

City of Fitchburg Solar Renewable Energy Potentials Study

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Photo: Ideal Energies, LLC





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Introduction



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Introduction

Intent of This Study

The intent of this study is to support the City in appropriate and effective renewable energy goalsetting within the City's Sustainability Planning process. This study seeks also to help the City establish strategies addressing renewable energy development. The primary focus of this study is to establish the Community-Wide rooftop solar PV potential throughout the City, including economic and environmental benefits.

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.

Structural Capacity for Rooftop Arrays

The assessments included in this report do not include assessments of rooftop 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 DO SOLAR PANELS MAKE ELECTRICITY?



Sunlight passes through the glass surface of the panel.

01



02

The sunlight strikes the atoms in the silicon and literally knocks electrons loose.

Once loose, the electrons are pushed to the metal conductive plates - and a DC electric current has begun!

03



04

Inverters then convert DC power into AC power for use.

When solar production exceeds building electric use, the meter measures your excess and you receive a credit.

05



06

Any surplus electricity simply flows into the main grid for use elsewhere.



Icons by Freepik from flaticon.com



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).

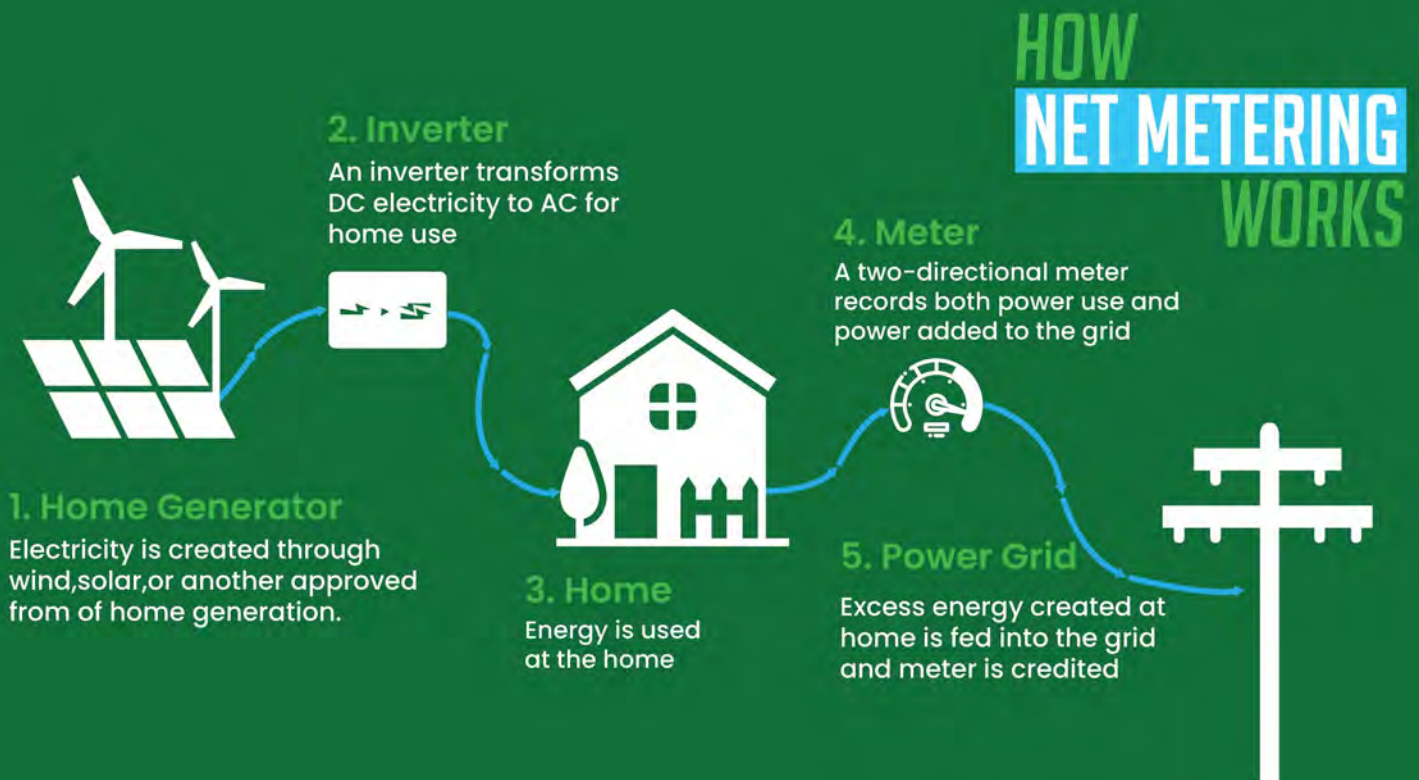
Net Metering in Fitchburg

According to the State of Wisconsin Public Service Commission:

Net metering (also known as net energy billing) is available in Wisconsin for investor-owned utility and municipal utility customers who wish to install an electric generator 20-kilowatts or less in size. Electric providers may also offer other buy-back rates for electricity produced by a customer-owned facility that vary by technology and system size.

Learn more about Net Metering in the State of Wisconsin here:

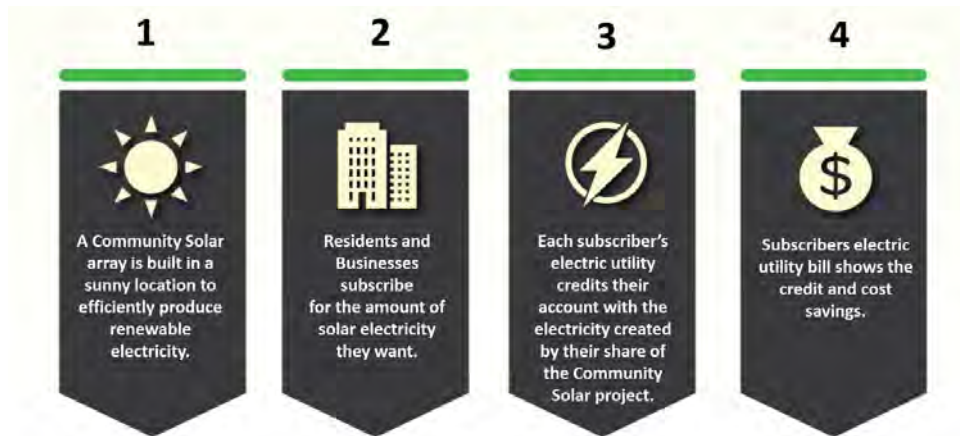
<https://psc.wi.gov/Pages/ForUtilities/Energy/NetMeteringandBuyBackTariffs.aspx>



Introduction

Wisconsin's Group Net Metering

Community solar is a distributed solar energy deployment model enabling customers to purchase or rent a portion of a larger solar photovoltaic (PV) system located offsite and shared with others. Members of the community who sign up for a solar facility get compensation for the energy their share generates, either through reduced electricity bills or energy credits. In Wisconsin, only licensed utilities and cooperatives are authorized to offer community solar energy to consumers. While some utility companies, such as Xcel Energy's Solar Connect or Madison Gas and Electric, do offer a communal solar subscription service, the majority of utilities in Wisconsin currently lack a similar program for their customer base.



How Does Community Solar Work 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's crucial to note that a Renewable Energy Certificate (REC) also represents the environmental benefits of generating electricity from renewable sources. Only the final holder of the REC has the exclusive right to make this 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.

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. 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. Building owners 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. It may be possible for building owners to retain REC credits, however, and paleBLUeDot recommends that any building owner looking into “third party” solar arrays explore the retention of all REC credits produced by the recommended projects if financially feasible.

