U.S. DEPARTMENT OF
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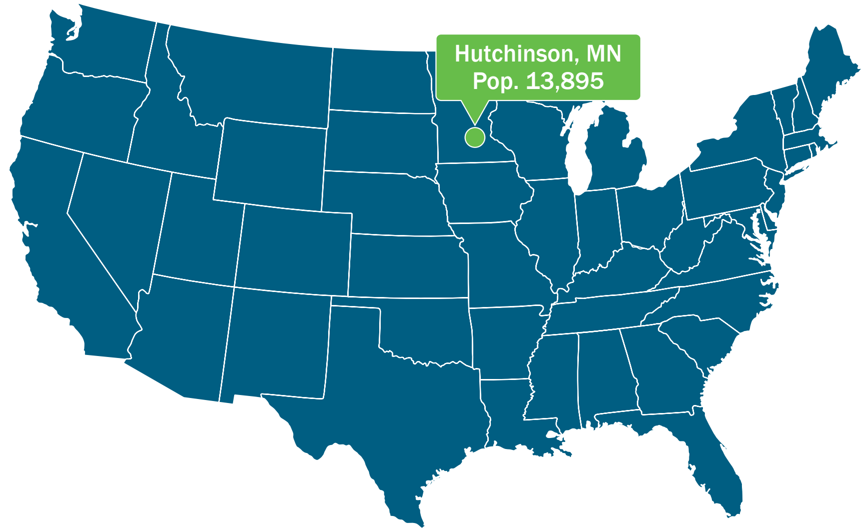
Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

CITY ENERGY: FROM DATA TO DECISIONS



Hutchinson, Minnesota: Evaluating Local Solar Energy Generation Potential

The City of Hutchinson, Minnesota, partnered with the Energy Department and the National Renewable Energy Laboratory (NREL) to demonstrate how data and analysis can inform more strategic energy decisions. NREL based its analysis in part on the City Energy Profiles on the State and Local Energy Data (SLED) website (eere.energy.gov/sled). The profiles contain data compiled by SLED and the Cities Leading through Energy Analysis and Planning (Cities-LEAP) program. Cities across the country can follow the same approach and use data-driven analysis in their own energy planning.

"The data provided through Cities-LEAP and SLED equipped Hutchinson with solar information not previously accessible to our community. Staff now has access to an important source of data that will help guide our energy planning goals. NREL's support helped prepare Hutchinson for a more diverse energy future."

— John Paulson, Environmental/Regulatory Manager, City of Hutchinson

City Energy Goals

As the City of Hutchinson, Minnesota, embarks on an energy and climate action planning process, it faces a data gap regarding the city's rooftop solar photovoltaic (PV) energy generation potential. The city asked for assistance in quantifying the rooftop solar energy generation technical potential to fill this data gap and inform the city's energy goal setting and prioritization processes.

Data and Analysis

The foundation for this analysis comes from estimated city energy data on SLED, supplemental data from publicly available sources, and data inputs obtained directly from the City of Hutchinson.

Rooftop Solar Technical Potential

NREL estimates that PV installed on all suitable rooftop areas in Hutchinson has the technical potential to meet 46% of the city's 2016 electricity consumption, based on existing commercially available PV technology.[1]

To estimate rooftop solar energy generation technical potential for all buildings in Hutchinson, NREL started with geographic information system (GIS) data provided by the city, which included the building footprint area and zoning district for every building in the city (see Figure 1). Google Project Sunroof's Data Explorer provides rooftop PV generation potential in many, but not all, U.S. cities (google.com/get/sunroof/data-explorer/).

Figure 1. Example of GIS buildings data for Hutchinson, Minnesota (Source: City of Hutchinson, Minnesota)

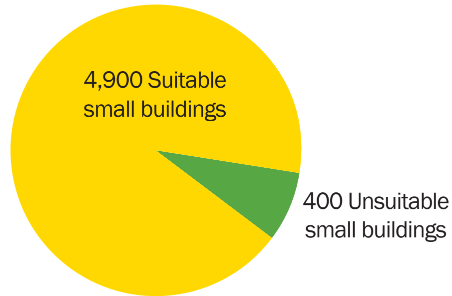
This analysis provides an approach to estimating rooftop PV generation potential in cities where such data, including from Google Project Sunroof, are not available, such as Hutchinson.

