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Date: September 5, 2017

To: Neighborhood & Comprehensive Planning Committees

From: Jake Reilly (266-6618/jake.reilly@ci.stpaul.mn.us)

Subject: Draft Alternative Energy Zoning Study Zoning Code Amendments

Introduction

Section 60.103(k) of the Zoning Code states that a purpose of the Zoning Code is "to promote the conservation of energy and the utilization of renewable energy resources." The Zoning Code contains no specific provisions for wind energy conversion systems (WECS). On April 15, 2011, the Planning Commission initiated a zoning study to consider amendments to the zoning code pertaining to wind turbines that will address issues specific to wind turbines and conditions under which wind turbines might be permitted in various zoning districts.

In 2013, while staff was studying wind turbine regulation, the Minnesota Legislature passed a suite of laws that are driving the market for solar installations and enabling local government authority. Minnesota Statute 216B.1641 established the Xcel Energy Community Solar Garden Program. This program allows for large solar farms or gardens on structures and on large plots of land. The goal was to allow people who want to use solar energy as part of their energy consumption, but are unable to do so on their own. Saint Paul's zoning code does not accommodate solar gardens on large plots of land.

At the April 26, 2017 Neighborhood Planning Committee meeting, staff provided information on solar gardens, following passage of a suite of laws that are driving the market for solar installations and enabling local government authority in 2013. That meeting also included discussion of amendments related to WECS.

This memo addresses issues raised at that meeting and at the August 18th meeting. Information presented at the August 18 meeting has been added to this memo and is highlighted. The additional clarifying information requested during the August 18 meeting is presented in <u>double-underlined text</u>.

Wind

Background

In 2002 Macalester College applied for and received a Determination of Similar Use (DSU) for a free-standing, 10 kW, 102-foot high wind turbine located on the campus. Since then a number of people have approached the Department of Safety and Inspections (DSI) seeking information about free-standing and building-mounted wind turbine regulation in the city. On April 12, 2011 Capitol Lien and Title at 1010 North Dale applied for a DSU for a free-standing wind turbine and three building-mounted wind turbines. This application was approved subject to several conditions, including the completion of a noise study by a qualified acoustical engineer. On December 1, 2011, Metropolitan State University applied for a conditional use permit for a 20kW wind turbine on a freestanding pole 104 feet high. That application was initially approved by the Planning Commission, but upon appeal from the neighborhood was denied by the City Council in 2012.

This section of the memo outlines types of wind turbines; contains a survey of city and county ordinances regulating turbines or WECS; and makes recommendations for a Saint Paul ordinance related to WECS.

Research

Categories and design of wind turbines

There are two categories that wind turbines fit into, according to the industry. The first is "large wind" which refers to turbines with a capacity of 5,000 kilowatts or more. "Small wind" is any turbine with a capacity of less than 5,000 kilowatts. The State of Minnesota Wind Siting Act (Chapter 203-S.F. No. 1076) uses the same categories in its wind turbine definitions.

Wind turbines also come in two different designs. Horizontal-axis turbines have blades that rotate perpendicular to the ground. These turbines must face into the wind in order to function and are similar to those seen in large wind farms, or locally at Macalester, in North Saint Paul, and in Maple Grove. Vertical-axis turbines have blades or rotors that rotate parallel to the ground and can capture turbulent wind, or wind in any direction. They have an egg beater-like appearance. Local examples include the three roof-top mounted, and one free-standing turbines at the Capitol Lien and Title company on Dale Street, on Como Avenue between Western and Virginia, and at the newly constructed Hy-Vee Grocery stores around the metro, including Oakdale, on the solar- and wind-powered electrical vehicle charging stations in their parking areas.

Like the Hy-Vee electrical vehicle charging station example, there are other hybrid wind/solar fixtures, usually light fixtures for use in parking lots or in public right of way with a solar power element and a wind power element. The solar element is a photovoltaic system and the wind element is a vertical axis wind turbine, or a small wind turbine.