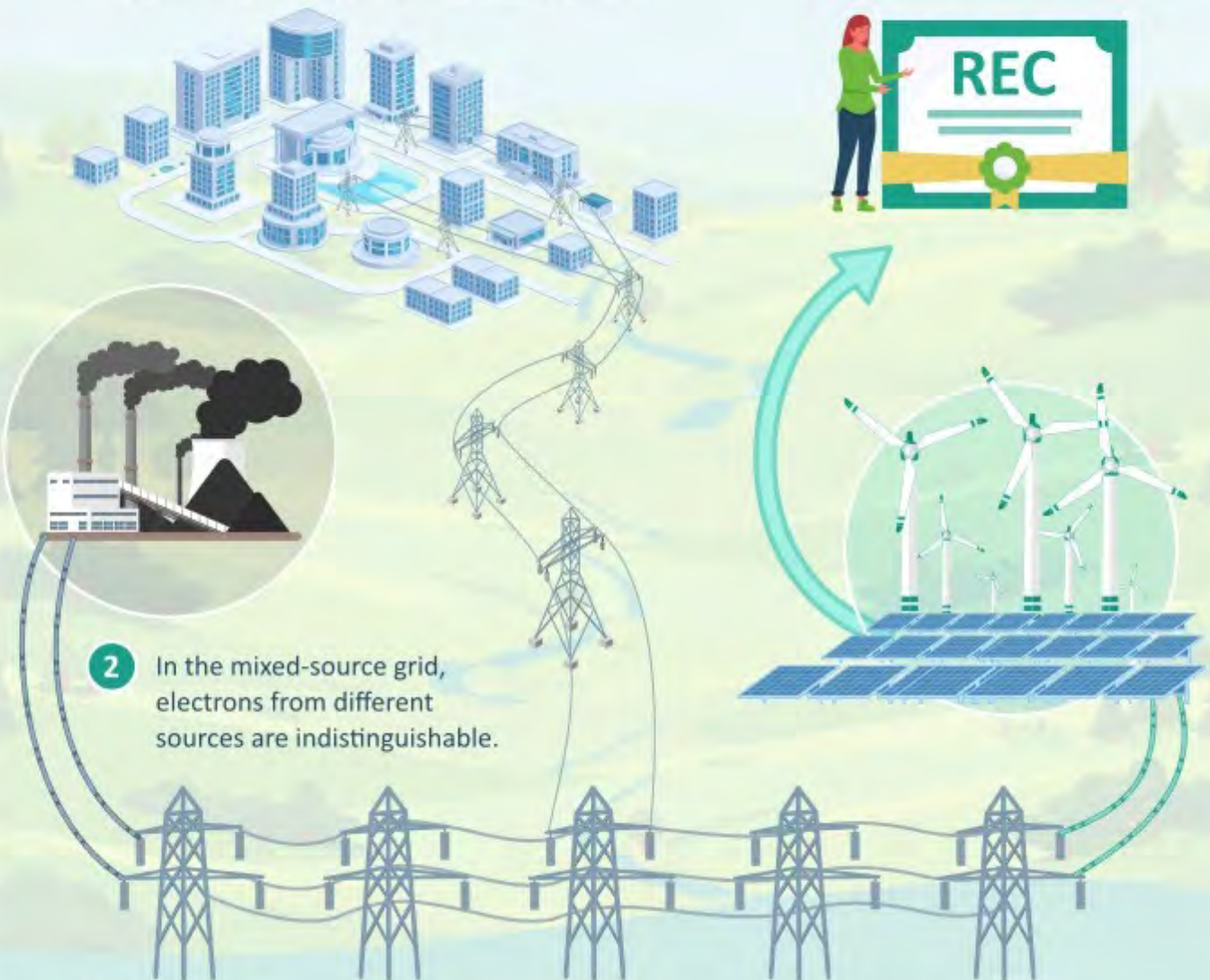
From a Greenhouse Gas accounting perspective, this means that facilities served through community solar subscriptions or third party ownership structures will not be able to account for emissions reductions due to renewable energy use unless REC credits are purchased. In this situation, without the purchase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



The Role of Renewable Energy Credits

3 Because the electricity from all sources is blended in the grid, it is unclear which customer receives the actual electrons produced from the renewable energy source.

4 Consumers can purchase RECs to legitimately claim the use of renewable energy.



2 In the mixed-source grid, electrons from different sources are indistinguishable.

1 A REC is generated for each megawatt-hour of renewable electricity added to the grid, representing its environmental benefits.

Introduction

Peak Shaving and Demand Charges

Customers pay for electricity based on consumption (in kWh) or demand (in kW). While residential users usually pay for consumption, many commercial users have tariffs that charge for both. Demand charges are based on the highest power usage within a set time, often a 15-minute interval, per billing cycle. These charges cover costs of running power plants and buying from other utilities.

For high-energy users, demand charges can make up 30% to 70% of their bill. To reduce these charges, many use "peak shaving." This strategy manages demand to avoid sharp spikes, smoothing out electricity use. By integrating solar arrays with battery systems that can be controlled to charge or discharge as needed, users can further lower their peak demand. These smart batteries, with learning algorithms, adjust to a customer's usage pattern, optimizing the switch between grid and battery to save on costs.

Peak Shaving and Local Utilities

Many local electric utilities and co-ops don't produce their own power. Instead, they buy electricity from larger generators and supply it to their customers. Often, these local utilities have long-term power purchase agreements with their suppliers. Sometimes, these agreements have higher prices for peak demand periods, similar to what end customers might face. For utilities with these peak pricing terms, introducing solar arrays and storage systems in their service area can reduce peak demand on the local grid, helping them avoid high peak demand costs.

Project Delivery Options

There are many options for pursuing solar projects for business or residential property including:

Purchasing a System:

Paying for the solar array directly is the simplest path for a property to own a solar array, but the initial cost of a solar panel system can be the biggest hurdle. Through a direct purchase, or "cash option", the property owner purchases the solar system just as a consumer would purchase a car or house.

Solar Lease:

A solar lease is one of the options for "third party ownership" where the solar array is owned by the leasing company and typically installed with no "up front" costs. In a solar lease the customer typically pays a set monthly rate for the solar panel system, but receives free electricity from the panels that offsets the monthly cost of the lease. Solar leases are allowable in many States, however, not all jurisdictions allow solar leases. The State of Wisconsin does allow for solar leases.

Power Purchasing Agreement (PPA):

A solar power purchase agreement (PPA) is a contract where a developer sets up a solar system on a customer's property. The customer buys the generated power from the developer, usually at a rate cheaper than the local utility. Monthly payments are based on the energy the system produces. This helps the customer reduce their grid electricity costs. The developer benefits from electricity sales, tax credits, and other incentives. Customers wanting to claim the solar energy's "green" benefits need to discuss retaining the Renewable Energy Credits with the developer.

Solar Financing and Incentives

Solar energy delivers positive environmental impacts, and contributes to our nation's energy independence. The 2019 U.S. Energy & Employment Report states that in 2018, clean energy generation and energy efficiency sectors provided 2.4 million jobs.¹ This is double the number of jobs in the fossil energy production sector. To encourage the continued expansion of solar, governments and utilities offer tax breaks and financial incentives to make solar more accessible for today's businesses and homeowners. The following are some of the incentives available in Wisconsin.

Focus on Energy renewable rewards

Wisconsin provides rebates to reduce the expenses of setting up solar panel systems. The rebates differ by customer category: up to \$500 for Residential, \$50,000 for Commercial, \$60,000 for Agricultural, and \$81,000 for Special sectors like nonprofits, schools, government, and Native American tribes and nations.²

1: 2019 U.S. Energy & Employment Report <https://cutt.ly/hwcOXTIT>

2: Focus on Energy, <https://www.focusonenergy.com/residential#program-renewable-energy>



Introduction

Wisconsin Solar Tax Exemptions

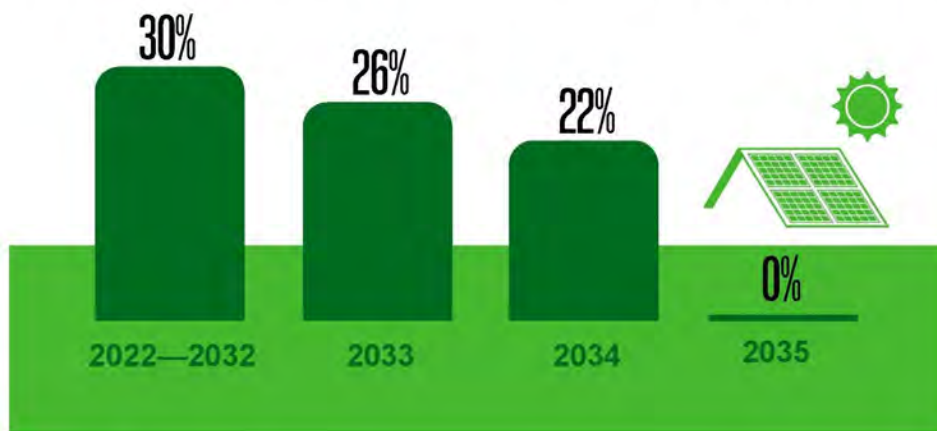
Wisconsin offers two sales tax exemptions for renewable energy technologies, including Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, and Solar Photovoltaics. This means there's no sales tax when installing solar panels in Wisconsin homes or businesses. Additionally, the added value from biogas, synthetic gas energy systems, solar energy systems, or wind energy systems is exempt from general property taxes, irrespective of whether the equipment is classified as real or personal property.

Federal Investment Tax Credit

A tax credit directly reduces the amount of income tax you owe. The federal solar energy credit lets taxpayers claim a percentage of the cost of their solar PV system on their federal income taxes. Solar PV systems installed in 2020 and 2021 qualified for a 26% tax credit. However, in August 2022, Congress extended the Investment Tax Credit (ITC), setting it at 30% for systems installed from 2022-2032. This rate drops to 26% in 2033, 22% in 2034, and the credit ends in 2035 unless extended by Congress. There's no cap on the credit amount.

(<https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics>)

SOLAR INVESTMENT TAX CREDIT



Federal Modified Accelerated Cost Recovery System (MACRS)

The Modified Accelerated Cost Recovery System (MACRS) established in 1986 lets businesses depreciate investments in specific tangible properties over set periods as a tax benefit. It's the primary depreciation method for many assets. Depending on the type of asset, the depreciation can range from three to 50 years. For instance, broadcast equipment has a five-year recovery period, while office furniture and equipment span seven years.

Solar equipment qualifies for a five-year recovery period. If an Investment Tax Credit (ITC) grant is claimed on this equipment, its depreciable basis must be reduced by half of the ITC value. As an example, if a solar array owner was able to claim a 30% ITC credit the depreciable basis must be reduced by 15%, resulting in a tax deduction basis of 85% of the installed equipment cost. The intricacies of the MACRS Depreciation benefit can be complex. Property owners should seek advice from an accountant familiar with solar tax matters before pursuing this benefit.