[1] Electricity consumption from Hutchinson Utilities Commission 2016 annual total. The analysis does not address technical issues related to existing electricity infrastructure (including distribution systems), the role of electricity storage, the need to balance electricity supply and demand, and considerations related to system reliability, solar valuation, or other challenges associated with implementing large amounts of rooftop PV (such as two-way information and energy transfer on existing grid infrastructure). The estimate does not incorporate the cost of PV or potential savings when generation costs are compared to retail electricity rates.

Metrics to estimate suitable roof area and solar energy generation and capacity technical potential used here are based on research conducted by Gagnon et al. (2016). Rooftop PV technical potential estimates for each state were developed using light detection and ranging (lidar) data for 128 cities from the U.S. Department of Homeland Security (DHS) Homeland Security Infrastructure Program for 2006–2014.[2]

Gagnon et al. analyzed rooftop PV potential according to the following size categories: small buildings (<5,000 square feet), medium buildings (5,000 to 25,000 square feet), and large buildings (>25,000 square feet). The small building rooftop potential estimates available for every city on the SLED site and shown for Hutchinson in Figure 2 are based on the methodology using ZIP code-level data for small buildings.

Gagnon et al. modeled rooftop suitability for medium and large buildings based on Census Division-level buildings data. To find a more localized metric to approximate the percentage of rooftop area suitable for solar energy generation in Hutchinson, NREL used the ratio of suitable rooftop area (roof area that passed screening for shading, azimuth, tilt, and minimum contiguous area) to the total roof area in the 10 ZIP codes closest to Hutchinson where DHS lidar data was available.[3] This analysis indicated that the following amounts of available rooftop area are suitable for solar energy generation: 23% for small buildings, 50% for medium buildings, and 78% for large buildings (see Table 1).[4]



Suitable area	294,638 m^2
Capacity potential	43,946 kW
Energy generation potential	49,183 MWh

Figure 2. Estimated small building rooftop PV technical potential in Hutchinson, Minnesota. These estimates are available for all cities on SLED. (Source: SLED)

Table 1. Estimated Rooftop Solar Energy Technical Potential Using Geospatial Data for Hutchinson, Minnesota

	Small Buildings (<5,000 ft^2)	Medium Buildings (5,000 ft^2–25,000 ft^2)	Large Buildings (>25,000 ft^2)	Total
Buildings*	7,299	343	68	7,710
Suitable Buildings†	6,748	343	68	7,159
Rooftop Area (ft^2)*	10,530,006	3,337,358	7,111,414	20,978,777
Percent Rooftop Area Suitable for PV§	23%	50%	78%	
Suitable Rooftop Area (ft^2)	2,421,901	1,668,679	5,546,903	9,637,483
Minnesota PV Capacity Technical Potential (kW/ft^2)**	0.01386	0.01117	0.01117	
PV Capacity on Suitable Rooftop Area (kW)	33,568	18,639	61,959	114,141
PV Generation Technical Potential in Minnesota (kWh/yr/ft^2)**	15.5	13	13	
Generation Potential on Suitable Rooftop Area (MWh/yr)††	37,539	21,693	72,110	131,342

*Source: Hutchinson, Minnesota GIS data. †Source: Derived for small buildings in Hutchinson from the percentage of suitable buildings indicated in Figure 2 and for medium and large buildings from Gagnon et al.'s estimate that 100% of medium and large buildings have at least a 10m^2 area of suitable roof plane. §Estimates based on the percentage of suitable rooftop area in nearby ZIP codes where lidar data was available. **Derived for small buildings in Hutchinson from data in Figure 2 available on SLED and for medium and large buildings from state level estimates in Table 5 in Gagnon et al. 2016. ††PV generation technical potential (kWh/yr/ft^2) multiplied by suitable rooftop area (ft^2)/1,000

[2] Gagnon et al., *Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment*, NREL (2016), NREL/TP-6A20-65298, http://www.nrel.gov/docs/fy16osti/65298.pdf.

[3] The ten zip codes are located along the western edge of the lidar coverage for the Twin Cities area, approximately 40 miles East of Hutchinson. A map of the zip codes is available at: https://www.energy.gov/eere/analysis/downloads/hutchinson-minnesota-evaluating-local-solar-energy-generation-potential

[4] For all ZIP codes in Minnesota for which lidar data was available, the following average amounts of available rooftop area are suitable for solar energy generation: 21% for small buildings, 53% for medium buildings, and 78% for large buildings. National averages of 26% for small buildings, 49% for medium buildings, and 66% for large buildings may be used where these are unavailable.

