	79%	40.87%	$0.1571	$9,839	$8,644	$2,766		$12,605	$0	($421)	($433)	$11,752	$109,457

Assumed Percentage of Demand
Charge Reduction*: 32.00%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$137,231
Grants, Rebates, No-Obligation Funds	$0
Total Interest Payments	$18,952
Operational Expense Allowance (insurance, O+M, 30-year)	$27,948
Total Lifetime Project Costs	$184,131

SAVINGS

Total Lifetime Project Savings	$293,587

OUTCOMES

Net Lifetime Project Costs or Savings	$109,457	
Total Project Cost Payback (Years)	18.8	Years
Value to Cost Ratio	1.59	to 1.0
Electricity Production (kWh, 30-year)	2,116,685	kWh
Percent of Electricity Usage Covered by Solar (Year	51.60%	

Groundmounted City of Northfield Fire and Rescue, 301 5th St W, Northfield, MN

Report

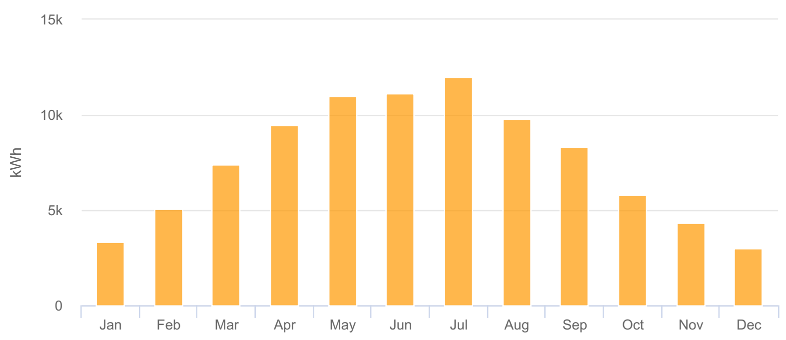
Project Name	City of Northfield Fire and Rescue
Project Address	301 5th St W, Northfield, MN
Prepared By	Del McNally bluedotdesignllc@gmail.com

System Metrics

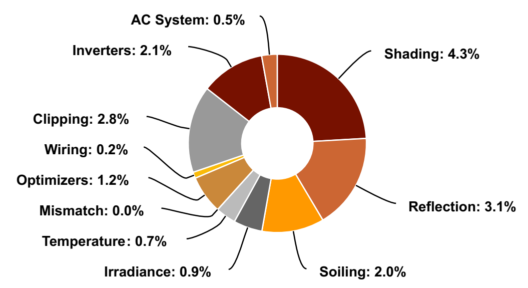
Design	Groundmounted
Module DC Nameplate	69.6 kW
Inverter AC Nameplate	55.2 kW Load Ratio: 1.26
Annual Production	90.70 MWh
Performance Ratio	84.1%
kWh/kWp	1,303.6
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Simulator Version	f899f52eda-b47c748d08-a4b7c942ee-9a23df64f4

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,394.3	
	POA Irradiance	1,550.0	11.2%
	Shaded Irradiance	1,483.9	-4.3%
	Irradiance after Reflection	1,438.4	-3.1%
	Irradiance after Soiling	1,409.6	-2.0%
	Total Collector Irradiance	**1,409.8**	**0.0%**
Energy (kWh)	Nameplate	98,672.2	
	Output at Irradiance Levels	97,761.5	-0.9%
	Output at Cell Temperature Derate	97,123.8	-0.7%
	Output After Mismatch	97,123.7	0.0%
	Optimizer Output	95,932.8	-1.2%
	Optimal DC Output	95,744.0	-0.2%
	Constrained DC Output	93,072.2	-2.8%
	Inverter Output	91,158.8	-2.1%
	Energy to Grid	**90,703.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		10.1 °C
	Avg. Operating Cell Temp		16.6 °C
Simulation Metrics			
	Operating Hours		4673
	Solved Hours		4673

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km grid (44.45,-93.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Module Characterizations