Vertical-axis turbines in use in the US tend to generate less energy and fall into the "small wind" category. Commercial/industrial wind farm installations in the US have typically been horizontal-axis turbines. Generally speaking, urban installations tend to both have lower generation capacity and be vertical-axis turbines.

Practical applications

According to The Renewable Energy Hub web site (https://www.renewableenergyhub.us/wind-turbines/how-much-does-wind-turbines-cost.html), residential sites should:

- have a wind speed minimum of 5 meters per second (to test, you can install an anemometer, which many states supply);
- ensure there are no obstructions (e.g., other houses, trees) that could cause turbulence;
- make sure your building is not subject to any state, federal or even county restrictions, whether you are installing a roof mounted system or free-standing one;
- decide if you have enough land for foundations if you are installing a free-standing wind turbine; and
- check whether you need planning permission to install a wind turbine.

Wind turbines for residential use vary in power from 0.2kW to 25 kW and can be used as a supplemental energy source. According to data from Xcel Energy, the average residence in Minnesota uses about 9000kWh/year. The average cost for a roof-mounted residential turbine is about $5,000, plus annual maintenance. Some wind turbines are able to store power in a battery.

System size	Approx. yearly system output*
.3kW (building-mounted)	669kWh

1kW (building-mounted)	1,750kWh
1.5kW (pole-mounted)	2,600kWh
2.5kW (pole-mounted)	4,400kWh
3.0kW (building-mounted)	6,500kWh
5kW (pole-mounted)	8,900kWh
10kW (pole-mounted)	21,500kWh
15kW (pole-mounted)	36,000kWh

*Assumes the average US wind speed of 5.6m/s for the sake of illustration. The actual system output is predicated upon a large range of factors. Larger, higher output turbines also tend to be mounted at greater heights, where wind speeds are higher.

Smaller turbines on residential structures are used to supplement electricity production from solar installations, particularly during winter months[a].

For a typical commercial district and commercial building in Saint Paul, similar systems could be applied, but with less effect, given commercial electricity consumption in Minnesota, which averages 80,400 kWh/month, according to Xcel Energy. Free-standing systems producing outputs like below would be horizontal systems, with a look similar to turbines in North Saint Paul, Maple Grove, and on windfarms throughout the country.

Freestanding system size	**Approx. yearly system output***
1500 kW (1.5MW)	5,000,000kWh (5,000MWh)
2000 kW (2.0MW)	8,000,000kWh (8,000 MWh)
2500 kW (2.5MW)	11,000,000kWh (11,000 MWh)
3000 kW (3.0MW)	13,000,000kWh (13,0000 MWh)

*Averages from: http://www.windpowerengineering.com/turbine-selector-app/

Vertical-axis wind turbines are small wind generators (200 W - 10kW) can be used as stand-alone systems or as grid connected systems, and both can be paired with other energy conversion systems, such as photovoltaics. With a height from 6 to 32 feet small wind turbines can be placed on rooftops, on streets or in gardens, they have relatively little visual impact and are able to produce energy even from modest wind flows. Places like China, India and Italy have large markets, but small wind installations grow by about 10 percent each year[b].

Although they are installed lower to the ground than horizontal-axis devices, rooftop installations have advantages over ground-mounted turbines. According to Casini's article, if the height of the rooftop mounted turbine shaft is approximately 50 percent of the building height, energy generation will be maximized.

Potential land use impacts

Siting of wind turbines may have potential land use impacts. For large wind, consideration of the "fall" zone is important. However, wind installations of either variety are unlikely to impact the amount of traffic congestion in the public streets, or impede the normal and orderly development and improvement of the surrounding property. There is debate about the impact on the public health and safety of wind turbine products, which will be discussed later in this memo.

[a] Casini, Marco. "Small Vertical Axis Wind Turbines for Energy Efficiency." *Journal of Clean Energy Technologies*, vol. 4, no. 1, Jan. 2016, pp. 56-65. Accessed 8/18/2017: http://www.jocet.org/vol4/254-H0020.pdf

[b] Ibid.