Next, the technical potential for installed PV capacity was estimated by determining the ratios of installed capacity and annual generation to suitable rooftop area. These ratios were derived for small buildings by using the SLED data shown in Figure 2.[5] The resulting technical potential ratios for Hutchinson are 0.01386 kW of capacity per square foot of suitable roof area and 15.5 kilowatt-hours (kWh) of solar energy generation per square foot per year.

Similar ratios were developed for medium and large buildings based on estimated state suitability averages included in Table 5 in Gagnon et al.[6] For Minnesota, the average technical potential is 0.01117 kW of capacity per square foot of suitable roof area and 13 kWh of solar energy generation per square foot per year for both medium and large buildings. These ratios reflect estimates of rooftop orientation.

This analysis indicates that, after screening for shading, azimuth, tilt, and minimum area, roof area in Hutchinson, Minnesota, can support solar energy generation of an estimated 131,342 MWh per year. This technical generation potential equals 46% of the 283,662 megawatt-hours (MWh) of electricity consumption in Hutchinson in 2016.[7]

Refining Technical Potential

The GIS data from the City of Hutchinson also includes the zoning district for each building. Zoning data allows the city to progress from the above analysis based on building size alone to targeted actions based on building use. For example, the city and its municipal utility may want to differentiate between policies and actions targeting the residential sector from those that may be more appropriate for the commercial and industrial sectors.

As evident in Figure 1, GIS data, like lidar data, captures all roof area including outbuildings such as sheds, detached garages, and other secondary structures. These secondary structures are counted as separate buildings and are included in the total building count (see Table 2). In Hutchinson, more than 1,500 of the total buildings are under 500 square feet, leading to zoning district building counts far higher than the number of buildings suitable for PV. The screening criteria from Gagnon et al. used here applied a minimum of 107.6 square feet of roof plane for a roof to be considered suitable for PV, which excludes many such outbuildings.[8]

Cities may also want to exclude manufactured homes from analyses of the area suitable for PV as these buildings may not have sufficient rooftop structural integrity to support PV.

Further analysis may be applied to progress from technical potential estimates to more near-term market and economic potential. Such an analysis could take into consideration return on investment, matching installed capacity to building-specific load, local and state incentives, capacity limits and other policies, and whether the building is owner-occupied.[9]

For long-term planning, cities may consider technical potential as the upper limit on electricity generation from rooftop solar. Planning scenarios may also need to address potential increases in electric load from electrification through technologies, such as electric vehicles and air source heat pumps.

Rooftop PV is only one of multiple supply options—and not necessarily the most cost-effective one—available to cities seeking to achieve high-penetration renewable goals. For example, in addition to rooftop PV initiatives, Washington, D.C., plans to purchase all generation from a 45-MW wind energy facility, which will supply 35% of electricity consumption by D.C. governmental operations and save $45 million over 20 years.[10] More than 20 cities in Minnesota participate in shared solar programs that supply between 50% and 100% of public sector electric energy use, at a lower cost than paid previously.[11] The City of Riverside, California, purchases geothermal electricity from the Imperial Valley.[12] Many states are implementing Community Choice Aggregation, which enables direct purchase of renewable energy by local governments.[13]

Other renewable energy sources, as well as community- and utility-scale PV, can also be less expensive—costing one-third to one-half less on a per kW basis than rooftop solar energy generation—for those communities with the opportunity to purchase it.[14]

[5] Square meters are converted to square feet to match the units used in Hutchinson's data.

[6] The Gagnon et al. analysis assumed sloped roofs would have modules installed flush with the roof, resulting in a high roof-area-to-module-area ratio of 0.98. In contrast, flat roofs were assumed to have modules installed at a 15-degree tilt, requiring additional spacing to avoid shading and an assumed ratio of module-area-to-roof-area of 0.70. Roof planes on small buildings in the lidar samples were predominated sloped and medium and large buildings were predominately flat, resulting in higher average installed-capacity-per-suitable-roof-area values for small buildings than medium and large buildings (see page 25).

[7] Electricity consumption from Hutchinson Utilities Commission annual total.

[8] As the minimum roof plane screening criteria is reflected in the percentage of rooftop area suitable for PV, eliminating buildings under this size threshold will help in determining the number of buildings or other criteria but should not be applied in addition to the suitability percentage as this will screen out such buildings twice.

[9] See for example, the Data to Decisions publication for San Jose, California: https://www.energy.gov/sites/prod/files/2017/10/f37/Cities-LEAP_Data%20to%20Decisions_San%20Jose%2C%20California.pdf.

