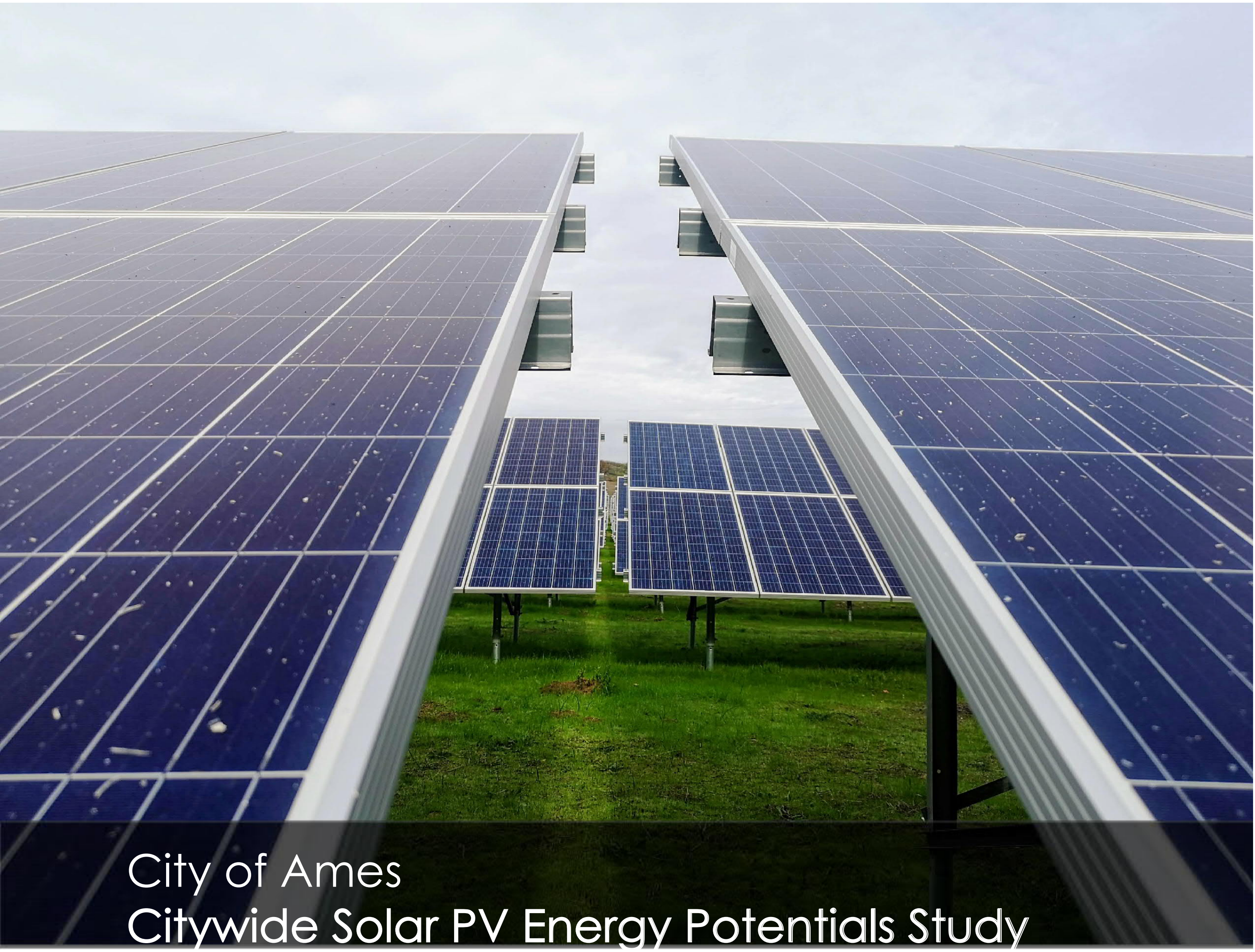
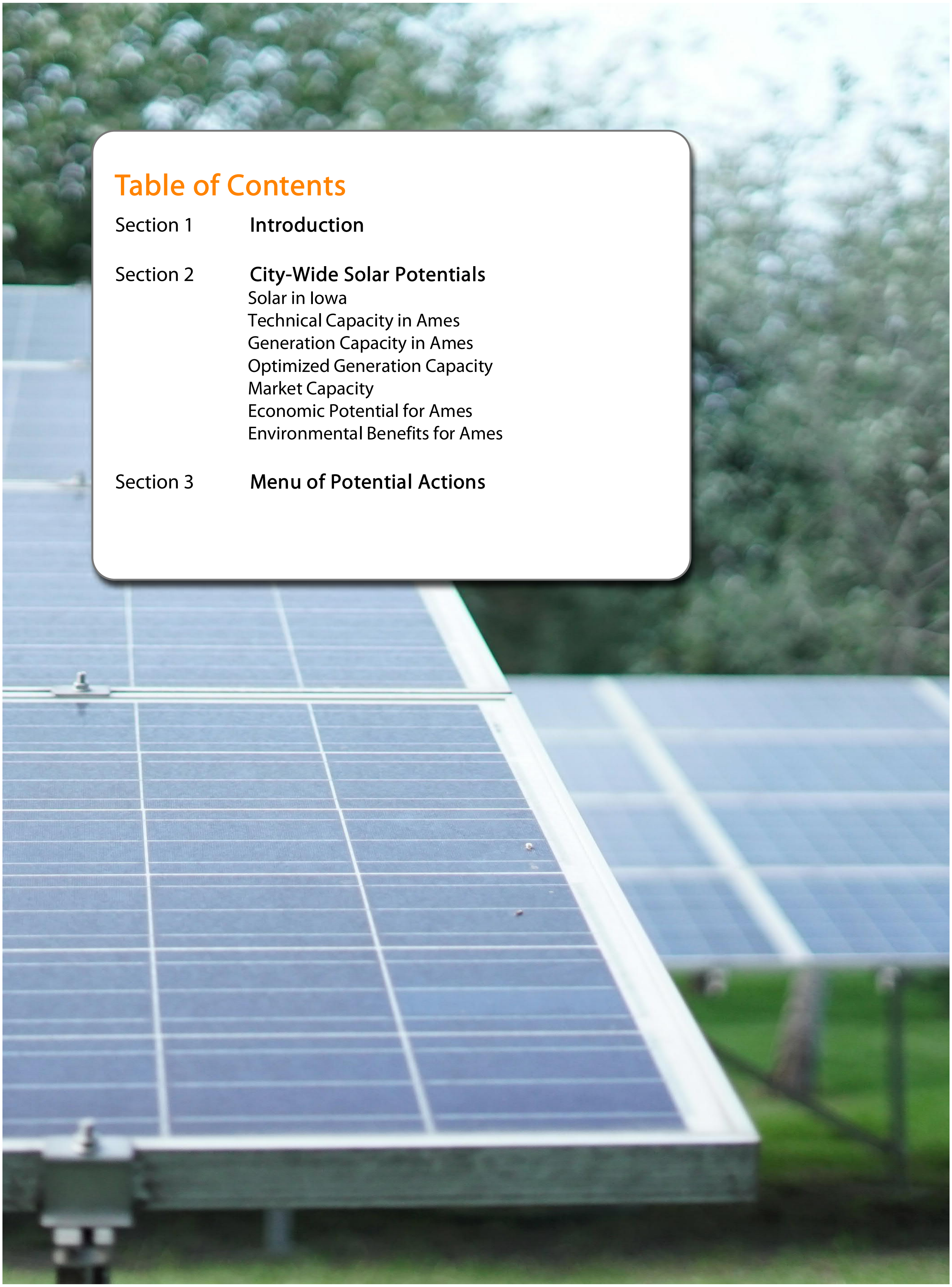
CITY OF Ames