Module	Uploaded By	Characterization
96M 490 (Heliene)	Folsom Labs	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P400 NA (SolarEdge)	Folsom Labs	Mfg Spec Sheet
SE27.6K (SolarEdge)	Folsom Labs	Spec Sheet

Components

Component	Name	Count
Inverters	SE27.6K (SolarEdge)	2 (55.2 kW)
Strings	10 AWG (Copper)	7 (572.9 ft)
Optimizers	P400 NA (SolarEdge)	142 (56.8 kW)
Module	Heliene, 96M 490 (490W)	142 (69.6 kW)

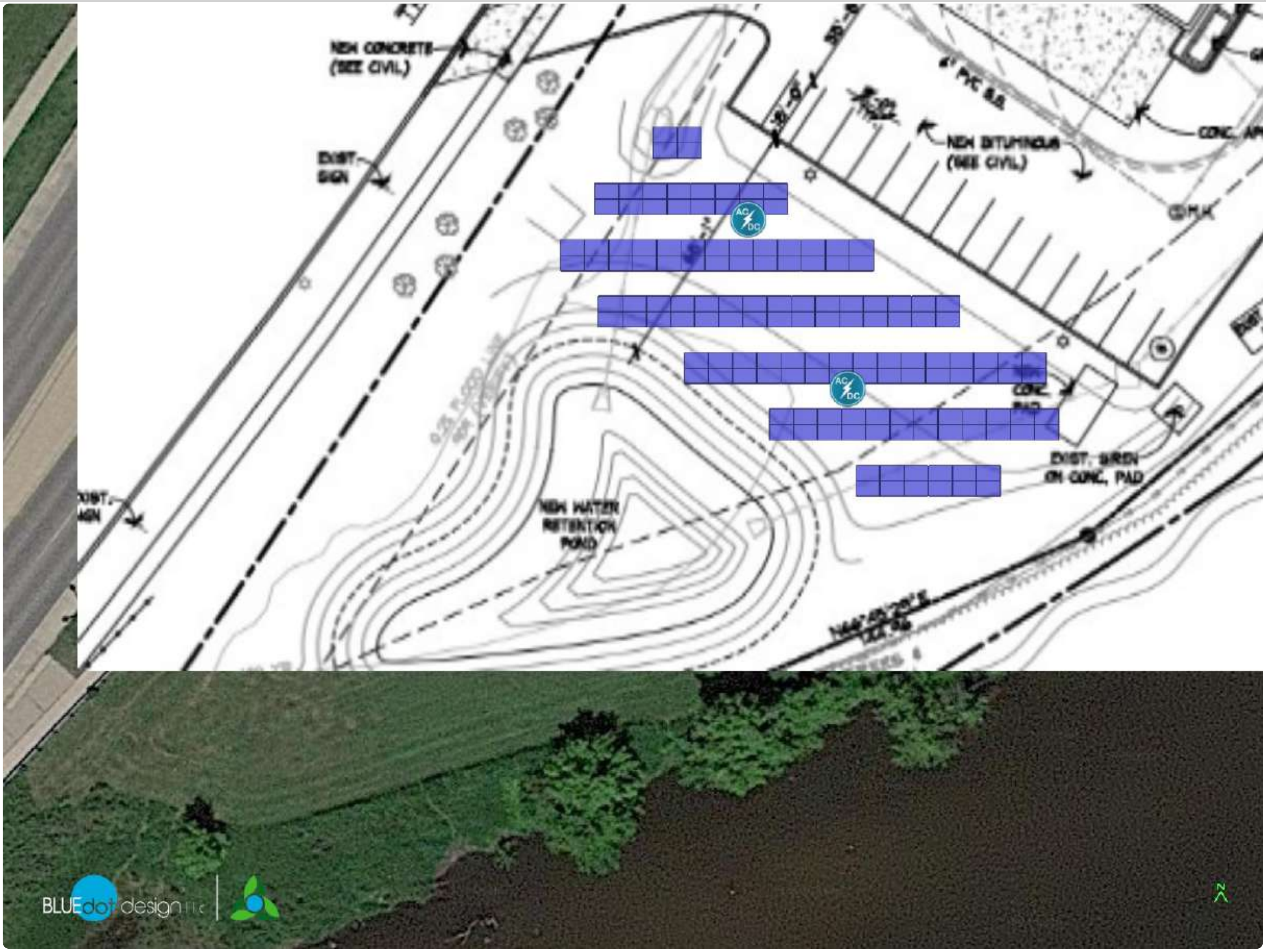
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	15-22	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	15°	180°	6.7 ft	2x1	71	142	69.6 kW