Resources:

<https://www.seia.org/initiatives/depreciation-solar-energy-property-macrs>

<https://www.irs.gov/credits-deductions/cost-recovery-for-qualified-clean-energy-facilities-property-and-technology>

SOLAR MYTHS

BUSTED

1 SOLAR PANELS WILL DAMAGE MY ROOF. **MYTH**

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 **MYTH**

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. **MYTH**

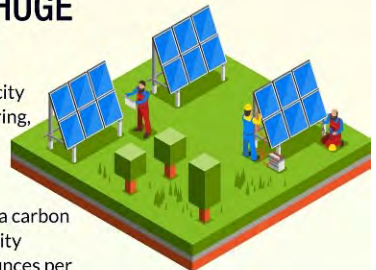
Fact: Detailed analysis indicates that the large-scale implementation of solar has the potential to reduce pollution-related environmental impacts of electricity production, such as GHG emissions, freshwater ecotoxicity, eutrophication, and particulate-matter exposure. The pollution caused by higher 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 **MYTH**

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 **MYTH**

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

Solar in Wisconsin



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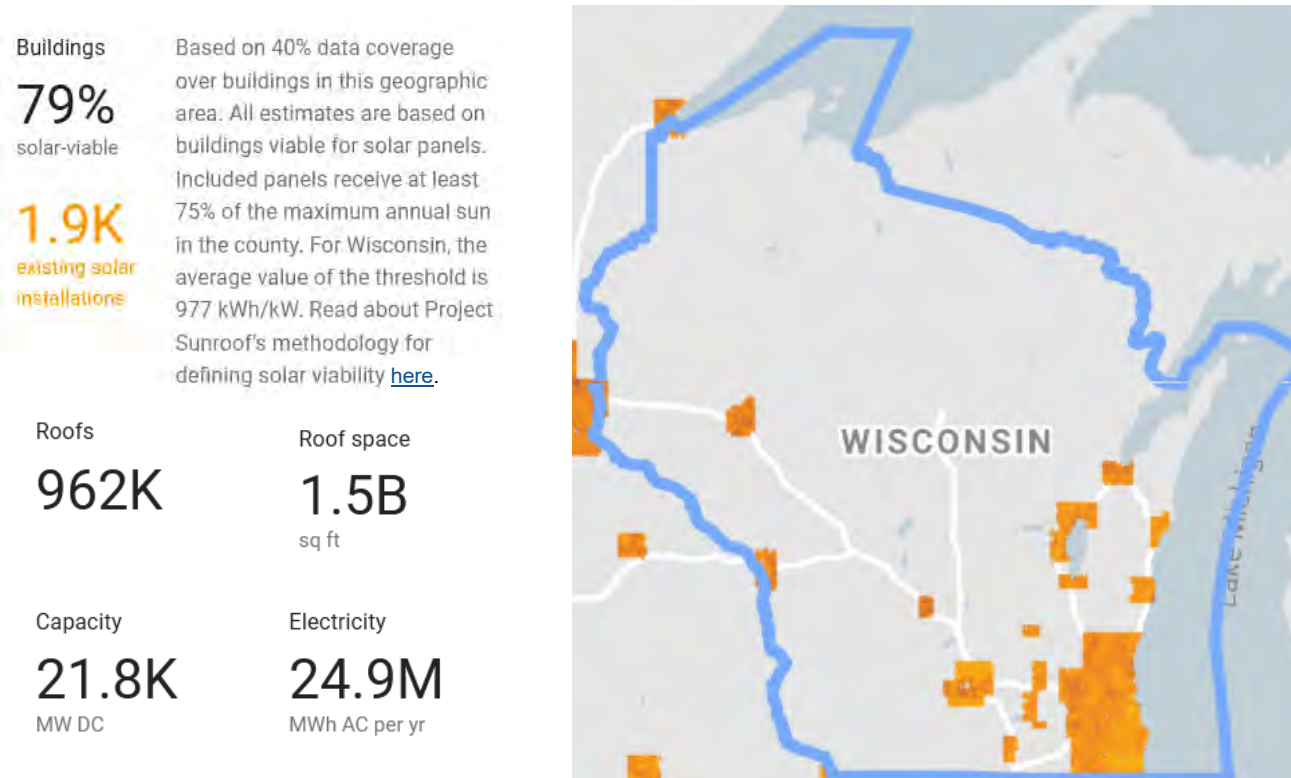
Solar in Wisconsin

As of June 2023, Wisconsin has a total of 1,251 megawatts (1,251,800,000 watts) of solar capacity installed statewide. There are a total of 13,923 solar installations in the State. The State of Wisconsin ranks 25th nationally for total solar energy production capacity.

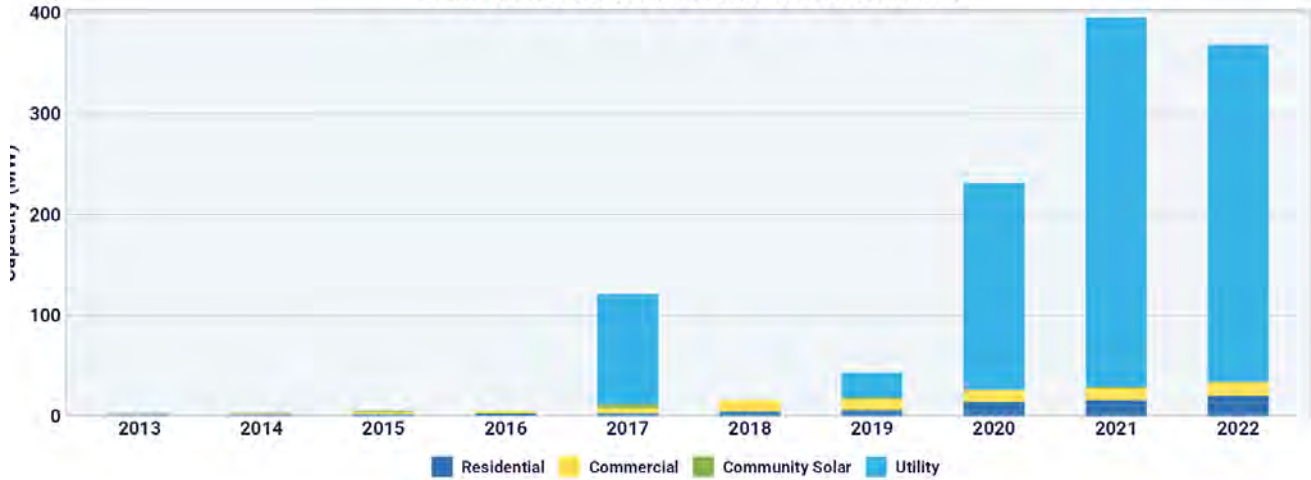
The State's solar installation total is enough to power 206,256 homes. The share of the State's total electricity use that comes from solar power is 2.11%. Current solar growth projections for the State equal an additional 4,049 MW over the next 5 years - a growth rate that ranks 12th nationally.

Costs for Solar PV installation in the State have declined 43% since 2013. Price declines have been accompanied with increasing rate of investment in solar energy. A total of \$1.5 billion has been invested in Solar PV installations in the state. The industry currently employs approximately 3,274 people in 185 companies Statewide (44 Manufacturers, 84 Installers/Developers, 57 Others).

(Sources and Graphics: Solar Energy Industries Association SEIA, Solar Foundation, Project Sunroof)

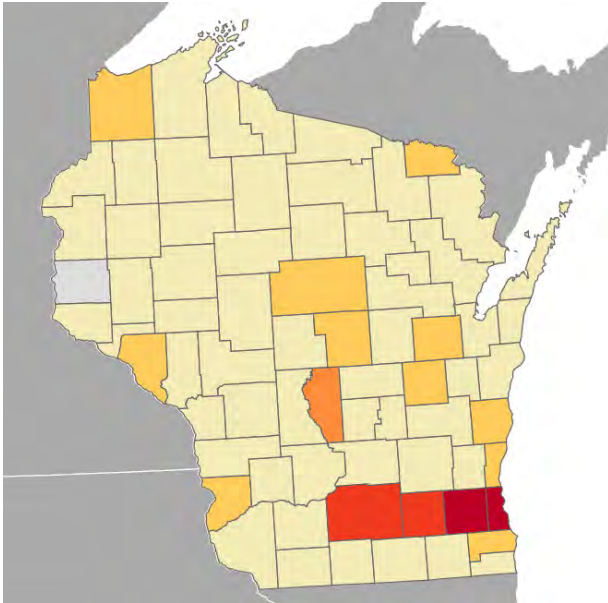


Wisconsin Annual Solar Installations

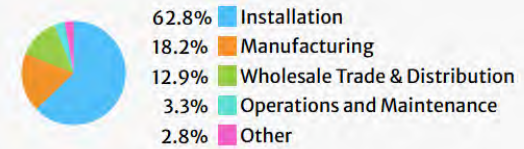


Solar in Wisconsin

Solar Jobs in Wisconsin (2019)

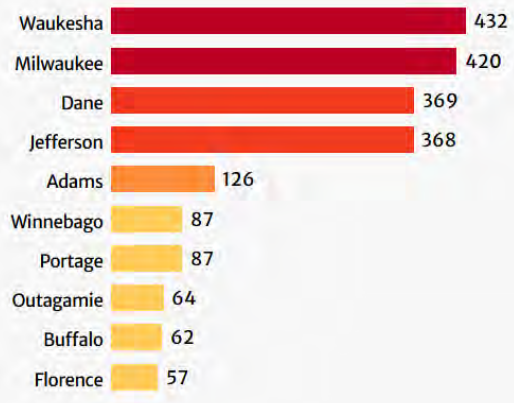


| | rank among states |
|--|-------------------|
| 2,871 Solar jobs | 26/51 |
| 1,802 Installation jobs | 28/51 |
| 523 Manufacturing jobs | 19/51 |
| 369 Wholesale Trade & Distribution jobs | 21/51 |
| 95 Operations and Maintenance jobs | 31/51 |
| 79 Other jobs | 28/51 |