City of Ames
Citywide Solar PV Energy Potentials Study

July 2020

Prepared by: making change personal paleBLUEdot LLC



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Section 01

Introduction

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Introduction

The intent of this study is to determine the overall rooftop solar pv potential throughout the City of **Ames.** 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 citywide solar pv implementation goals through 2040. In addition, this section reviews the potential economic and environmental impacts of this citywide solar pv potential. Section 3 provides a menu of potential actions to advance solar pv installations in the city. Final actions should be established through a Climate Action Plan planning effort.

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.

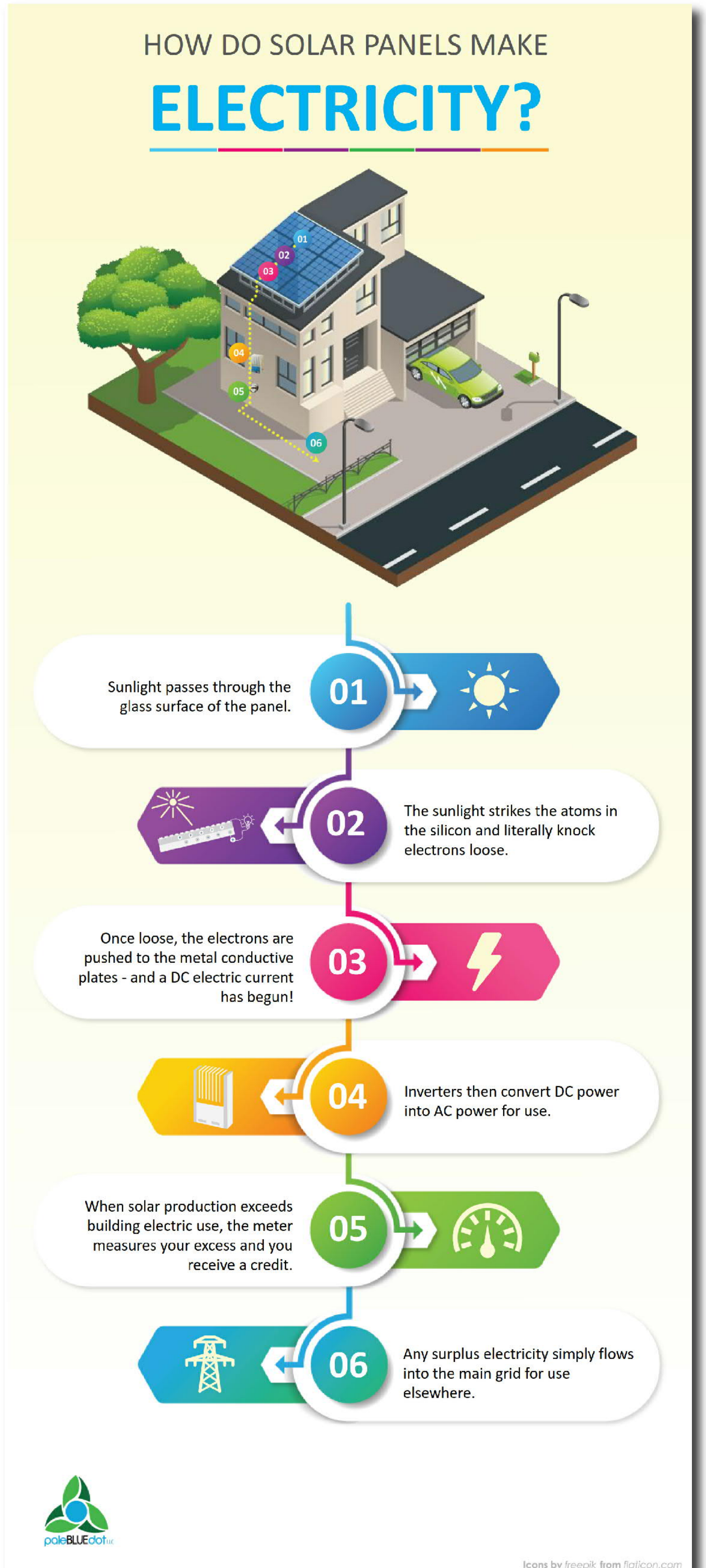
Introduction

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

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.



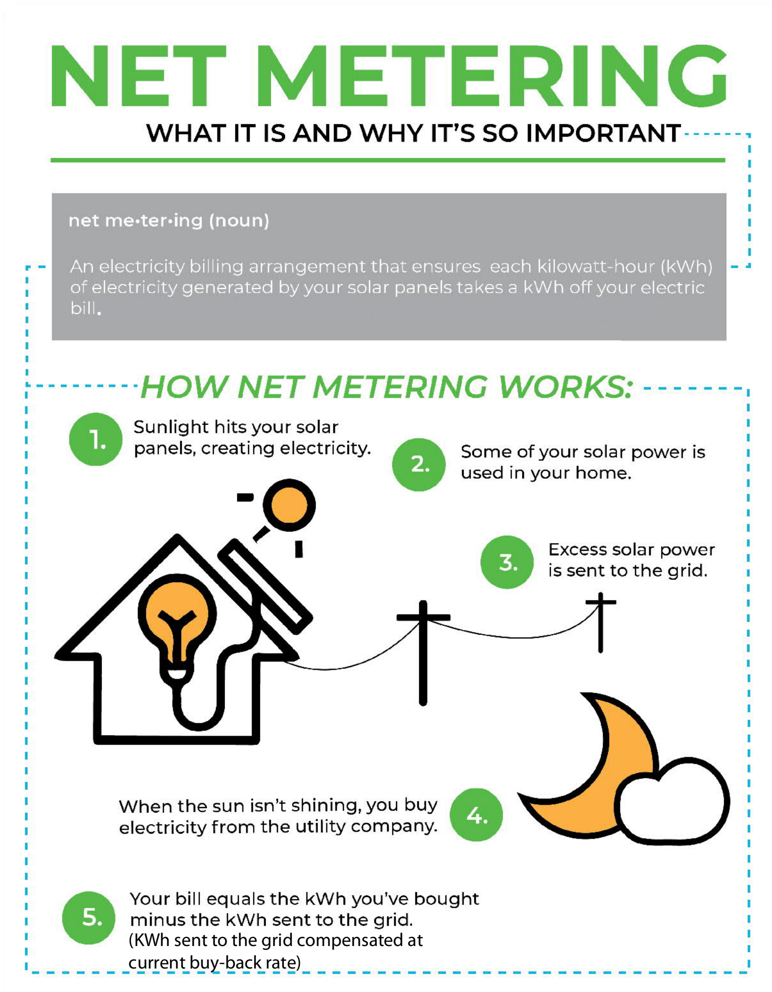
Introduction

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).