Other cities' regulations:

Staff reviewed nearly 20 ordinances from half a dozen states examining type of wind systems permitted, method of permitting; addressed zoning districts, heights, setbacks and other life/safety concerns, environmental concerns around humans and animals, including model ordinances proposed by sustainability experts in Minnesota and the US. Staff also spoke with regulators at the State and solar and wind-energy providers operating in Minnesota.

Height, setbacks, and blade clearance
Large wind systems generally require a conditional use permit, as in Minneapolis, and are not permitted in residential or office districts. The regulations usually restrict large wind installations to lots of one acre or greater and with no more than one turbine per acre. However, in Maple Grove and Eden Prairie, they are permitted as an accessory structure in all districts.

For large wind, setbacks are generally a 1.1 x height from any property lines (Cleveland, Lincoln, New York State Energy Research and Development Authority (NYSERDA)) or simply based on the tower height (Duluth, Madison, Plymouth), sometimes with a total height restriction (Duluth). The Distributed Wind Energy Association's model ordinance, suggests a 1.1 to 1.25 x height distance from property lines.

Height of large wind turbines generally depends on the lot size. Minneapolis restricts height to 100' tall on sites of five or more acres and 60' on sites of one to five acres. NYSERDA recommends that the height of the turbine from the ground to the top of the rotor at its highest position be 30', while in Plymouth, blade arcs "shall have a minimum of 30 feet of clearance *over* any accessory structure or tree." The American Wind Energy Association recommends that on a 1/2 to 1-acre lot, the height maximum should be no more than 150'.

Small wind turbines are generally permitted in all districts without a conditional use permit (Wisconsin). Lincoln, NE and Schaumburg, IL permit small wind turbines as a conditional or special use. Ground-mounted units are permitted as an accessory structure (Chicago, Duluth) and roof mounted ones are permitted in all districts (Henderson, NV and Minneapolis). In Minneapolis one may not install a wind turbine on a residential structure with fewer than four stories.

For small wind, setbacks vary from being a simple 1:1 height ratio (Wisconsin) to 10' to 15' from the property line for smaller units (Oakland, Cleveland, Denver, AWEA). Chicago and Schaumberg, IL both require a 20' setback from all lot lines. Minneapolis sites wind turbines at least 10' from the wall of a structure.

Height restrictions generally refer to building-mounted small wind turbines but there are some restrictions for ground-mounted ones in residential districts. For ground-mounted turbines they must not be more than a certain height taller than the building on the property. This varies from 7' (Oakland) to 75' (Denver). Minneapolis and Chicago, two urban cities surveyed from our region, require the turbine to be not greater than 15' above the rooftop or parapet, whichever is greater.

Noise
Noise regulations of large wind turbines vary from place to place. Cleveland limits sound to not more than 50 decibels measured from the nearest residential property line. This matches the MN Model ordinance and MN State noise rules (MN Rule 7030). NYSERDA suggests not more than 55 dB(A) at property line and AWEA 60 dB(A) at nearest building or not more than 5 dB(A) above ambient noise. Reno, Nevada and Schaumburg, IL limit wind turbine sound levels to 50 decibels over ambient noise, in residential districts and 60 decibels over ambient noise in other districts, according to "Planning for

Wind Energy," a publication of the APA. The APA recommends using that standard. The output of a typical 2 kW turbine (the size to serve a single-family residence) is about 55 dBA at a distance of 50 feet. This is about the same level as a household air conditioning unit at 100 feet. In comparison, a passenger car at 65 mph at 25 ft is 77 dB, which is noted as being "annoyingly loud to some people," by the acoustic engineering firm IAC Acoustics. Decibels are additive which means a sound that is 50 dB (for example, standing 100 feet away from a large electrical transformer) is 1/4th as loud as that traffic example, and 80 dB is actually two times louder than 70 dB. Vertical-axis devices have very low sound generation, in comparison with horizontal-axis systems[c].