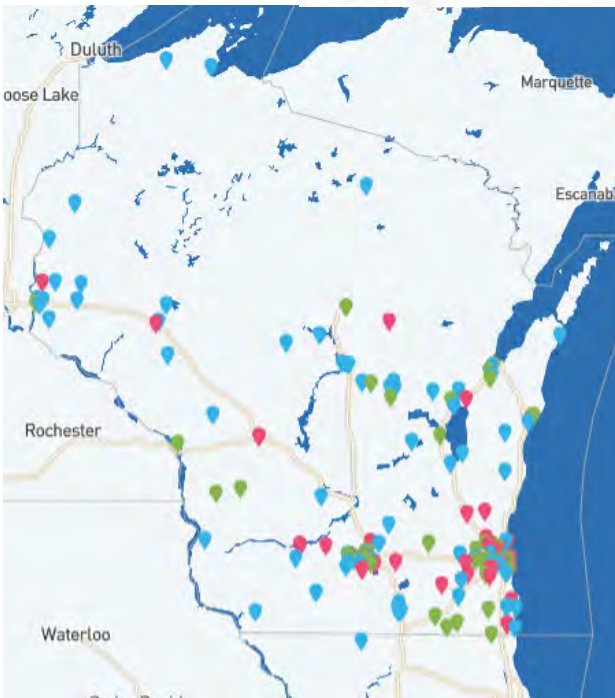
| | |
|------------------------|--------------------------------|
| -135 | New solar jobs since 2018 |
| -4.5% | Solar jobs growth rate in 2019 |
| 32nd | Solar jobs per capita rank |

Top Ten Counties

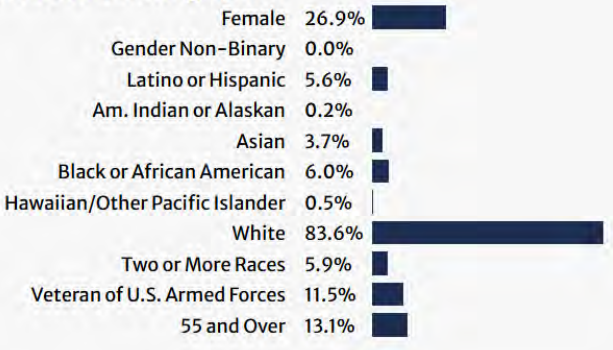


Solar Companies in Wisconsin

National Solar Database:
● Manufacturer
● Installer
● Other



Solar Worker Demographics



(sources: Solar Energy Industries Association SEIA, Solar Foundation)



Section

03

Solar in Fitchburg



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Solar in Fitchburg

Based on information available from National Renewable Energy Lab (NREL) Tracking The Sun Tool, it is estimated that Fitchburg has 225 solar installations with a capacity of 3,010 KW. This is equal to 1.49% of the total solar generating Capacity in the State, compared to the City's 0.5% share of State population. Fitchburg has an average of 7.6 solar PV installations per 1,000 homes. This is approximately 297% of the State average.

The total solar installation Capacity in Fitchburg is estimated to generate 3,010 kWh annually - enough to power 316 homes. As noted in Section 2, costs for Solar PV installation in the State have declined significantly since 2015. According to Solar Energy Industries Association (SEIA) the City currently has 1 solar company, or approximately 1/2% of the State's total solar business entities.

City of Fitchburg's Solar Share

| | State | Community | Community Share |
|--|-----------|-----------|-----------------|
| Population | 5,892,539 | 30,834 | 0.50% |
| Number of Solar Installations | 15,094 | 225 | 1.49% |
| Average Solar Installations / 1,000 households | 2.56 | 7.60 | 296.69% |
| Estimated Solar Capacity (MW) | 1,217 | 3.01 | 0.25% |
| Estimated Electricity Generated Annually (GWH) | 1,359.47 | 3.36 | 0.25% |
| Average Array Size (KW) | 80.63 | 13.38 | 17% |
| Solar Industry Businesses | 185 | 1 | 0.54% |



Solar in Fitchburg

Estimated Solar PV Installation Cost by Component in Fitchburg

(For 6kW solar array after tax credits)

\$2.60 per watt



Graphic Source: SolarReviews.com





Section

04

City Wide Solar Potential



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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 is custom calculated for the City of Fitchburg using methodology based on the National Renewable Energy Laboratory (NREL).¹ The community specific calculations in this study use raw data from NREL provided dataset(s) as outlined in "Input Data" below.

Input Data

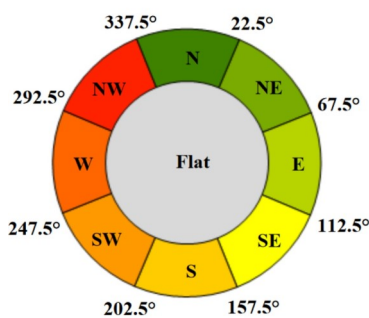
The National Renewable Energy Laboratory (NREL) provides roof plane data based on lidar readings from the U.S. Department of Homeland Security between 2006-2014. We used the "Small Building Suitability" dataset to estimate suitable building rooftops, by zip code, for solar installations up to 54,000 square feet.²

Tilt and Orientation

Roof plane's tilt and orientation are crucial for evaluating PV suitability. The "Small Building Suitability" data obtained from NREL noted above includes roof tilts in 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° - 60°)

Orientations in the data are West, Southwest, South, Southeast, East, and flat. Roofs tilted over 60° and certain orientations are excluded.



Azimuth Classifications

Graphic source: NREL

Generation Potential

Using NREL's data, we calculate the "Nameplate Capacity" based on the panel assumptions below. a typical 400 watt panel size of 79 inches x 40 inches. Tilted rooftops assume 85% solar panel coverage, reserving 15% for setbacks and obstructions. Flat roofs assume spacing to avoid self-shading based on the tilt described in the panel assumptions below. We use this to estimate potential installed capacity (KW dc) for each roof class.

Panel Assumptions:

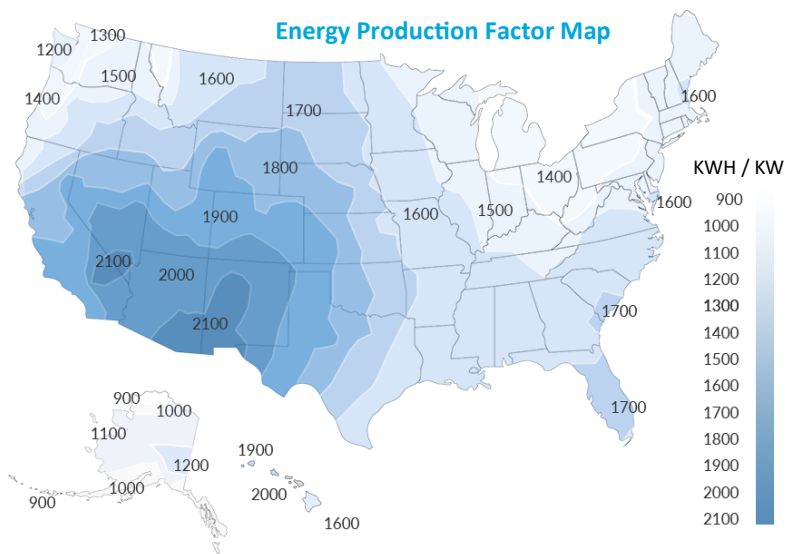
- Rated Capacity: **400 watt**
- Dimensions: **79" x 40"**
- Tilt used on flat roofs: **15°**

Solar Energy Estimates

To estimate the energy generation for each roof tilt and orientation class, the above calculated total potential installed capacity (KW dc) is multiplied by the specific yield factor or "energy production factor" (kWh produced to KW capacity installed) for the region. Adjustments account for system and shading losses: 15% for flat roofs and 30% for angled roofs.

Capacity & Market Scenarios

We outline the Technical Rooftop Capacity, representing total potential. To set a solar goal, we pinpoint the "optimized" capacity for better financial returns and gauge potential market demand in the community. Further details on these capacities and market scenarios are provided later.



Data Source: NREL; Graphic Source: LetsGoSolar.com

1: Rooftop Solar Photovoltaic Technical Potential in The United States: A Detailed Assessment, NREL, <https://www.nrel.gov/docs/fy16osti/65298.pdf>
 2: Small Building Suitability dataset, NREL, <https://data.nrel.gov/submissions/47>



City Wide Solar Potentials

Rooftop Technical Capacity In Fitchburg

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 13,000 total buildings in Fitchburg, of those, it is estimated that over 10,000 are “solar suitable” buildings.

These solar suitable buildings have an estimated 18,568 roof planes which are either flat or with an azimuth orientation of East, Southeast, South, Southwest, or West, with a total estimated square footage of 5.9 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 86.4 Megawatts DC.

Rooftop Generation Capacity In Fitchburg

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.