Learn more about Net Metering in the State of Iowa here: https://iub.iowa.gov/regulated-industries/electric/site-distributed-generation

Learn more about Ames solar interconnection and net metering policies here: https://www.cityofames.org/government/departments-divisions-a-h/electric/smart-energy/solar-energy/installing-a-rooftop-solar-energy-system



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. It is important to remember that a REC also embodies the claim to the greenness attributes of renewable electricity generation, and only the ultimate consumer of the REC has rights to the claim; 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 owner and user of a Renewable Energy Certificate (REC) is the only party that can claim the environmental benefits of that REC and claim to be using renewable energy because of that REC. Naturally, issues of REC ownership, validity of certain claims and avoiding double counting are central to a robust voluntary renewable energy market.

Many building owners interested in pursuing the installation of a solar pv system on their property are motivated from an interest in using (and claiming) renewable energy for operations. When all such motivated organizations are engaging in the purchase of solar pv arrays or the purchase of solar power, very careful understanding of a project’s Renewable Energy Credits and the status of their ownership is critical. Failure to carefully define ownership of REC may cause the inability of a building owner to claim the renewable benefits they wish to obtain.

Any building or site owner purchasing solar PV through a “third party” project delivery method, community solar subscription, or any project which utilizes a utility subsidized approach, should assume that RECs will not be available to the site owner. In those project delivery methods, the building or site owner would assume that all RECs will be retained by the array owner unless explicitly stated otherwise in the third party solar agreement.

From a Greenhouse Gas accounting perspective, this means that facilities served through community solar subscriptions or third party ownership structures will typically 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 building or site owner’s GHG Inventory will need to use the regional electric grid emissions factors for calculation of emissions.

It may be possible for the building or site owner to retain REC credits, however, and paleBLUEdot recommends that building or site owners pursuing “third party” project delivery methods explore the retention of all REC credits produced by the recommended projects if financially feasible.

Project Delivery Options

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 many building and site owners, 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 26%.

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.

Section 02

City-Wide Solar Potentials

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City-Wide Solar Potentials

Solar In Iowa

As of March, 2020, Iowa has a total of 139.6 megawatts (139,600,000 watts) of solar capacity installed statewide. There are a total of 5,462 solar installations in the State. The State of Iowa ranks 39th nationally for total solar energy production capacity.

The State's solar installation total is enough to power 17,300 homes. The share of the State's total electricity use that comes from solar power, however, is less than 0.3%. This indicates great potential for growth throughout the State. Current solar growth projections for the State equal an additional 374 MW over the next 5 years - a growth rate that ranks 38th nationally.

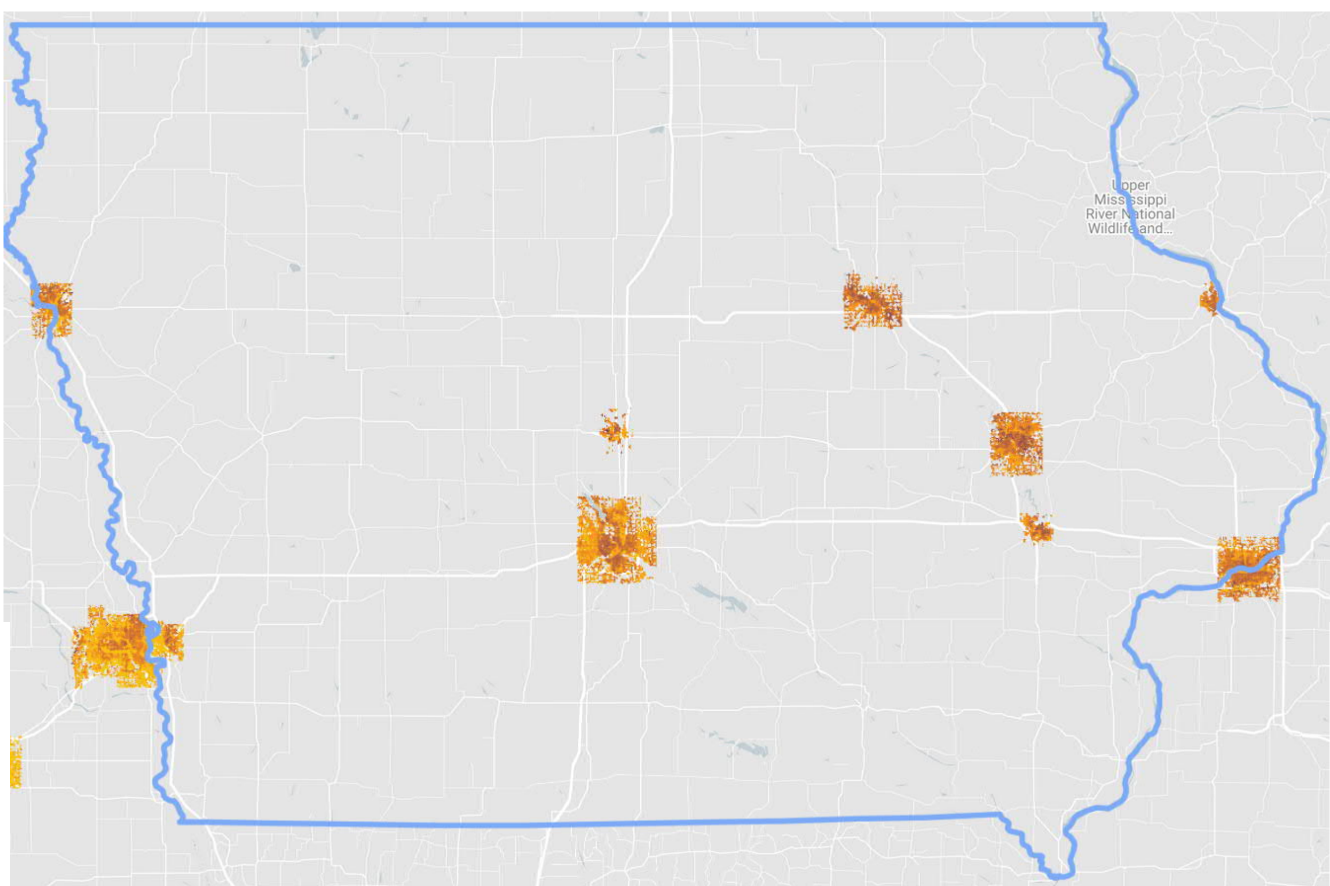
Costs for Solar PV installation in the State have declined 36% since 2015. Price declines have been accompanied with increasing rate of investment in solar energy. A total of $223,860,000 has been invested in Solar PV installations. The industry currently employs 844 people in 72 companies Statewide.