Detailed Layout



Owner Input & Results Worksheet

paleBLUEdot LLC

Project

Fire and Rescue
301 5th St W
Groundmounted

Date
6/25/2020

The intent of this worksheet is to provide the Site Owner with a tool to explore the long-term energy generation and economic payback for any proposed solar array. To use this worksheet, simply enter the required information in the designated (white) spaces below. Once entered, a summary of results will show to the right. You can proceed to the "30 Year Energy Output sheet for detailed, by year, results.

Information on Your Solar Array (from solar bid)

2021	First Year of Operation
69.60	Array Size (kW DC)
490	Watt Rating
0	Number of Solar Modules (Roof)
142	Number of Solar Modules (Ground)
0	Number of Solar Modules (Carport)
55.20	Capacity (kW AC)
80.00%	Efficiency Warrantee Level (%)
0.80%	Maximum Annual Production Degradation Rate (%)
90,700	First Year Generation (kWh)
$146,138.76	Total Contractor Bid
$2,500.00	Other Owner Expenses (legal, etc.)
$6,901.09	Owner Contingency (if any)
$155,539.85	Total Project Budget
$2.23	Total Cost Per Watt

Information on Your Solar Array Operation and Maintenance (from solar bid)

$4.20	Annual O+M Costs (per kW DC)
2.00%	O+M Annual Escalation Rate
$4.00	Annual Insurance Costs (per kW DC)
$9,144	Inverter Replacement Cost (Assumes year 20)

Information on Your Electric Use (all meters)

Xcel Energy	Electric Utility
153,270	Total Annual Electric Use (kWh)
444.00	Total Annual Demand (kW)
13,536	Building Area (Square Feet)
60.00%	Est % of Elec used between 10am and 3pm
2.50%	Estimated annual electric escalation rate**
11.32	Electric Use Intensity (kWh/SF)
113%	EUI as % of National Average
$11,763.00	Annual Energy Charge ($)
$4,224.00	Annual Demand Charge ($)
$15,987.00	Total Annual Electric Cost
$0.0767	Effective Electric Rate ($/kWh)*
$9.51	Effective Demand Charge ($/kW)
37.00	Average Monthly Demand (kW)

Financial Information

$31,107.97	Array Cash / Down Payment
$0.00	Rebates, Grants, etc.
$0.00	Other no-obligation funds
$124,431.88	Remaining Array Cost Requiring Financing
3.25%	Loan / Bond Interest Rate (6 year)
10	Loan/Bond Term (assumed)

* Effective Electric Rate is calculated based on user entry for Annual Energy Charge and Total Annual Electric Use and may differ from utility reported rate per kWh.
** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Results

Total Production (kWh)	2,427,710	kWh
Total Electricity Bill Savings	$338,432	

Cash Purchase Payback
Allowance for annual expenses and financing costs excluded

Capital Cost	$155,540	
Grants, Rebates, No-Obligation Funds	$0	
Net Cost	$155,540	
Simple Project Payback	13.79	Years

Financed Purchase Payback
Allowance for annual expenses excluded. Financing costs included

Financed Capital Cost	$177,020	
Financed Capital Payback	15.69	Years

Financed Array Lifetime Payback
30 year allowance for annual expenses and financing costs included.