The chart below illustrates the total generation potential by roof azimuth and by roof tilt classifications. The Grand Total rooftop solar PV energy generation potential for the City is 97,285,000 KWH annually. This is estimated to be approximately 29.6% of the City’s total electric consumption.

Technical Rooftop Capacity In Fitchburg

| | | | Flat | Low Tilt | Mid-Low Tilt | Mid-High Tilt | High Tilt |
|------------------------------|------------|--------|----------------------------|---------------------------|-------------------------------|--------------------------------|----------------------------|
| Subtotal Flat | | | | | | | |
| Suitable Buildings | 2,695 | 26.71% | 2,695 | - | - | - | - |
| Suitable Roof Planes | 4,959 | 26.71% | 4,959 | - | - | - | - |
| Square Footage | 1,567,697 | 26.70% | 1,567,697 | - | - | - | - |
| Capacity (KW dc) | 16,490 | 19.08% | 16,490 | - | - | - | - |
| Generation (KWH) | 21,725,744 | 22.33% | 21,725,744 | - | - | - | - |
| Subtotal South Facing | | | | | | | |
| Suitable Buildings | 2,604 | 25.80% | - | 715 | 1,558 | 328 | 3 |
| Suitable Roof Planes | 4,791 | 25.80% | - | 1,315 | 2,867 | 604 | 5 |
| Square Footage | 1,514,723 | 25.80% | - | 415,750 | 906,340 | 191,022 | 1,610 |
| Capacity (KW dc) | 24,621 | 28.49% | - | 6,758 | 14,732 | 3,105 | 26 |
| Generation (KWH) | 26,599,687 | 27.34% | - | 7,300,891 | 15,916,022 | 3,354,497 | 28,277 |
| West + Southwest | | | | | | | |
| Suitable Buildings | 2,387 | 23.65% | - | 586 | 1,488 | 311 | 1 |
| Suitable Roof Planes | 4,392 | 23.65% | - | 1,079 | 2,739 | 572 | 2 |
| Square Footage | 1,388,675 | 23.66% | - | 341,170 | 865,934 | 180,842 | 728 |
| Capacity (KW dc) | 22,572 | 26.12% | - | 5,546 | 14,075 | 2,940 | 12 |
| Generation (KWH) | 24,386,176 | 25.07% | - | 5,991,204 | 15,206,462 | 3,175,728 | 12,782 |
| East + Southeast | | | | | | | |
| Suitable Buildings | 2,405 | 23.84% | - | 633 | 1,492 | 279 | 1 |
| Suitable Roof Planes | 4,426 | 23.84% | - | 1,164 | 2,746 | 514 | 2 |
| Square Footage | 1,399,373 | 23.84% | - | 368,021 | 868,063 | 162,561 | 728 |
| Capacity (KW dc) | 22,746 | 26.32% | - | 5,982 | 14,110 | 2,642 | 12 |
| Generation (KWH) | 24,574,049 | 25.26% | - | 6,462,727 | 15,243,844 | 2,854,697 | 12,782 |
| Grand Total | | | Subtotal: Flat Roof | Subtotal: Low Tilt | Subtotal: Mid-Low Tilt | Subtotal: Mid-High Tilt | Subtotal: High Tilt |
| Suitable Buildings | 10,091 | | 2,695 | 1,934 | 4,539 | 918 | 5 |
| Suitable Roof Planes | 18,568 | | 4,959 | 3,558 | 8,352 | 1,690 | 9 |
| Square Footage | 5,870,468 | | 1,567,697 | 1,124,941 | 2,640,338 | 534,426 | 3,066 |
| Capacity (KW dc) | 86,430 | | 16,490 | 18,286 | 42,918 | 8,687 | 50 |
| Generation (KWH) | 97,285,656 | | 21,725,744 | 19,754,822 | 46,366,328 | 9,384,921 | 53,840 |

Share of Community Electricity Use Met Through Total Potential Technical Generation 29.6%

City Wide Solar Potentials

Optimized Generation Capacity In Fitchburg

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 Fitchburg, 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 tend to have limited timeframes during which their solar exposure is optimal, 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 Rooftop Solar Generation Capacity in Fitchburg is estimated to be 75,985,000 KWH annually, approximately 23.1% of the City’s total electric consumption.

Optimized Rooftop Capacity In Fitchburg

| | | | Flat | Low Tilt | Mid-Low Tilt | Mid-High Tilt | High Tilt |
|------------------------------|------------|--------|----------------------------|---------------------------|-------------------------------|--------------------------------|----------------------------|
| Subtotal Flat | | | | | | | |
| Suitable Buildings | 2,695 | 33.66% | 2,695 | | | | |
| Suitable Roof Planes | 4,959 | 33.66% | 4,959 | | | | |
| Square Footage | 1,567,697 | 33.66% | 1,567,697 | | | | |
| Capacity (KW dc) | 16,490 | 24.72% | 16,490 | | | | |
| Generation (KWH) | 21,725,744 | 28.59% | 21,725,744 | | | | |
| Subtotal South Facing | | | | | | | |
| Suitable Buildings | 2,604 | 32.52% | | 715 | 1,558 | 328 | 3 |
| Suitable Roof Planes | 4,791 | 32.52% | | 1,315 | 2,867 | 604 | 5 |
| Square Footage | 1,514,723 | 32.52% | | 415,750 | 906,340 | 191,022 | 1,610 |
| Capacity (KW dc) | 24,621 | 36.91% | | 6,758 | 14,732 | 3,105 | 26 |
| Generation (KWH) | 26,599,687 | 35.01% | | 7,300,891 | 15,916,022 | 3,354,497 | 28,277 |
| West + Southwest | | | | | | | |
| Suitable Buildings | 2,075 | 25.92% | | 586 | 1,488 | | |
| Suitable Roof Planes | 3,818 | 25.92% | | 1,079 | 2,739 | | |
| Square Footage | 1,207,104 | 25.92% | | 341,170 | 865,934 | | |
| Capacity (KW dc) | 19,621 | 29.41% | | 5,546 | 14,075 | | |
| Generation (KWH) | 21,197,666 | 27.90% | | 5,991,204 | 15,206,462 | | |
| East + Southeast | | | | | | | |
| Suitable Buildings | 633 | 7.90% | | 633 | | | |
| Suitable Roof Planes | 1,164 | 7.90% | | 1,164 | | | |
| Square Footage | 368,021 | 7.90% | | 368,021 | | | |
| Capacity (KW dc) | 5,982 | 8.97% | | 5,982 | | | |
| Generation (KWH) | 6,462,727 | 8.51% | | 6,462,727 | | | |
| Grand Total | | | Subtotal: Flat Roof | Subtotal: Low Tilt | Subtotal: Mid-Low Tilt | Subtotal: Mid-High Tilt | Subtotal: High Tilt |
| Suitable Buildings | 8,006 | | 2,695 | 1,934 | 3,047 | 328 | 3 |
| Suitable Roof Planes | 14,732 | | 4,959 | 3,558 | 5,606 | 604 | 5 |
| Square Footage | 4,657,546 | | 1,567,697 | 1,124,941 | 1,772,275 | 191,022 | 1,610 |
| Capacity (KW dc) | 66,715 | | 16,490 | 18,286 | 28,808 | 3,105 | 26 |
| Generation (KWH) | 75,985,824 | | 21,725,744 | 19,754,822 | 31,122,484 | 3,354,497 | 28,277 |

Share of Community Electricity Use Met Through Total Potential Technical Generation 23.1%



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 Wisconsin section of this report, the installed cost of solar PV in the state has dropped 11% since 2017 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 Wisconsin, the new installed capacity that went on line in 2020 was nearly 231 MW; equal to 37% of the cumulative total of all solar PV installations in the state for **all previous years**.

Based on information available from Project Sunroof, it is estimated that the City of Fitchburg has 200 solar installations with a generating capacity of 1.5 MW. This is equal to 2.21% of the total number of arrays or 0.24% of the total solar generating capacity installed in the State. These can be compared against the City's share of the total State population of 0.89% - meaning that when reviewed by the number of arrays installed, the City is almost 2.5 times the State average on a per capita basis, but when reviewed by the total generating capacity, it is estimated that the city may be closer to 30% of the State per capita average.

State Market Projections

The Solar Energy Industries Association (SEIA) projects solar PV installation capacity in the State to increase 4,630MW by 2028. This is equal to a sustained compound increase of installed capacity of 36% annually. The timeframe of this projection overlaps with the currently established Federal Income Tax incentive program (see Introduction). For years 2033 and beyond, the tax incentive is expected to be phased out for residential solar pv installations.