(source: Solar Energy Industries Association SEIA)

Buildings 74% solar-viable	Roof space 528M sq ft	Roofs 350K
4,015 existing solar installations	Capacity 7.5K MW DC	Electricity 8.8M MWh AC per yr

Based on 35% data coverage over buildings in this geographic area. All estimates are based on buildings viable for solar panels. Included panels receive at least 75% of the maximum annual sun in the county. For Iowa, the average value of the threshold is 1,012 kWh/kW

(source: Project Sunroof, SEIA)



City-Wide Solar Potentials

The SOLAR FOUNDATION™ for a bright future

IOWA

SOLAR JOBS CENSUS 2018

There are 242,343 Americans working in solar as of 2018, according to The Solar Foundation's latest *National Solar Jobs Census*. Visit SolarStates.org to view an interactive map of solar jobs in 2018 by state, county, metro area, and congressional district.

Iowa supported over 800 solar jobs in 2018. With the right policies, the state has the potential to catch up to other Midwestern states and create thousands of additional jobs.

STATE SOLAR JOBS: 844

39 STATE RANKING FOR SOLAR JOBS

45 STATE RANKING FOR SOLAR JOBS PER CAPITA

29 New Solar Jobs, 2018

3.6% Solar Jobs Growth, 2018

27 State Rank by Net Solar Jobs Added, 2018

11.5% Projected Jobs Growth, 2019

15.4% Percentage of State Solar Workers Who Are **Veterans**

SOLAR JOBS BY SECTOR

INSTALLATION
545 *(1% increase)*

MANUFACTURING
143 *(7% decrease)*

WHOLESALE TRADE & DISTRIBUTION
69 *(12% decrease)*

OPERATIONS & MAINTENANCE
54

OTHER
34 *(25% decrease)*

SOLAR POLICY CONTEXT

B Net Metering Policy Grade[6]

A Interconnection Policy Grade[12]

Solar installations up to 1 MW receive compensation for solar sent back to the grid credited at the retail rate, though utilities can reduce compensation based on customer demand. There is no limit to the number of systems covered under net metering.

RENEWABLE PORTFOLIO STANDARD[10]
105 MW
by no specified date

RENEWABLE PORTFOLIO STANDARD CARVEOUTS[10]
N/A
Solar
N/A
Distributed Generation

COMMUNITY SOLAR[8]
N/A

COMMUNITY CHOICE AGGREGATION STATUS[9]
CCA Not Available

LEGAL STATUS OF THIRD PARTY OWNERSHIP[10]
Authorized by state, at least in certain jurisdictions

PROPERTY ASSESSED CLEAN ENERGY FINANCING (PACE) STATUS[11]
N/A

STATE INSTALLER LICENSING REQUIREMENTS[7]
Electrician's License

33%
Employers Reporting It Was "Very Difficult" to Hire Qualified Employees

36
STATE RANKING FOR AVERAGE ELECTRICITY PRICE[3]
(Highest to Lowest)

9.35
CENTS/kWh
AVERAGE ELECTRICITY PRICE[3]

(source: Solar Foundation)

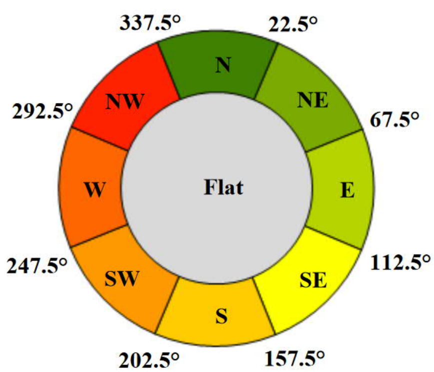
City-Wide Solar Potentials

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

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 codes 52001, 52002, 52003 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.

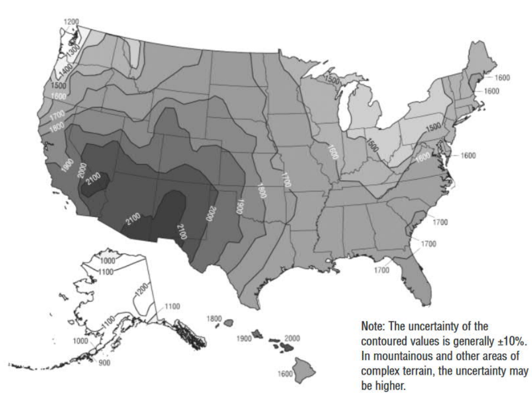
All roof planes with Northwest, North, and Northeast azimuths were excluded from this study.

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.



Citywide Electric Use

2014 Electric Use

Total:	Residential	Comm/Industrial
743.1 Gwh	175.5 Gwh (25.8%) 2,724 kWh/Resident	549.6 Gwh (70.9%) 15,836 kWh/Job

2018 Electric Use

Total:	Residential	Comm/Industrial
765.1 Gwh	197.7 Gwh (25.8%) 2,973 kWh/Resident 9.1% per capita increase	543.0 Gwh (70.9%) 14,986 kWh/Job 6.4% per job reduction

(Source: Ames GHG Inventory, US Census OnTheMap)

City-Wide Solar Potentials

Technical Capacity In Ames

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 12,910 total buildings in Ames, of those, it is estimated that 10,061 are "solar suitable" buildings.

These solar suitable buildings have an estimated 18,497 roofplanes which are either flat or with an azimuth orientation of East, Southeast, South, Southwest, or West, with a total estimated square footage of 5.8 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 93.2 Megawatts DC. As a reference, the City's historical peak energy demand has been 130 Megawatts.

Generation Capacity In Ames

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 2-4).

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 101,217,582 KWH annually, approximately 14% of the City's total electric consumption (based on US Energy Information Agency data, City of Ames Greenhouse Gas Inventory).