30 year Operational Expense Allowance (ins/O+M)	$32,204	
Financed Array Lifetime Cost	$209,224	
Financed Array Lifetime Payback	18.55	Years
Net Project Savings (30 year)	$0	
Total Electricity Bill Savings Per kWh	$0.1394	
Project Cost Per Solar Per kWh	$0.0862	
Net Electricity Bill Savings Per kWh	$0.0532	
Value to Cost Ratio	1.62	to 1.0

OWNER: 0

PROJ: Fire and Rescue
LOC.: 301 5th St W
TITLE: Groundmounted

25-Jun-20

pale BLUE dot LLC

Order of Magnitude Budget - Solar PV Project Public Sector

DC Nameplate Capacity	69.6
Year 1 Generation Projection	90.7

Note: Costs are intended to illustrate Order of Magnitude and are preliminary in nature. Cost unit prices are based on 2017 national averages provided by the National Renewable Energy Laboratory, modified using local construction cost indices and escalated to 2020 dollars. All information is preliminary

Acres: 0

	Material	Labor	Combined
Cost Indices	1.10	1.10	1.10

DESCRIPTION	Watt Rating	Quantity	Unit Allow	Project Cost	SUB TOTAL	PERCENT TOTAL	Cost per watt
ADMINISTRATION COSTS					**$2,500**	**1.61%**	$0.04
LEGAL, FISCAL & ADMINISTRATIVE		1	2500	$2,500			
LAND AQCUISITION		0	0	$0			
LAND SALE - EXISTING STRUCTURES		0	0	$0			
SOIL BORINGS		0	4200	$0			
SURVEY		0	3500	$0			
INSTALLATION COSTS	Watt Rating				**$138,022**	**88.74%**	$1.98
PV Modules - Rooftop (Heliene 350W)	490	0	276	$0		0.00%	
PV Modules - Ground Mount (Heliene 350W)	490	142	276	$39,157		28.37%	
PV Modules - Carport/Parking (Heliene 350W)	490	0	276	$0		0.00%	
Inverters		1	7951	$7,951		5.76%	
Optimizers		142	60	$8,520		6.17%	
Structural BOS		1	0	$0		0.00%	
Electrical BOS		1	11073	$11,073		8.02%	
Racking - Roof		1	0	$0		0.00%	
Racking - Ground Mount		1	13252	$13,252		9.60%	
Racking - Carport		1	0	$0		0.00%	
Sales Tax		1	0	$0		0.00%	
Installation Labor		1	10543	$10,543		7.64%	
Site Fencing		496	15	$7,440		5.39%	
Site Grading		0	21780	$0		0.00%	
Roof Patch/Repair		1	0	$0		0.00%	
Building Renovation - Not Included		0	0	$0		0.00%	
Haz Mat Removal - Not Included		0	0	$0		0.00%	
Permitting, Inspection, Interconnection		1	7656	$7,656		5.55%	
Bid Contingency		1	8562	$8,562		6.20%	
Overhead		1	11934	$11,934		8.65%	
Profit		1	11934	$11,934		8.65%	
DEVELOPER OVERHEAD AND PROFESSIONAL FEES					**$8,117**	**5.22%**	$0.12
PROCUREMENT MANAGEMENT - Owner's Representative / Procurement Management				$0			
PROCUREMENT MANAGEMENT - Design/Build Package				$3,451			
PROCUREMENT MANGEMENT - Utility Project Terms Determination (interconnection, process, and tariff)				$429			
ENGINEERING - Structural Assessment				$0			
ENGINEERING - Structural Modifications (not included)				$0			
ENGINEERING - Civil				$3,500			
Reimbursable Expenses				$738			
CONTINGENCY					**$6,901**	**4.44%**	$0.10
OWNER"S PROJECT CONTINGENCY				$6,901			
Project Total - FY 2020					**$155,540**	**100.00%**	$2.23

OWNER 0

PROJ: Fire and Rescue
LOC.: 301 5th St W
TITLE: Groundmounted

25-Jun-20

30-Year Energy Output Calcs

Note: Energy generation projections are based on manufacturer efficiency loss warrantee information, applied as a constant annual value, however, efficiency losses may vary from year to year. All information is preliminary.