Access

Access to a wind turbine is typically limited by fencing and a lock and/or limiting climbing apparatus to not less than 8' above the ground, with the most common restriction being no climbing apparatus within 12' of the ground (NYSERDA, Minneapolis, Schaumberg, MN Model, Plymouth)

Animal impacts

Bat and bird impacts are not specifically mentioned in any codes currently established in the US. However, there have been some studies that suggest that at large wind sites anywhere from 1 to 3 birds are killed per tower per year. Bats potentially experience a kill rate of almost three times that. Wind turbines generally pose risks to individuals, not populations. Birds are more likely to be killed by other human infrastructure and utilities like vehicles, windows, communications towers, pollution and house cats, according to "Planning for Wind Energy." For most urban applications wind turbines are mounted lower than bird and bat migration paths. "Because of the relatively smaller blades and short tower heights, home-sized wind machines are considered too small and too dispersed to present a threat to birds. Researchers do not consider a study of home-sized wind systems worth funding." (focusonenergy.com) Small WECS have very limited wildlife impacts, according to the APA. The blade areas do not create as much of a hazard and there is typically plenty of maneuvering space around them. The number of birds killed annually by WECS is fewer than by housecats or glass windows and doors. In fact, in 2006 the Audubon Society issued a statement in support of well-located WECS. No research was found specifically about birds or bats and vertical wind turbines. An industry representative has stated that vertical wind turbines appear to be solid objects when spinning, which would cause birds and bats to fly around them, rather than try to go through them. There is no evidence to suggest that vertical wind turbines create enough disturbance in the wind to draw birds or bats in to them.

A review of current literature as of August 20, 2017 demonstrates that there is still little evidence to suggest that wind turbines create enough disturbance in the wind to draw birds or bats into them, particularly in urban areas.

Other regulations

When addressed, the following criteria are found for all wind turbines: The wind turbines are not to interfere with electromagnetic communications; they are not to be used for advertising; the color or finish should blend in with the architecture or be screened or painted a subdued, non-reflective color. The American Wind Energy Association and Boston both refer to the systems minimizing glare and flickering shadows, which may be caused by the rotor spinning. Wind turbines must be removed when abandoned, which is defined differently based on the city, but most commonly after a 12-month period (Minneapolis, Maple Grove).

[c] Ibid.

Hybrid (Wind/Solar) Fixtures

Hybrid (wind/solar) fixtures include light fixtures and mechanisms for powering electric vehicle charging stations are light fixtures for use in parking lots or in public right of way with a solar power element and a wind power element. The solar element is a photovoltaic system and the wind element is a small vertical axis wind turbine. The light fixtures are similar to cobra head lights and reflect downward, as required by the zoning code. The electric vehicle charging stations are similar to existing free-standing models used in city facilities, but with a similar solar/wind element to the light fixtures. The zoning code does not address these stations.

The zoning code as currently written does not preclude the use of a hybrid (wind/solar) light fixture. The hybrid light fixture is similar to standard light fixtures used in parking lots, and would be treated the same by the zoning code. The kinetic feature of the vertical-axis wind turbine is designed to minimize flicker impacts and the solar panel is similar to solar panels on other fixtures on light posts such as solar-powered wireless broadband internet systems in use around the country.

While zoning code does not specify lighting as a use, accessory or otherwise it does set standards in Section 63 and in the T districts.

Section 63.116 Exterior Lighting of the zoning code addresses standards for exterior lighting. It requires that lighting be shielded to reduce glare and arranged as to reflect lights away from all adjacent residential districts in such a way as not to exceed 3 footcandles measured at the residential district boundary. Lighting illuminating the exterior of a building must also be placed and shielded to avoid interference with the vision of people on highways or adjacent property.

Section 63.318 sets the standard for lighting in parking facilities. It requires that parking facilities be illuminated to a level to allow safe, secure access to the parking facility and within it, and states that all lighting shall conform to Section 63.116.

Additionally, the Traditional Neighborhood district design standards in Section 66.343 state that pedestrian-scale lighting shall be provided in parking areas but that poles shall not be more than 25 feet in eight in parking lots and 16 feet in height along interior sidewalks and walkways.