Generation Capacity In Ames By Roof Slope and Orientation

Breakdown by Roof Orientation (Azimuth)

Breakdown by Roof Tilt			Flat		Low Tilt		Mid-Low Tilt		Mid-High Tilt		High Tilt	
Flat												
Suitable Buildings	2,111	20.98%	**2,111**		0		0		0		0	
Suitable Roof Planes	3,884	20.98%	**3,884**		0		0		0		0	
Square Footage	1,227,774	21.01%	**1,227,774**		0		0		0		0	
Capacity (KW dc)	19,582	21.01%	**19,582**		0		0		0		0	
Generation (KWH)	24,438,600	24.14%	**24,438,600**		0		0		0		0	
Subtotal South Facing												
Suitable Buildings	2,624	26.08%	0		**561**		**1,683**		**379**		**1**	
Suitable Roof Planes	4,829	26.08%	0		**1,033**		**3,097**		**697**		**2**	
Square Footage	1,526,668	26.12%	0		**326,523**		**979,051**		**220,366**		**728**	
Capacity (KW dc)	24,349	26.12%	0		**5,208**		**15,615**		**3,515**		**12**	
Generation (KWH)	27,087,904	26.76%	0		**5,595,235**		**17,329,902**		**4,149,610**		**13,157**	
West + Southwest												
Suitable Buildings	2,640	26.24%	0		**480**		**1,711**		447		2	
Suitable Roof Planes	4,858	26.24%	0		**883**		**3,149**		822		4	
Square Footage	1,536,070	26.28%	0		**279,158**		**995,568**		259,889		1,456	
Capacity (KW dc)	24,499	26.28%	0		**4,452**		**15,879**		4,145		23	
Generation (KWH)	24,960,281	24.66%	0		**4,369,453**		**16,096,615**		4,470,177		24,037	
East + Southeast												
Suitable Buildings	2,687	26.71%	0		**490**		1,749		447		2	
Suitable Roof Planes	4,945	26.71%	0		**901**		3,218		822		4	
Square Footage	1,554,611	26.60%	0		**284,766**		1,017,328		251,060		1,456	
Capacity (KW dc)	24,795	26.60%	0		**4,542**		16,226		4,004		23	
Generation (KWH)	24,730,796	24.43%	0		**4,365,925**		16,111,479		4,229,848		23,544	
Grand Total			**Subtotal: Flat Roof**		**Subtotal: Low Tilt**		**Subtotal: Mid-Low Tilt**		**Subtotal: Mid-High Tilt**		**Subtotal: High Tilt**	
Suitable Buildings	10,061		2,111	20.98%	1,531	15.21%	5,143	51.11%	1,272	12.64%	5	0.05%
Suitable Roof Planes	18,516		3,884	20.98%	2,817	15.21%	9,464	51.11%	2,341	12.64%	10	0.05%
Square Footage	5,845,123		1,227,774	21.01%	890,447	15.23%	2,991,947	51.19%	731,316	12.51%	3,639	0.06%
Capacity (KW dc)	93,226		19,582	21.01%	14,202	15.23%	47,720	51.19%	11,664	12.51%	58	0.06%
Generation (KWH)	101,217,582		24,438,600	24.14%	14,330,612	14.16%	49,537,996	48.94%	12,849,634	12.70%	60,739	0.06%

City-Wide Solar Potentials

Optimized Generation Capacity In Ames

Though the total energy generation outlined above is reasonably feasible, for purposes of establishing Citywide 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 Ames, 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.

The chart below illustrates all solar suitable roof planes with roof tilt and azimuth orientation combinations likely to be consistently cost effective. These 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 Ames is estimated to be 76,358,497 KWH annually, approximately 10.7% of the City's total electric consumption.

Optimized Generation Capacity In Ames By Roof Slope and Orientation

Breakdown by Roof Orientation (Azimuth)

Breakdown by Roof Tilt			Flat		Low Tilt		Mid-Low Tilt		Mid-High Tilt		High Tilt	
Flat												
Suitable Buildings	2,111	28.46%	**2,111**		0		0		0		0	
Suitable Roof Planes	3,884	28.46%	**3,884**		0		0		0		0	
Square Footage	1,227,774	28.46%	**1,227,774**		0		0		0		0	
Capacity (KW dc)	19,582	28.46%	**19,582**		0		0		0		0	
Generation (KWH)	24,438,600	32.01%	**24,438,600**		0		0		0		0	
Subtotal South Facing												
Suitable Buildings	2,624	35.39%	0		**561**		**1,683**		**379**		**1**	
Suitable Roof Planes	4,829	35.39%	0		**1,033**		**3,097**		**697**		**2**	
Square Footage	1,526,668	35.39%	0		**326,523**		**979,051**		**220,366**		**728**	
Capacity (KW dc)	24,349	35.39%	0		**5,208**		**15,615**		**3,515**		**12**	
Generation (KWH)	27,087,904	35.47%	0		**5,595,235**		**17,329,902**		**4,149,610**		**13,157**	
West + Southwest												
Suitable Buildings	2,191	29.55%	0		**480**		**1,711**		0		0	
Suitable Roof Planes	4,032	29.55%	0		**883**		**3,149**		0		0	
Square Footage	1,274,725	29.55%	0		**279,158**		**995,568**		0		0	
Capacity (KW dc)	20,331	29.55%	0		**4,452**		**15,879**		0		0	
Generation (KWH)	20,466,067	26.80%	0		**4,369,453**		**16,096,615**		0		0	
East + Southeast												
Suitable Buildings	490	6.60%	0		**490**		0		0		0	
Suitable Roof Planes	901	6.60%	0		**901**		0		0		0	
Square Footage	284,766	6.60%	0		**284,766**		0		0		0	
Capacity (KW dc)	4,542	6.60%	0		**4,542**		0		0		0	
Generation (KWH)	4,365,925	5.72%	0		**4,365,925**		0		0		0	
Grand Total			**Subtotal: Flat Roof**		**Subtotal: Low Tilt**		**Subtotal: Mid-Low Tilt**		**Subtotal: Mid-High Tilt**		**Subtotal: High Tilt**	
Suitable Buildings	7,415		2,111	28.46%	1,531	20.64%	3,394	45.77%	379	5.11%	1	0.01%
Suitable Roof Planes	13,646		3,884	28.46%	2,817	20.64%	6,246	45.77%	697	5.11%	2	0.01%
Square Footage	4,313,933		1,227,774	28.46%	890,447	20.64%	1,974,619	45.77%	220,366	5.11%	728	0.02%
Capacity (KW dc)	68,805		19,582	28.46%	14,202	20.64%	31,494	45.77%	3,515	5.11%	12	0.02%
Generation (KWH)	76,358,497		24,438,600	32.01%	14,330,612	18.77%	33,426,517	43.78%	4,149,610	5.43%	13,157	0.02%

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 Iowa section of this report, the installed cost of solar PV in Iowa has dropped 36% since 2015 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.