DC Nameplate Capacity	69.6
Year 1 Generation Projection (MWH)	90.7
Annual Site Energy Use (MWH)	153.3
Assumed Energy Use During Solar Production Hours	60%

Energy Generation Schedule (Based on Predicted Loss)						Potential Revenue Value						Simplified Cash Flow Projection				
Operation Year	Calendar Year	Annual Energy Generation		% of 1st Year	% of Use	Utility Energy Usage Rate ($/kWh)	Energy Savings (Value of Energy Used)	Utility Demand Charge (annual)	Estimated Potential Demand Charge Reduction	Xcel Solar Rewards Payment	Total Electricity Bill Savings	Cash Investment + Loan Payment	Insurance	Forecasted O+M Costs	Forecasted Annual Cash Flow	Forecasted Cumulative Cash Flow
1	2021	90,700	kWh	100%	59.18%	$0.0767	$6,961	$4,224	$1,589	$0	$8,550	($45,699)	($278)	($292)	($37,720)	($37,720)
2	2022	89,974	kWh	99%	58.70%	$0.0787	$7,078	$4,330	$1,629	$0	$8,707	($14,591)	($284)	($298)	($6,467)	($44,186)
3	2023	89,255	kWh	98%	58.23%	$0.0806	$7,197	$4,438	$1,670	$0	$8,866	($14,591)	($290)	($304)	($6,319)	($50,505)
4	2024	88,541	kWh	98%	57.77%	$0.0826	$7,318	$4,549	$1,711	$0	$9,029	($14,591)	($295)	($310)	($6,168)	($56,673)
5	2025	87,832	kWh	97%	57.31%	$0.0847	$7,441	$4,663	$1,754	$0	$9,195	($14,591)	($301)	($316)	($6,014)	($62,687)
6	2026	87,130	kWh	96%	56.85%	$0.0868	$7,566	$4,779	$1,798	$0	$9,364	($14,591)	($307)	($323)	($5,858)	($68,545)
7	2027	86,433	kWh	95%	56.39%	$0.0890	$7,693	$4,899	$1,843	$0	$9,536	($14,591)	($314)	($329)	($5,698)	($74,243)
8	2028	85,741	kWh	95%	55.94%	$0.0912	$7,822	$5,021	$1,889	$0	$9,711	($14,591)	($320)	($336)	($5,536)	($79,779)
9	2029	85,055	kWh	94%	55.49%	$0.0935	$7,953	$5,147	$1,936	$0	$9,890	($14,591)	($326)	($342)	($5,370)	($85,149)
10	2030	84,375	kWh	93%	55.05%	$0.0958	$8,087	$5,275	$1,985	$0	$10,072	($14,591)	($333)	($349)	($5,202)	($90,351)
11	2031	83,700	kWh	92%	54.61%	$0.0982	$8,223	$5,407	$2,034		$10,257	$0	($339)	($356)	$9,561	($80,790)
12	2032	83,030	kWh	92%	54.17%	$0.1007	$8,361	$5,542	$2,085		$10,446	$0	($346)	($363)	$9,736	($71,053)
13	2033	82,366	kWh	91%	53.74%	$0.1032	$8,501	$5,681	$2,137		$10,639	$0	($353)	($371)	$9,915	($61,138)
14	2034	81,707	kWh	90%	53.31%	$0.1058	$8,644	$5,823	$2,191		$10,835	$0	($360)	($378)	$10,097	($51,042)
15	2035	81,053	kWh	89%	52.88%	$0.1084	$8,790	$5,968	$2,245		$11,035	$0	($367)	($386)	$10,282	($40,760)
16	2036	80,405	kWh	89%	52.46%	$0.1112	$8,937	$6,118	$2,302		$11,239	$0	($375)	($393)	$10,471	($30,289)
17	2037	79,762	kWh	88%	52.04%	$0.1139	$9,087	$6,271	$2,359		$11,446	$0	($382)	($401)	$10,663	($19,626)
18	2038	79,124	kWh	87%	51.62%	$0.1168	$9,240	$6,427	$2,418		$11,658	$0	($390)	($409)	$10,859	($8,767)
19	2039	78,491	kWh	87%	51.21%	$0.1197	$9,395	$6,588	$2,479		$11,874	$0	($398)	($418)	$11,059	$2,291
20	2040	77,863	kWh	86%	50.80%	$0.1227	$9,553	$6,753	$2,540		$12,094	$0	($406)	($9,570)	$2,118	$4,410
21	2041	77,240	kWh	85%	50.39%	$0.1258	$9,714	$6,922	$2,604		$12,318	$0	($414)	($426)	$11,478	$15,888
22	2042	76,622	kWh	84%	49.99%	$0.1289	$9,877	$7,095	$2,669		$12,546	$0	($422)	($434)	$11,690	$27,577
23	2043	76,009	kWh	84%	49.59%	$0.1321	$10,043	$7,272	$2,736		$12,779	$0	($430)	($443)	$11,905	$39,482
24	2044	75,401	kWh	83%	49.19%	$0.1354	$10,211	$7,454	$2,804		$13,016	$0	($439)	($452)	$12,125	$51,607
25	2045	74,798	kWh	82%	48.80%	$0.1388	$10,383	$7,640	$2,874		$13,257	$0	($448)	($461)	$12,349	$63,955
26	2046	74,199	kWh	82%	48.41%	$0.1423	$10,557	$7,831	$2,946		$13,504	$0	($457)	($470)	$12,577	$76,532
27	2047	73,606	kWh	81%	48.02%	$0.1458	$10,735	$8,027	$3,020		$13,755	$0	($466)	($480)	$12,809	$89,341
28	2048	73,017	kWh	81%	47.64%	$0.1495	$10,915	$8,228	$3,095		$14,010	$0	($475)	($489)	$13,046	$102,387
29	2049	72,433	kWh	80%	47.26%	$0.1532	$11,098	$8,433	$3,173		$14,271	$0	($485)	($499)	$13,288	$115,675
30	2050	71,853	kWh	79%	46.88%	$0.1571	$11,285	$8,644	$3,252		$14,537	$0	($494)	($509)	$13,534	$129,208