Chapter 63, Article 2 of the zoning code addresses other parking requirements, and allows for reductions in parking minimums for provision of energy efficient vehicles.

Analysis

Staff recommends code amendments to permit wind energy conversion systems that are consistent with regulations of surrounding communities, in order to incentivize such systems by providing regulatory simplicity and predictability while still protecting neighborhoods.

Code recommendations suggest dealing with wind energy conversion systems as an accessory use, rather than as a primary use. Accessory uses are those that are "clearly incidental to, customarily found in connection with, and (except as provided in section 63.300) located on the same zoning lot as, the principal use to which it is related." This will regulate wind energy conversions systems the same way solar energy systems are regulated. Due to the nature of development and the market in Saint Paul, it is unlikely that a wind energy systems would be proposed as a primary use. Large wind (greater than 5,000 kW and generally a vertical turbine) might be considered as a primary use, but staff believes that users of wind turbines will seek to power a business or facility as an accessory use and not a primary use. If the market or patterns of development changes or interest arrives, wind energy conversion systems as a primary use may be considered.

Code recommendations cover issues such as height, setback, minimizing flicker impact, and minimizing noise impact, and when and where to consider a Conditional Use Permit application.

Staff does not recommend establishing hybrid light fixtures as a use in the zoning code, but recommends adding language to Sec. 63.116 Exterior Lighting.

Solar

In 2011 Saint Paul amended the zoning code to better accommodate solar installations.

Since then, state law enabling the creation of Community Solar Gardens was passed in 2013. Community Solar Gardens are centrally-located solar photovoltaic (PV) systems that provide electricity to participating subscribers. Xcel Energy customers can participate in projects offered by private developers. Members of other utilities in Minnesota can subscribe to a community solar garden if one is offered by the utility. The first solar garden project was launched by the Wright-Hennepin Cooperative Electric Association that year. The first solar garden in Xcel Energy's Minnesota region went online in Kasota, MN in 2015. Most solar gardens are being built on the urban fringe in Dakota, Wright, and Sherburne Counties, and solar gardens on rooftops have not yet come to fruition, according to resources available from the Clean Energy Resource Teams (CERTs) organizations.

Because Minnesota state statutes leave most solar development regulation to local governments, it is important for Saint Paul to have development regulations that are "solar ready," which means ordinances will address all the types of solar land uses the community is likely to see. At this time, Saint Paul's ordinance, while providing an as-of-right solar installation opportunity for accessory use solar, it does not address solar as a principal use. Additionally, the zoning code does not include information on solar access associated with solar easements; solar roof incentives such as offering bid preferences to purchasers/developers of publicly-owned lots who commit to providing solar capacity on the site when fully built out; density bonuses for kilowatt or square foot of solar capacity per unit; or commercial parking lot reductions. Finally, the zoning code does not specifically state that community solar gardens are permitted, as either principal or accessory uses. The committee chose not to make a recommendation for amendments to the zoning code regarding solar installations and solar access.

DSI experience

At the April 2017 meeting, the committee directed staff to check with staff with the Department of Safety and Inspections about issues in permitting solar installations with the code as written. DSI staff said they had no difficulty with interpreting the existing zoning code related to solar installations, nor had they had requests for solar installations they could not permit.

Staff recommendation

Staff recommends that the Committee forward the study and related amendments to the Planning Commission, and that the Commission set a public hearing date of November 3, 2017.

Staff has a goal to move forward with any amendments in a timely manner so that any code amendments are forwarded to the City Council before the end of 2017.

Attachments

a. Proposed code amendments for wind energy conversion systems
b. Renderings of wind turbines on Saint Paul buildings

Recommended code language, wind

Sec. 63.116. Exterior lighting.

...

(d) Hybrid (wind/solar) light fixtures will be placed so as to minimize flicker impacts and shall not exceed 25 feet in height. They shall be set back from other principal structures by at least one (1) times the height of the fixture.