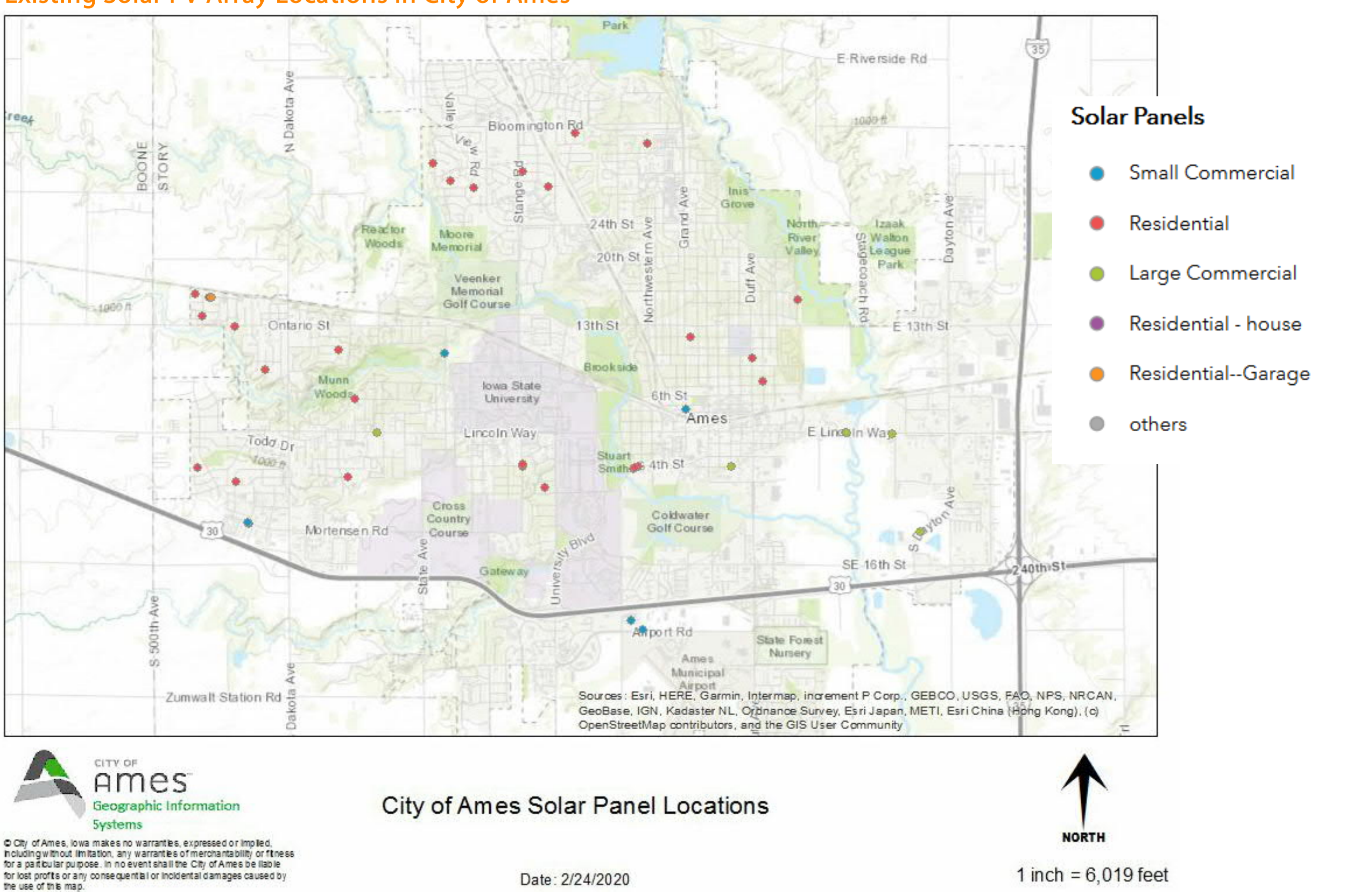
Market History

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 Iowa, the new installed capacity that went on line in 2016 was 22 MW; equal to 1/3rd of the cumulative total of all solar PV installations in the state for all previous years.

Existing Ames Market

According to the Ames Electric Solar Panel Locations tracker managed by the City of Ames Electric Department, there was a total of 142 solar PV arrays with a total installed capacity of 1,031 as of March 2020. The current citywide solar PV share of the State of Iowa's solar market is 0.75% based on existing installed capacity, while the number of arrays installed in Ames is equal to 2.6% of the total number of arrays in the State - an absorption rate higher than State average. This means that the average array size in the city of Ames is smaller than the average array size statewide. Comparing these numbers to the city's share of the State's population (2.11% of State population) we can see that the city of Ames is slightly out-pacing the rate of solar adoption in terms of number of arrays constructed, but behind the statewide average in terms of total installed capacity. In the coming years, the City of Ames may wish to explore opportunities to increase new installations of larger scaled arrays as a strategy to keep pace with the projected statewide solar market trends.

Existing Solar PV Array Locations in City of Ames



City-Wide Solar Potentials

State Market Projections

The Solar Energy Industries Association (SEIA) projects solar PV installation capacity in the State to increase 374 MW by 2025. This is equal to a sustained compound increase of installed capacity of 30% annually. The timeframe of this projection overlaps 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.

Ames Market Absorption Projections

Scenario A: Maintaining Current City Adoption Rate and Average Array Size (7.3 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 (0.74% of State installations based on installed generating capacity) with an assumed maintained average array size of 7.3 KW would mean an increase of 2,762 KW of installed capacity within the city by 2025, for a total of 3,793 KW citywide. This is equivalent to approximately 2.96% of the total rooftop technical capacity potential or 4% of the optimized capacity potential within the city.

Following the projected elimination of the residential portion and a scaling back of the commercial portion of the Federal residential tax incentive, a reasonable assumption may be a partial reduction in the annual growth rate for years 2025 through 2030. As the market continues to mature through the 2020's it may, again, be reasonable to assume another reduction in the growth rate of new installed capacity beginning in year 2031. For purposes of this study, we recommend a 2/3rd reduction of the annual rate of growth for 2025 and then again at 2030. This would result in a growth rate of 37% through 2025 (as projected by SIEA), a 12% growth rate for years 2025 through 2030, and a mature market growth rate of 3.4% beginning in 2031.

Scenario A: Maintaining Current City Adoption Rate and Average Array Size (7.3 KW)

Ames Solar PV Projection

Based Maintaining Existing Share of Installed Capacity x Potential Market Absorption

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of City Electric Consumption
2025	3,793	4,118,292	**0.67%**
2030	6,685	7,257,837	**1.19%**
2040	9,857	10,702,123	**1.75%**

NOTE: This projection does not include distributed ground-mounted solar pv potentials nor utility scale solar pv installation potential.

Ames Market Absorption Projections

Scenario B: Based on Potential Market Absorption and Increasing City Adoption Rate to Population Share

As noted earlier, the city of Ames 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 7,880 KW of installed capacity within the city by 2025 for a total of 8,911 KW citywide. This is equivalent to approximately 8.5% of the total rooftop technical capacity potential or 11.5% of the optimized capacity potential within the city.