City Wide Solar Potentials

Fitchburg Market Absorption Projections

Growth Scenario: Share of Projected Statewide Annual Increase Based on Population Share

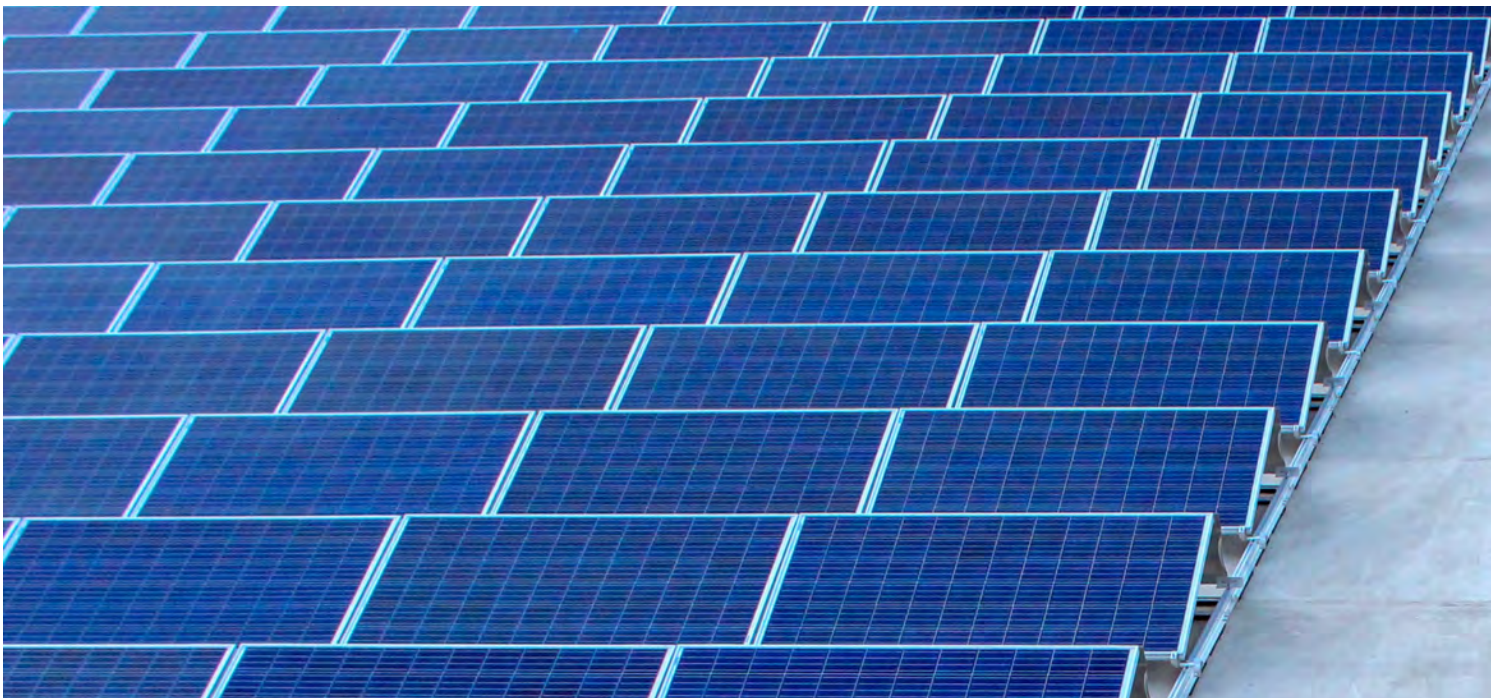
This scenario anticipates the City’s rate of increase in solar PV installed capacity matches the projected 5 year Statewide annual rate of increase. This scenario would mean an increase of approximately 16,040 KW of installed capacity resulting in a total of 19,051 KW, equivalent to 28% of the optimized capacity potential within the City by 2030.

As the market continues to mature through the 2030’s it may be reasonable to assume a reduction in the growth rate of new installed Capacity. For purposes of this study, we use an annual growth rate of 50% reduction of the scenario growth rate years 2031 through 2035, and another 50% reduction for years 2036 through 2040. The chart below shows projections through 2040 using the assumptions outlined above. It should be noted that the recently passed Inflation Reduction Act is likely to increase the projections for increased capacity installations in the State.

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

Share of Projected Statewide Annual Increase Based on Population Share

| Year | Cumulative Installed (KW) | Annual Generation (KWH) | % of Community Electric Consumption | This is Equivalent to adding (x) Average 9KW Residential Arrays Annually: | Or Equivalent to adding (x) 40KW Commercial Arrays Annually: |
|------|---------------------------|-------------------------|-------------------------------------|---|--|
| 2030 | 19,051 | 21,698,345 | 6.60% | 297 | 66.8 |
| 2035 | 43,584 | 49,640,558 | 15.10% | 545 | 123 |
| 2040 | 103,179 | 117,517,253 | 35.76% | 662 | 149 |



City Wide Solar Potentials

Fitchburg Market Absorption Projections

Growth Scenario: Share of Projected Statewide Annual Increase Based on Population Share Adjusted for Median Household Income

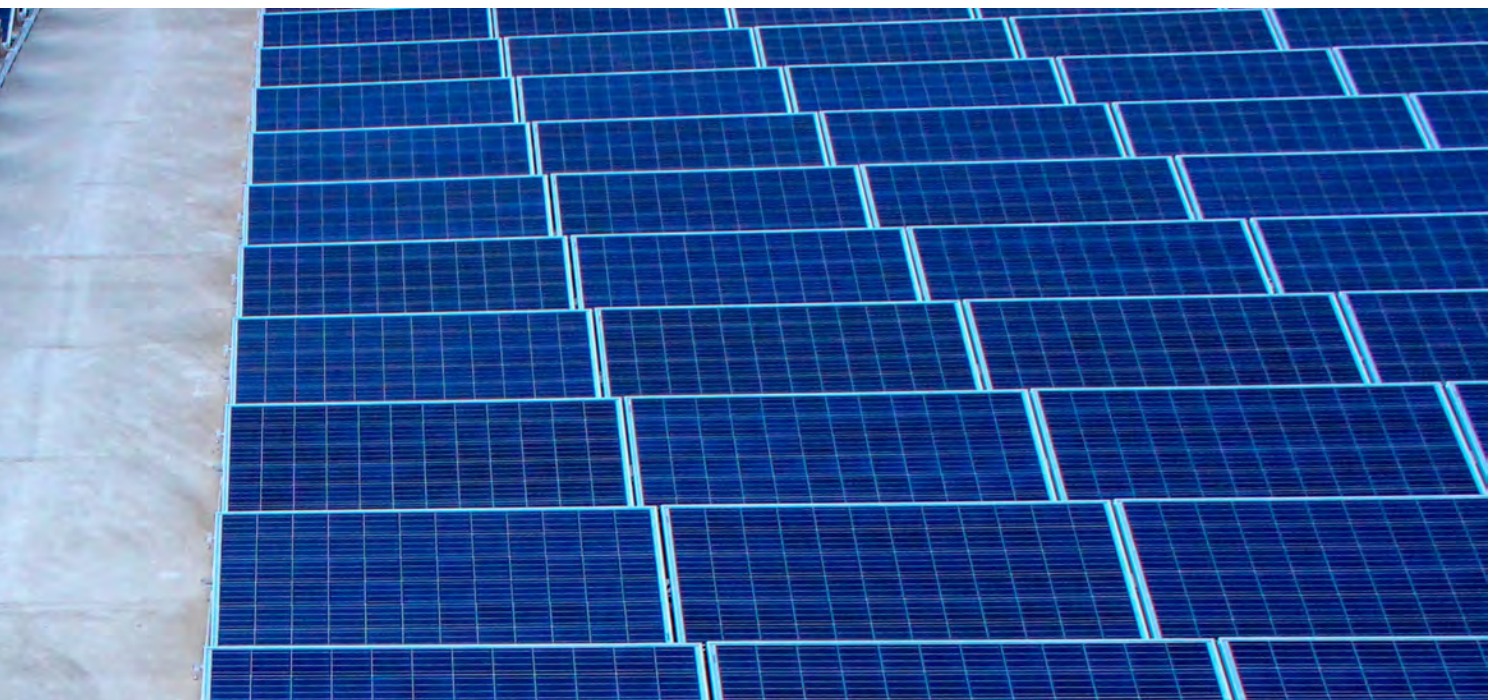
This scenario anticipates the City's rate of increase in solar PV installed capacity adjusts the projected 5 year Statewide annual rate of increase by the community's median household income compared to the state median household income. The City's median household income of \$76,240 is 120% of the statewide median income of \$63,293. Adjusting the projected statewide growth rate by 120%, then, adjusts the community's projected solar adoption in alignment with potential financial considerations of the community compared to the statewide average. This scenario would mean an increase of approximately 23,130 KW of installed capacity resulting in a total of 26,141 KW, equivalent to 39% of the optimized capacity potential within the City by 2030.

As the market continues to mature through the 2030's it may be reasonable to assume a reduction in the growth rate of new installed Capacity. For purposes of this study, we use an annual growth rate of 50% reduction of the scenario growth rate years 2031 through 2035, and another 50% reduction for years 2036 through 2040. The chart below shows projections through 2040 using the assumptions outlined above. It should be noted that the recently passed Inflation Reduction Act is likely to increase the projections for increased capacity installations in the State.

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

Share of Projected Statewide Annual Increase Based on Population Share, Adjusted for Community Median Household Income Compared to State Median Household Income

| Year | Cumulative Installed (KW) | Annual Generation (KWH) | % of Community Electric Consumption | This is Equivalent to adding (x) Average 9KW Residential Arrays Annually: | Or Equivalent to adding (x) 40KW Commercial Arrays Annually: |
|------|---------------------------|-------------------------|-------------------------------------|---|--|
| 2030 | 26,141 | 29,773,816 | 9.06% | 428 | 96.4 |
| 2035 | 69,736 | 79,426,701 | 24.17% | 969 | 218 |
| 2040 | 195,191 | 222,316,267 | 67.65% | 1,394 | 314 |



City Wide Solar Potentials

Suggested Rooftop Targeted Scenario

Based on the City's current higher-than-average per capita installed solar Capacity (when measured by KW), we recommend striving to keep pace with the projected growth for the state. We believe using the growth scenario "Share of Projected Statewide Annual Increase Based on Population" should be reasonably achievable while resulting in this goal.