Sec. 65.925. Wind energy conversion system.

Any device such as a windmill or wind turbine that converts wind energy to electrical energy, and associated facilities including the support structure of the system.

Standards and conditions:

(a) A building-mounted wind energy conversion system shall be subject to the maximum building height specified for the district or a maximum of fifteen (15) feet above the height of the building to which it is attached, whichever is greater. In residential districts the system shall be set back a minimum of ten (10) feet from all exterior walls of the building to which it is attached.

(b) In residential, traditional neighborhood and business districts, a conditional use permit is required for a freestanding wind energy conversion system with a capacity of more than two (2) kilowatts (kW) ~~on a freestanding pole~~.

(c) In residential, traditional neighborhood and business districts, a freestanding wind energy conversion system with a capacity of more than two (2) kilowatt shall be subject to the following standards and conditions:

(1) Freestanding systems shall not exceed one hundred (125) feet in height.

(2) The system shall not be located in a required front or side yard and shall be set back one and one tenth (1.1) times the height of the system from residential buildings.

(3) In residential and traditional neighborhood districts, the freestanding wind energy conversion system shall be on institutional use property at least one (1) acre in area. In business districts, the zoning lot on which the freestanding system is located shall be in an area of contiguous business or industrial zoning at least five (5) acres in area. A maximum of one (1) wind energy conversion system per acre of lot area shall be allowed.

(d) In industrial districts, a freestanding wind energy conversion system shall not exceed one hundred fifty (150) feet in height, shall not be located in a required front or side yard, and shall be set back one and one tenth (1.1) times the height of the system from residential buildings.

(e) Wind energy conversion systems shall conform to the uniform building code, electric code, Minnesota Rules Section 7030 governing noise, and Chapter 293, Noise Regulations. System noise shall not exceed 50 dB(A) at the nearest residential property line. For property within a locally designated heritage preservation site or district, the system shall be subject to review and approval of the heritage preservation commission.

(f) Freestanding systems shall be mounted on a monopole type tower with a non-reflective, subdued finish that does not require guyed wires or any other means to support the tower.

(g) Blade arcs created by the WECS shall have a minimum of thirty (30) feet of clearance over any structure or tree within a two hundred (200) foot radius.

(h) Wind energy facilities shall be sited in a manner that minimizes shadowing or flicker impacts. The applicant has the burden of proving that this effect does not have significant adverse impact on adjacent uses.

(i) Electrical equipment shall be housed within an existing structure whenever possible. If a new equipment building is necessary, it shall be permitted and regulated as an accessory building.

(j) Wind energy conversion systems that are no longer used shall be removed within one (1) year of nonuse.

(k) An applicant for a building permit for a wind energy conversion system shall provide written certification to the building official from a licensed structural engineer that:

(1) For building-mounted systems, the structure has the structural integrity to carry the weight and wind loads;

(2) The system is designed not to cause electrical, radio frequency, television and other communication signal interference.

(l) If the applicant plans to connect the system to the electricity grid, written evidence that the electric utility service provider serving the property has been informed of the applicant's intent to install a wind energy conversion system shall also be submitted to the building official.

Sustainable power zoning code amendments

Recommended changes to allow for wind energy systems in all districts

Neighborhood and Comprehensive Planning Committee joint meeting

Sept. 5, 2017

Wind energy as an accessory use

- As are solar installations
- Understood to be permitted in all districts
- Standards/conditions express where/how
- Not listed in a use table – convention has been to list accessory uses in use tables only when they are exceptions
- Regulated similar to surrounding communities
- Code language allows for changes in technology