[10] "Mayor Bowser Announces Groundbreaking Wind Power Purchase Agreement," DC.gov, July 14, 2015, https://mayor.dc.gov/release/mayor-bowser-announces-groundbreaking-wind-power-purchase-agreement.

[11] "What Cities Learned From Their First-Ever Group Purchase of Community Solar," Greentech Media, April 21, 2017, https://www.greentechmedia.com/articles/read/what-cities-learned-from-their-first-ever-group-purchase-of-community-solar#gs.n5LKy4Y.

[12] "Riverside Public Utilities Signs Historic Salton Sea Geothermal Power Agreement with CalEnergy LLC," Riverside, California, June 20, 2013, https://www.riversideca.gov/utilities/news-display.asp?newsid=363.

[13] "Community Choice Aggregation (CCA) Helping Communities Reach Renewable Energy Goals," NREL, September 18, 2017, https://www.nrel.gov/technical-assistance/blog/posts/community-choice-aggregation-cca-helping-communities-reach-renewable-energy-goals.html.

[14] Page 41 of the "Q3/Q4 2017 Solar Industry Update," NREL (2018), indicates the cost per watt for systems 500 kW–5 MW was 55% less than the cost per watt for systems 2.5 kW–10 kW (https://www.nrel.gov/docs/fy18osti/70917.pdf).

Resources

The following resources may be useful to guide further actions for increasing local solar electricity generation:

PV System Cost Analysis

- Estimate energy production and costs of grid-connected PV systems with the NREL PVWatts Calculator: http://pvwatts.nrel.gov

Planning for Solar

- Solar Powering Your Community: A Guide for Local Governments: https://www1.eere.energy.gov/solar/pdfs/47692.pdf
- Planning for Solar Energy: Promoting Solar Energy Use Through Local Policy and Action: http://www.grow-solar.org/wp-content/uploads/2014/10/Planning-for-Solar-Energy-2014_PAS-575.pdf
- Local Solar: What Do Leading Solar Communities Have in Common? It May Not Be What You Expect: http://www.nrel.gov/docs/fy16osti/64883.pdf
- Expanding Midscale Solar: Examining the Economic Potential, Barriers, and Opportunities at Offices, Hotels, Warehouses, and Universities: http://www.nrel.gov/docs/fy16osti/65938.pdf
- Are Cities Codifying Clean Energy Policy? The Answer is Yes: https://www.nrel.gov/tech_deployment/state_local_governments/blog/are-cities-codifying-clean-energy-policy-the-answer-is-yes
- Local Government Solar Toolkit – Minnesota: http://www.betterenergy.org/blog/minnesota-solar-toolkit/.

High-Penetration PV Analysis

- U.S. Department of Energy Solar Energy Technologies Office – On the Path to SunShot: https://energy.gov/eere/solar/path-sunshot
- Eastern Renewable Generation Integration Study: https://www.nrel.gov/grid/ergis.html

Table 2. Building Count and Area by Zoning District for Hutchinson, Minnesota (2018)

Zoning District	Zoning Description	Footprint Aggegate ft^2)	Count of Buildings
C-1	Neighborhood Convenience Commercial	4,476	2
C-2	Automotive Service Commercial	100,408	22
C-3	Central Commercial	791,334	141
C-4	Fringe Commercial	2,461,119	204
C-5	Conditional Commercial	77,924	28
GT	Gateway	39,003	1
I/C	Industrial/Commercial	764,890	124
I-1	Light Industrial Park	4,044,584	132
I-2	Heavy Industry	492,774	80
R-1	Single Family Residential	1,924,845	922
R-1 PD	Single Family Residential Planned Dev.	132,368	47
R-2	Medium Density Residential—1 or 2 Family & Duplexes	7,111,734	4,626
R-2 PD	Medium Density Residential Planned Dev.	312,867	110
R-2B	Medium Density Residential = R-2 Platted after 1987	331,242	156
R-3	Medium-High Density Residential	1,149,742	433
R-3 PD	Medium-High Density Residential Planned Dev.	287,051	122
R-4	High Density Residential—2 Family and Larger	558,883	48
R-5	Manufactured Home Park	393,533	512
Total		**20,978,777**	**7,710**

Source: Hutchinson, Minnesota GIS data

- Estimating Renewable Energy Economic Potential in the United States: Methodology and Initial Results: https://www.nrel.gov/docs/fy15osti/64503.pdf.

Find additional resources in the SLED Local Energy Action Toolbox: http://apps1.eere.energy.gov/sled/cleap.html. ■

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