Following the projected elimination of the residential portion and a scaling back of the commercial portion of the Federal residential tax incentive, a reasonable assumption may be a partial reduction in the annual growth rate for years 2025 through 2030. As the market continues to mature through the 2020's it may, again, be reasonable to assume another reduction in the growth rate of new installed capacity beginning in year 2031. For purposes of this study, we recommend a 2/3rd reduction of the annual rate of growth for 2025 and then again at 2030. This would result in a growth rate of 37% through 2025 (as projected by SIEA), a 12% growth rate for years 2025 through 2030, and a mature market growth rate of 3.4% beginning in 2031.

Scenario B: Based on Potential Market Absorption and Increasing City Adoption Rate to Population Share

Ames Solar PV Projection

Based Population Share of Potential Market Absorption

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of City Electric Consumption
2025	8,911	9,675,208	**1.58%**
2030	15,705	17,051,022	**2.78%**
2040	23,158	25,142,769	**4.11%**

NOTE: This projection does not include distributed ground-mounted solar pv potentials nor utility scale solar pv installation potential.

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 Ames

According to the National Renewable Energy Laboratory (NREL), the 22.1 MW of additional solar pv capacity which could be installed in the city by 2040 in Scenario B has a total construction value of $49 million (2020 dollars). The potential share of those investments for the local economy totals 24 jobs and $6.24 million in local income potential during construction and 14 jobs and $0.94 million in local income potential for maintenance annually through the lifetime of the installations. Below is a breakout of the Ames economic development potential of new installed solar pv capacity through 2040 based on Scenario B projection numbers:

Ames Local Economic Impacts - Summary Results

Based Scenario B Projection

	Jobs	Earnings	Output	Value Added
During construction period		**Million$ 2020**	**Million$ 2020**	**Million$ 2020**
Project Development and Onsite Labor Impacts	24	$3.38	$4.61	$3.76
Construction and Interconnection Labor	16	$2.91		
Construction Related Services	9	$0.47		
Equipment and Supply Chain Impacts	24	$1.59	$6.50	$3.20
Induced Impacts	21	$1.26	$3.50	$1.91
Total Impacts	**69**	**$6.24**	**$14.60**	**$8.87**
	Annual Jobs	**Annual Earnings**	**Annual Output**	**Annual Value Added**
During operating years (annual)		**Million$ 2020**	**Million$ 2020**	**Million$ 2020**
Onsite Labor Impacts	10	$0.68	$0.68	$0.68
Local Revenue and Supply Chain Impacts	2	$0.12	$0.35	$0.24
Induced Impacts	2	$0.14	$0.38	$0.20
Total Impacts	**14**	**$0.94**	**$1.41**	**$1.12**

Additional Economic Benefit

In addition to the local re-investment share of the construction and maintenance costs, Ames 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 2025 outlined in Scenario B in the previous section, this could mean $1.7 million up to $4.6 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 Ames under Scenario B is $85,000 to $110,000 annually by 2025 (These numbers assume third party ownership structure with common savings per kWh consumed. Long-term savings for direct ownership can be significantly higher)

City-Wide Solar Potentials

Environmental Benefits for Ames

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 Ames 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 Ames is 5,306,500 gallons.

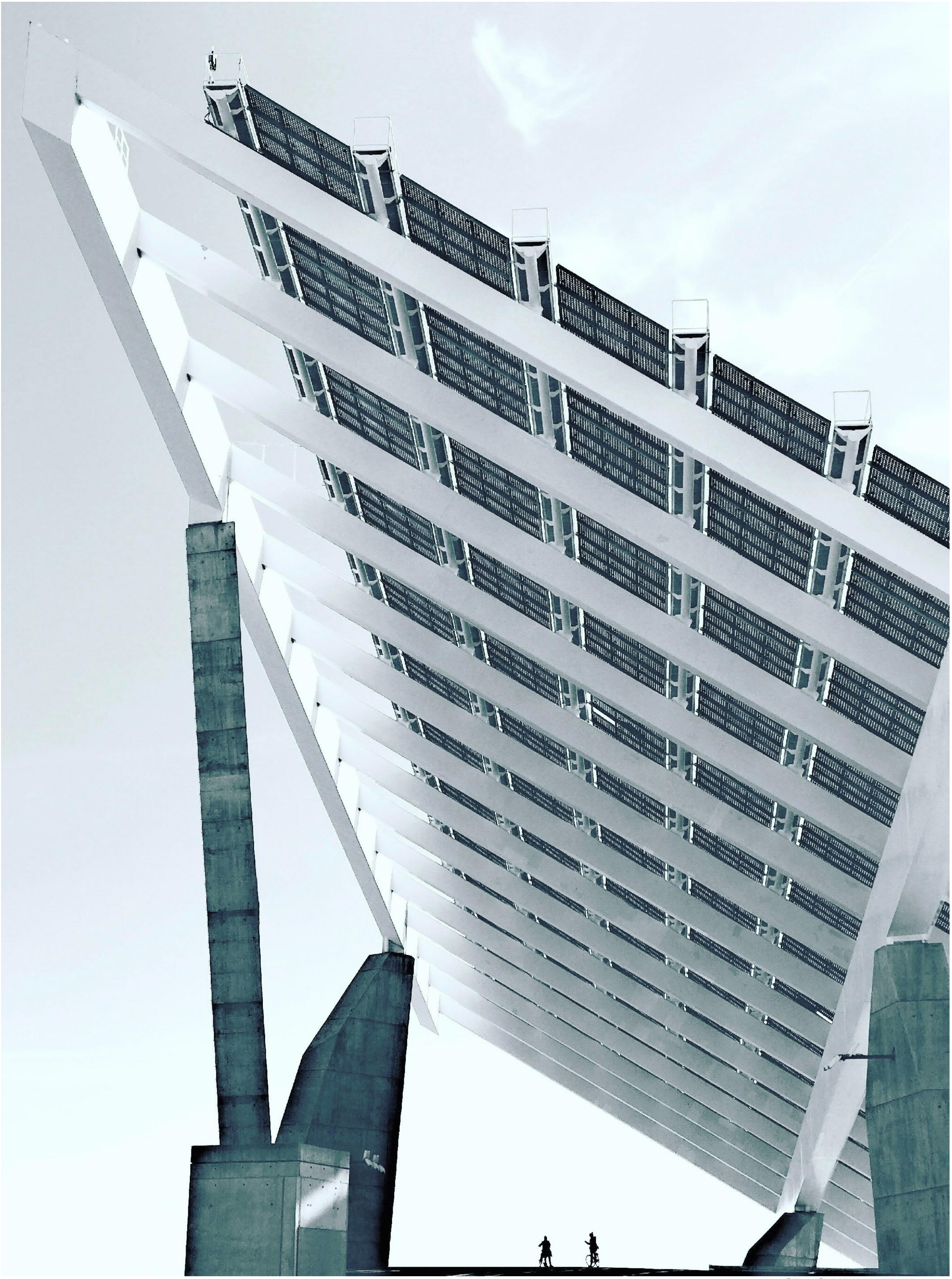
Based on these numbers, by 2025 the additional solar pv installed in the city of Ames in Scenario A can reduce its Greenhouse Gas emissions by 2,578 metric tons (51.1 million cubic feet of man-made greenhouse atmosphere), while the additional solar installed in Scenario B can reduce its Greenhouse Gas emissions by 6,057 (120.2 million cubic feet of man-made greenhouse atmosphere). These reductions are based on the average electric emissions factor as identified in the *Community Greenhouse Gas Inventory*.