Estimating Additional Capacity

In addition to roof mounted solar PV potential, the City of Fitchburg has significant solar PV potential associated with ground mounted arrays as well as arrays mounted over parking—known as "Carport" arrays. Compiling a detailed estimate of the reasonable Capacity for ground mounted or carport arrays requires a much higher level of understanding of each potential subject site in order to determine the feasibility of a ground mounted or carport array at that site than what is feasible within the scope of this project effort. Some of the site use considerations on the feasibility of ground mounted arrays for specific sites include:

- Land status and planned future use
- Land quality and alternative use options
- Distance to electric grid interconnection
- Accessibility and security
- Slope and configuration
- Flooding and wetland considerations
- Proximity to primary air traffic lanes and air traffic control jurisdictions relative to glare concerns

For this report, however, we have estimated the percentage of "bare ground" and share of parking pavement which may potentially be anticipated to receive solar PV installations. The total acreage of ground and parking pavement is estimated from ground cover survey readings conducted for the Fitchburg Ground Cover, Heat Island, and Carbon Sequestration Study.

For both Carport and Ground Mounted arrays, the "Nameplate Capacity" potential per square foot of covered ground or parking plane area was calculated. This calculation assumed a typical 400 watt Capacity panel with a footprint of 79" x 40" with an assumed panel tilt angle of 22 degrees and 35.6" spacing between panel rows to avoid shading at winter solstice conditions. Next, this nameplate Capacity was adjusted for assumed system losses including shading, heat loss, mismatch, snow, dirt, etc. Additionally, losses were calculated for 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 earlier.

Carport Potential

The total paved area within the City of Fitchburg is estimated to be 2,240 acres—approximately 11% of all land in the City. We estimate parking takes up 20% of this number. From a technical standpoint, much of this area is likely to be reasonably suitable for carport solar arrays, however, many locations may not perform well financially based on use and utility rate cases. Using a modest 1% assumed near-term availability and suitability rate, this still represents up to 192,000 square feet of near-term carport solar array coverage potential. Based on the above calculation factors, this would result in a total of 1763 KW of installed capacity producing 2,185,545 KWH annually by 2030, approximately 0.7% of the City's total electric consumption.

Ground Mounted Potential

The total lawn and "bare ground" area within the City of Fitchburg, excluding tree canopy coverage areas, is estimated to be 3,178 acres—approximately 15% of all land in the City. From a technical standpoint, much of this area is likely to be reasonably suitable for ground mounted solar arrays, however, many locations may not be appropriate for ground mounted arrays due to one or more of the site use considerations outlined above. Using a moderate 1% assumed near-term availability and suitability rate, this still represents up to 1,384,600 square feet of near-term ground mounted array coverage potential. Based on the above calculation factors, this would result in a total of 6,442 KW of installed capacity producing 7,988,275 KWH annually, approximately 2.4% of the City's total electric consumption.



City Wide Solar Potentials

Potential Distributed Solar Goal by 2030

Summarizing the calculations for the Optimized Rooftop Solar Potential, Carport Potential, and Ground Mounted Potential outlined previously illustrates a potential pathway for the City of Fitchburg to increase its distributed solar Capacity by 2030. Combining the Recommended Rooftop Targeted Scenario with the Carport Potential and Ground Mounted Potential indicates a potential 2030 goal as follows:

| Source Potential | Cumulative Installed (KW) | Annual Generation | Share of Demand |
|------------------------|---------------------------|-------------------|-----------------|
| Estimated Existing | 3,011 | 3,429,203 | 1.04% |
| New Rooftop | 19,051 | 21,698,345 | 6.60% |
| New Carport | 2,020 | 2,661,502 | 0.81% |
| New Ground Mounted | 7,384 | 9,727,922 | 2.96% |
| Total Potential | 31,465 | 37,516,972 | 11.42% |

To achieve this solar PV Capacity, the Region would need to achieve the following solar PV installation coverage by 2030:

| | | |
|-----------------------------|-----------|-------------|
| Rooftop Coverage | 1,119,806 | Square Feet |
| Parking Lot Coverage | 4.4 | Acres |
| Lawn / Bare Ground Coverage | 31.8 | Acres |





Section

05

City Wide Solar Benefits



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City Wide Solar Benefits

Economic Potential for Fitchburg

According to the National Renewable Energy Laboratory (NREL), the additional solar PV capacity which could be installed in the City by 2030 (Scenario C as well as the estimated ground mounted and carport arrays) has a total construction value of over \$40 million (2022 dollars). Below is a breakout of the Fitchburg Economic Development potential of new installed solar PV capacity through 2030 based on population share of Statewide market absorption projection numbers:

Local Economic Impacts Through 2030 Summary Results Based on Potential Distributed Solar Goal*

| | Jobs | Earnings \$000 (2023) | Output \$000 (2023) | Value Added \$000 (2023) |
|---|--------------|--------------------------|------------------------|-----------------------------|
| During construction and installation period | | | | |
| Project Development and Onsite Labor Impacts | | | | |
| Construction and Installation Labor | 47.8 | \$3,421.5 | | |
| Construction and Installation Related Services | 93.6 | \$5,499.1 | | |
| Subtotal | 141.5 | \$8,920.6 | \$17,502.3 | \$12,550.3 |
| Module and Supply Chain Impacts | | | | |
| Manufacturing Impacts | 0.0 | \$0.0 | \$0.0 | \$0.0 |
| Trade (Wholesale and Retail) | 32.8 | \$2,286.9 | \$7,705.0 | \$4,259.6 |
| Finance, Insurance and Real Estate | 0.0 | \$0.0 | \$0.0 | \$0.0 |
| Professional Services | 29.5 | \$1,610.1 | \$5,015.0 | \$2,877.1 |
| Other Services | 45.8 | \$4,276.3 | \$11,509.9 | \$6,637.4 |
| Other Sectors | 68.2 | \$1,432.4 | \$4,065.9 | \$2,385.8 |
| Subtotal | 176.3 | \$9,605.8 | \$28,295.8 | \$16,160.0 |
| Induced Impacts | 104.4 | \$4,927.8 | \$17,001.4 | \$9,574.8 |
| Total Impacts | 422.1 | \$23,454.2 | \$62,799.5 | \$38,285.0 |
| During operating years | | | | |
| Onsite Labor Impacts | | | | |
| PV Project Labor Only | 4.0 | \$264.8 | \$264.8 | \$264.8 |
| Local Revenue and Supply Chain Impacts | 1.3 | \$83.9 | \$297.6 | \$164.5 |
| Induced Impacts | 0.9 | \$44.0 | \$151.9 | \$85.5 |
| Total Impacts | 6.2 | \$392.7 | \$714.2 | \$514.9 |

*Includes estimated Ground Mounted and Carport array potential through 2030.

Additional Economic Benefit

In addition to the local re-investment share of the construction and maintenance costs, Fitchburg 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 30% of the cost of installation. In addition, all commercial solar PV owners can harvest additional tax benefits through the federal accelerated depreciation. At the projected additional installation through 2030 outlined in the previous section, this could mean \$21 million in savings and local re-investment potential through 2030.
- 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 Fitchburg is \$350,000 to \$450,000 annually by 2030 (based on a third party ownership structure, long-term savings for direct ownership can be significantly higher*).

* Note: third party ownership structure not yet allowed in Wisconsin



City Wide Solar Benefits

Environmental Benefits for Fitchburg

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. “[Water use of electricity technologies: A global meta-analysis](#)” from *Renewable and Sustainable Energy Reviews*, Volume 115, 2019, the average fresh water use for 1 Gwh of electricity by fuel type is as follows:

| Electricity Source | Gallons/GWh |
|--------------------|-------------|
| Hydroelectric | 1,311,000 |
| Wind | 11,000 |
| Nuclear | 605,000 |
| Biomass | 22,481,000 |
| Geothermal | 270,000 |
| Solar PV | 87,000 |
| Natural gas | 158,000 |
| Coal | 586,000 |

Current Electric Grid Profile

According to utility data, the total GHG emissions per MWh equal approximately 0.596 metric tons (2022 reporting). Using the above average fresh water use by fuel type, the average water use per 1 Gwh of electricity in the community is likely 400,000 to 500,000 gallons.

Based on these numbers, by 2030 the additional solar PV installed in the City of Fitchburg can reduce its annual Greenhouse Gas emissions and its annual water footprint* as follows:

Scenario Carbon and Water Footprint Reduction Potential

| Year | Annual Generation (GWh) | GHG Emission Reduction (mTons) | GHG Emission Reduction (Million Cubic Feet of Atmosphere) | Water Footprint Reduction (Mgallons) |
|------|----------------------------|-----------------------------------|--|--|
| 2030 | 42.16 | 25,129 | 493 | 15 |
| 2035 | 91.82 | 54,722 | 1,074 | 33 |
| 2040 | 234.71 | 139,885 | 2,745 | 85 |

*Note, as a measure of energy consumption, water footprint is a measure of a community’s full energy supply chain impacts on water consumption and is not reflected directly on a community’s local water consumption.