Residential roof-mounted systems

500W wind turbines

Residential roof-mounted systems

500W wind turbines

9th Street Lofts

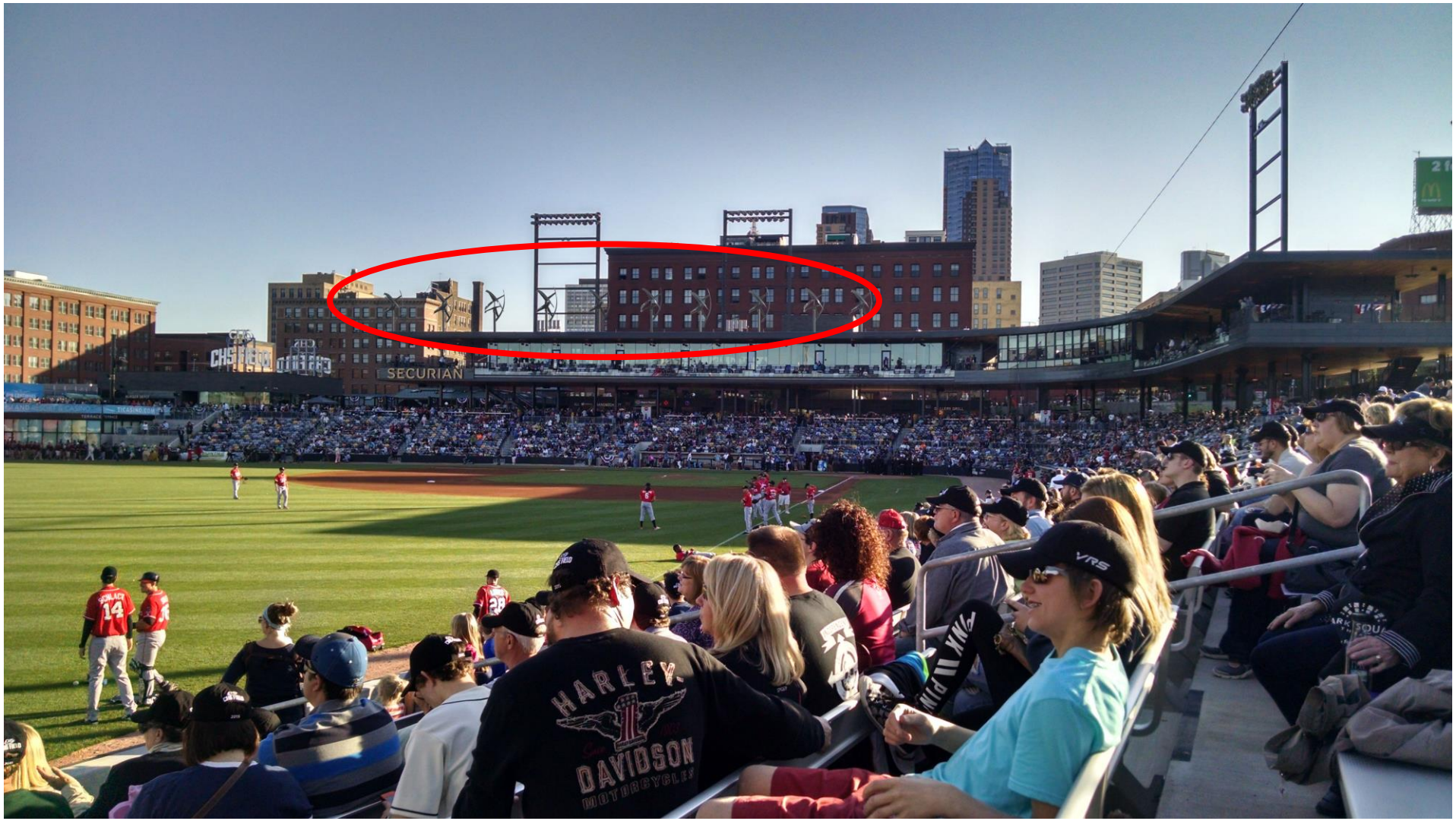
4kW wind turbines

CHS Field

4kW wind turbines

CHS Field

4kW wind turbines