Carbon and Water Footprint Reduction Potential - Sceanario A

Year	Annual Generation (GWH)	GHG Emission Reduction (mTons)	GHG Emission Reduction (Cubic Feet of Atmosphere)	Water Footprint Reduction (Mgallons)
2025	4.12	2,578	51,152,133	21.85
2030	7.26	4,543	90,147,536	38.50
2040	10.70	6,700	132,928,030	56.77

Carbon and Water Footprint Reduction Potential - Scenario B

Year	Annual Generation (GWH)	GHG Emission Reduction (mTons)	GHG Emission Reduction (Cubic Feet of Atmosphere)	Water Footprint Reduction (Mgallons)
2025	9.68	6,057	120,173,009	51.32
2030	17.05	10,674	211,785,904	90.45
2040	25.14	15,739	312,291,209	133.37



Section 03

Menu of Potential Actions

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City-Wide Solar Potentials

Community-Wide Solar Menu of Potential Actions

In support of the City's interest in Greenhouse Gas emissions reductions and increase in renewable energy generation, the following are a menu of potential actions for the City's consideration and exploration. Note, final actions should be established through a detailed Climate Action Planning effort):

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 incentives and opportunities for financing.

    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) Conduct a "Solar Top 50" study to identify the top 50 commercial and industrial properties for on-site solar generation. Develop feasibility assessments for each property illustrating energy generation potential and estimated return on investment. Combine feasibility information with information developed in item a above and provide to each subject property owner.

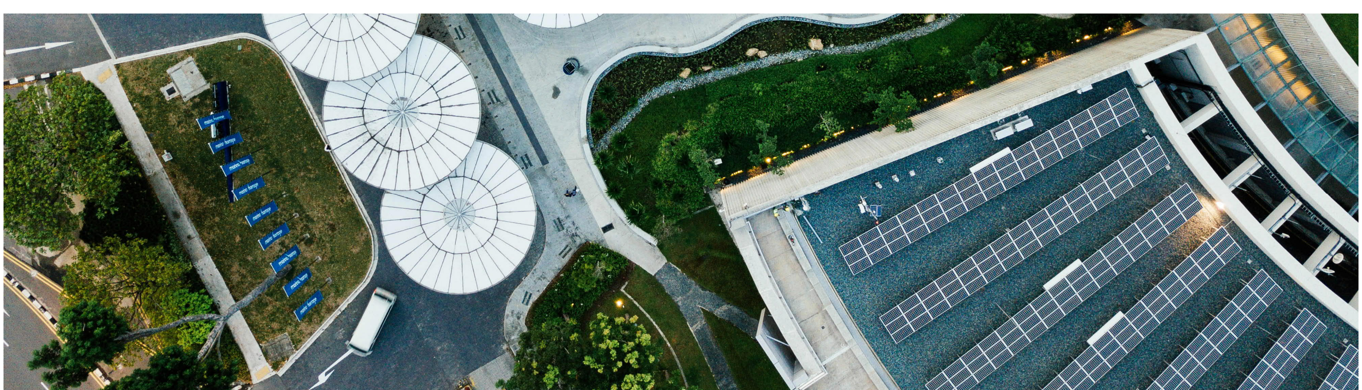
    d) Organize and lead a Commercial Group Purchasing campaign in 2020 and 2021 to competitively bid contractors to offer maximum cost savings based on power of quantity buying. This program could focus on the Solar Top 50 sites identified in item c above as well as combined with City facilities. Program should explore the inclusion of cash purchase as well as third party purchase options.

    e) 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.

    f) 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.

    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 be Solar Ready.

    h) 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)



Community-Wide Solar Menu of Potential Actions (continued)

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

i) Continue the City's SolSmart designation efforts and advance to Gold level

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

k) Establish a requirement that all new construction projects requiring a Conditional Use Permit or Planned Unit Development be designed to the City's Solar Ready Guidelines developed in item f above.

l) 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)

m) Establish a requirement that all private or public projects receiving City of Ames funding be constructed as fully solar ready and include an on-site solar pv array.

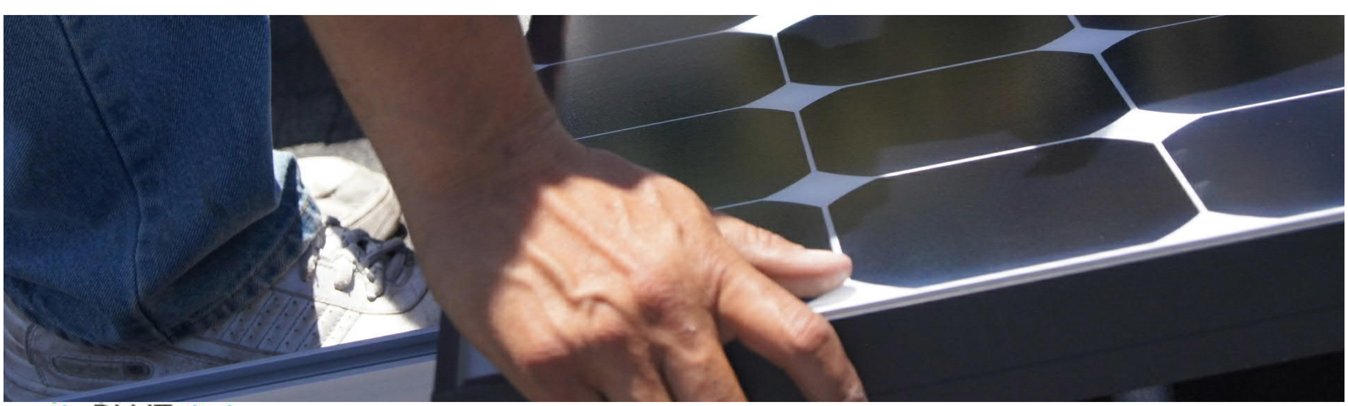
n) Coordinate with other Iowa municipalities and advocate for the establishment of Property Assisted Clean Energy (PACE) financing legislation. Coordinate with Story County to establish a Countywide PACE program.

o) 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 based funding sources.

p) 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 Ames. The goal of establishing a robust business atmosphere capable not only of serving Ames renewable energy and green economy needs but fulfilling a unique economic niche within the region.

Municipal Refuse Derived Fuel (RDF)

3) Explore implementation of options which result from the pending the completion of the City's Refuse Derived Fuel (RDF) study identifying opportunities to maximize energy production and reduce rejects sent to the landfill.



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