Section

06

**City Wide Municipal
Solid Waste Plasma
Gasification Potential**



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City Wide Municipal Solid Waste Plasma Gasification Potential

What is Plasma Gasification

Plasma gasification uses electricity and high heat to turn city waste into useful materials without burning it. Some people think this method is just like burning trash, but it's not. Instead of burning the trash, plasma gasification changes organic materials into a gas rich in energy and turns other materials into a glass-like substance called slag. This process reduces landfill waste while providing an energy source that can be used for electricity or liquid fuel.

How does Plasma Gasification Work

In plasma gasification, a strong electric current creates an arc between two points. A non-reactive gas is then sent through this arc into a closed container with waste. This electric arc gets hotter than the Sun's surface, breaking down most of the waste into basic gas elements and simplifying complex molecules to single atoms.

What Is Produced By Plasma Gasification

The plasma gasification process results in makes three things:

1. Syngas is a gas made of hydrogen and carbon monoxide. A large portion of the waste, like plastics, turns into syngas. Before you can use this gas for power, harmful chemicals have to be filtered. After that, Syngas can burn like natural gas, or converted into a human-made diesel fuel or hydrogen. Typically some of the syngas produced is used to power the gasification plant, but the rest can replace use of these other fuels or sold to utilities or companies to generate electricity.
2. Slag is like a black, glassy rock. It can be cleaned to remove bad metals like mercury. After that, it can be turned into bricks or gravel.
3. Extra heat comes from the process, this heat can be used to make steam, which can also help to generate more electricity.

Is Plasma Gasification Carbon Neutral

Plasma gasification happens in a sealed environment, so it doesn't release any emissions directly. While burning its produced syngas does emit CO₂, this is considered carbon-neutral because the fuel comes from biomass. Even counting these emissions, plasma gasification is a lower-emission option for managing waste. A 2010 study by SCS found that it produced significantly fewer greenhouse gases compared to other methods like landfills and incineration.¹ Specifically, it emitted 31 million tons less CO₂ per megawatt-hour than landfills that capture energy and 50,000 tons less than burning natural gas, making it a more eco-friendly choice.

Environmental Considerations of Plasma Gasification

Research indicates that two-stage plasma gasification is a greener alternative to incineration for managing trash.² Not only is it more environmentally friendly, but it also generates more electricity and can readily produce liquid fuels like hydrogen. This method excels at reducing harmful emissions and waste, positioning it as a top contender for future waste management practices. Unique benefits, like converting waste into reusable materials, further differentiate it from other waste disposal methods. By breaking waste down to its core components, plasma gasification bypasses the environmental issues tied to landfills and incineration.

The Economics of Plasma Gasification

Running a plasma gasification plant does cost money, which could make small-scale operations financially unfeasible. However, research indicates that these plants start turning a profit when they process around 100 tons of waste per day, thanks to the energy they produce and sell.³ This suggests that a community, or a group of communities, generating between 26,000 and 36,000 tons of landfill waste each year could likely support a cost-effective plasma gasification plant.

1: Plasma Gasification—The Waste-to-Energy Solution For The Future, <http://large.stanford.edu/courses/2021/ph240/jibodu2/docs/birsan-2014.pdf>

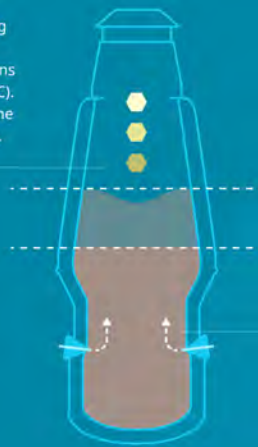
2: Environmental Assessment of Municipal Solid Waste by Two-Stage Plasma Gasification, <https://www.mdpi.com/1996-1073/12/1/137>

3: Thermal Plasma Gasification of Municipal Solid Waste (MSW), <http://large.stanford.edu/courses/2021/ph240/jibodu2/docs/byun-12.pdf>



Polisher zone

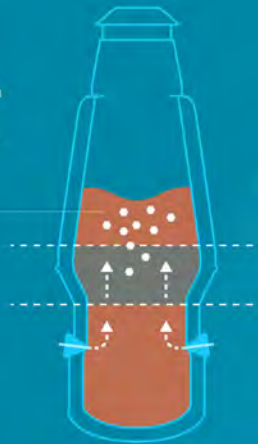
Condensable tars in the raw syngas exiting the top of the bed are fully converted to additional syngas using controlled reactions with oxygen and steam at 2,000°F (1,100°C). The tar-free syngas then exits the top of the gasifier ready for downstream processing.



Oxygen and steam are injected into the bottom of the gasifier producing hot syngas that rises and exchanges heat with the bed of waste material. This supports additional gasification reactions, devolatilization, and drying.

Drying and devolatilization zone

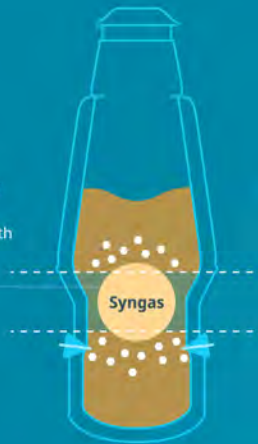
Waste enters the side of gasifier and is dried by rising hot syngas. The waste then descends into the devolatilization zone where a mix of light gases, hydrocarbons, and condensable tars are released at 1,300°F (704°C).



Solids that escape with the gas are cleaned out of the syngas and recycled back into the gasifier during gas cleaning.

Gasification zone

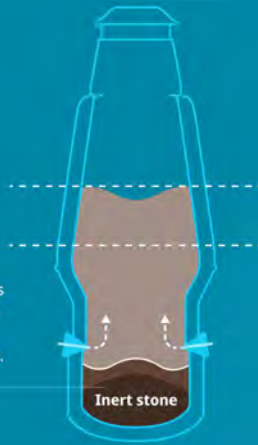
Gasification occurs in the lower section of the vessel where the remaining carbon-containing materials in the waste react with the steam and oxygen.



The exothermic gasification reaction raises the temperature of the lower zone from about 2,500°F (1,371°C) to 4,000°F (2,204°C) allowing for the thorough conversion of remaining carbon into syngas; the large amount of energy produced at this stage allows the FastOx® system to be self-sustaining.

Melting zone

At 4,000°F (2,204°C), inorganic compounds and metals melt and collect at the bottom in a molten state. This is removed as non-leaching inert stone and recovered metals.

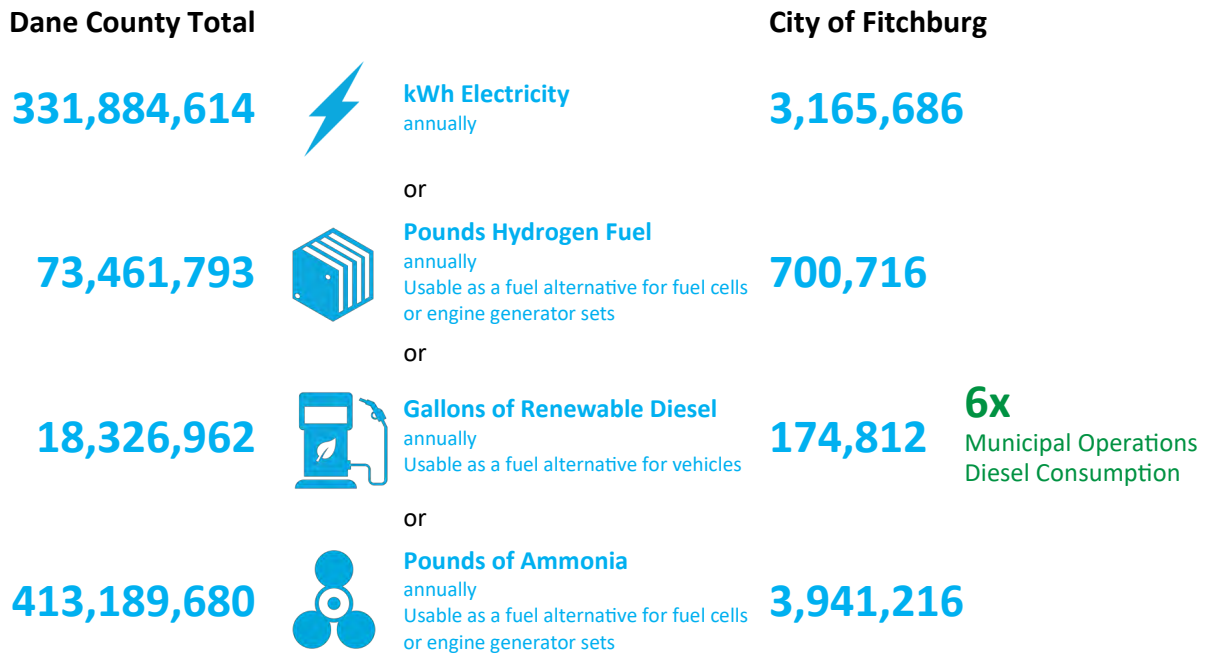


The ultra high temperatures of FastOx® gasification allow the system to completely convert mixed waste without producing toxic by-products.

City Wide Municipal Solid Waste Plasma Gasification Potential

Plasma Gasification Potential in City of Fitchburg

According to Sierra Energy, based on the City of Fitchburg’s total landfilled municipal solid waste, the current waste stream within Fitchburg could support the following gasification derived energy potential:



Source: Sierra Energy







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