Assumed Percentage of Demand Charge Reduction*: 37.62%

* Estimated Demand Charge Reduction assumes potential reduction of total demand charge based on possible demand service direct from solar array. The value is based on the array capacity's percentage of the average demand, multiplied by 30% reflecting an assumption that 1/3rd of the operating months will have solar capacity to meet demand peak. For more information see NREL report: https://www.nrel.gov/docs/fy17osti/69016.pdf

** Escalation rate recommended to be based on EIA Data Browser 10 year State history: https://www.eia.gov/electricity/data/browser/

Note: All information provided is intended as a good-faith order of magnitude estimation of costs and benefit values. Impacts of potential Investment Tax Incentive or depreciation benefits which may be leveraged through 3rd party engagement may not all be included in these calculations. Please consult investment and tax professionals for a more detailed and accurate projection of benefits.

COSTS AND FINANCING

Total Installed Array Cost (incl. contingency, other owner expenses)	$155,540	
Grants, Rebates, No-Obligation Funds	$0	
Total Interest Payments	$21,480	
Operational Expense Allowance (insurance, O+M, 30-year)	$32,204	
Total Lifetime Project Costs	$209,224	

SAVINGS

Total Lifetime Project Savings	$338,432	

OUTCOMES

Net Lifetime Project Costs or Savings	$129,208	
Total Project Cost Payback (Years)	18.5	Years
Value to Cost Ratio	1.62	to 1.0
Electricity Production (kWh, 30-year)	2,427,710	kWh
Percent of Electricity Usage Covered by Solar (Year	59.18%	

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