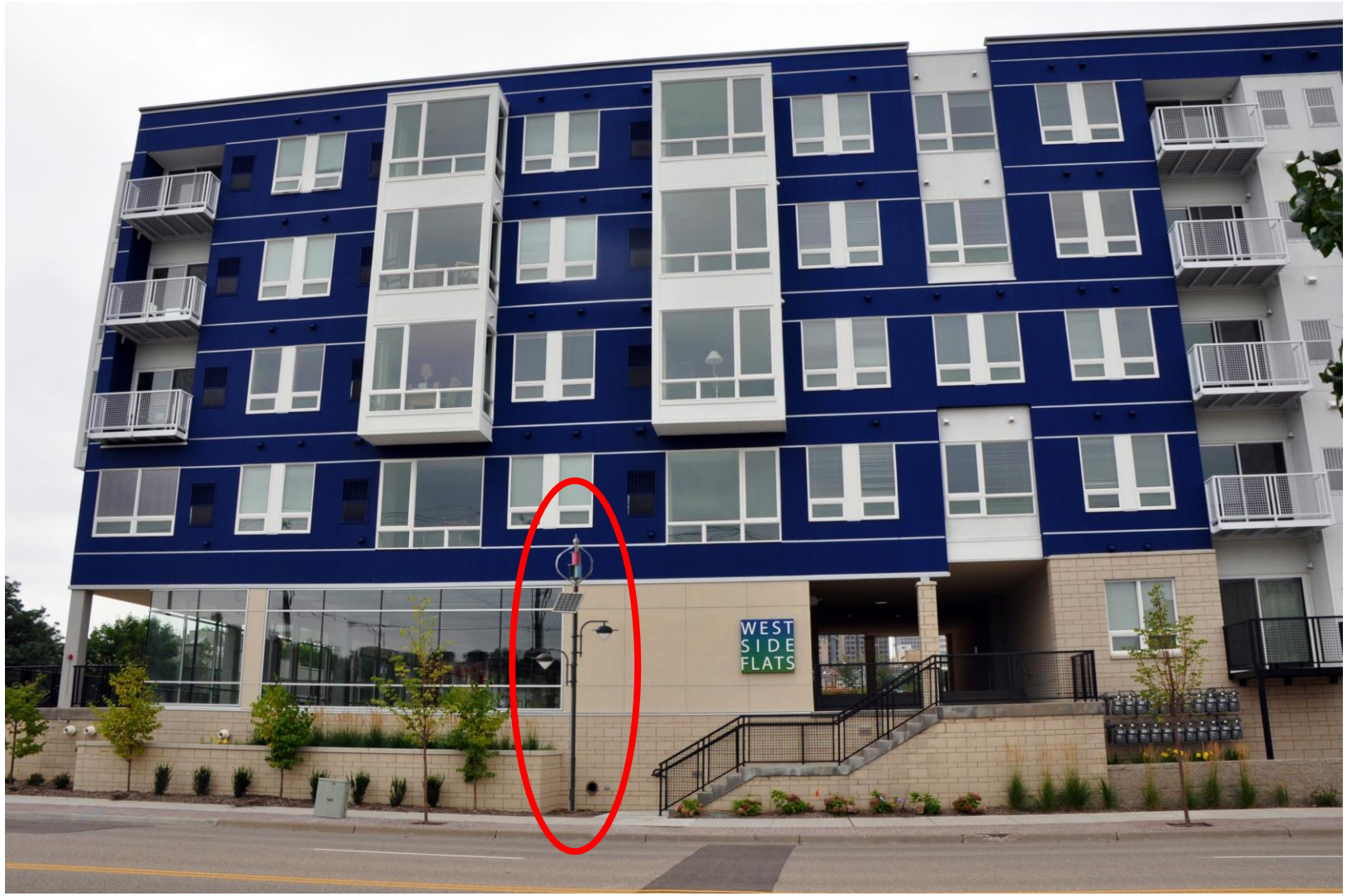


Hybrid lamppost

300w (shown at West Side Flats)

Hybrid lamppost

300w (shown at West Side Flats)



Capitol Lien 1010 N. Dale

1.5 kW roof-mounted

3 kW free-standing

Existing determination of similar use approved in 2011.

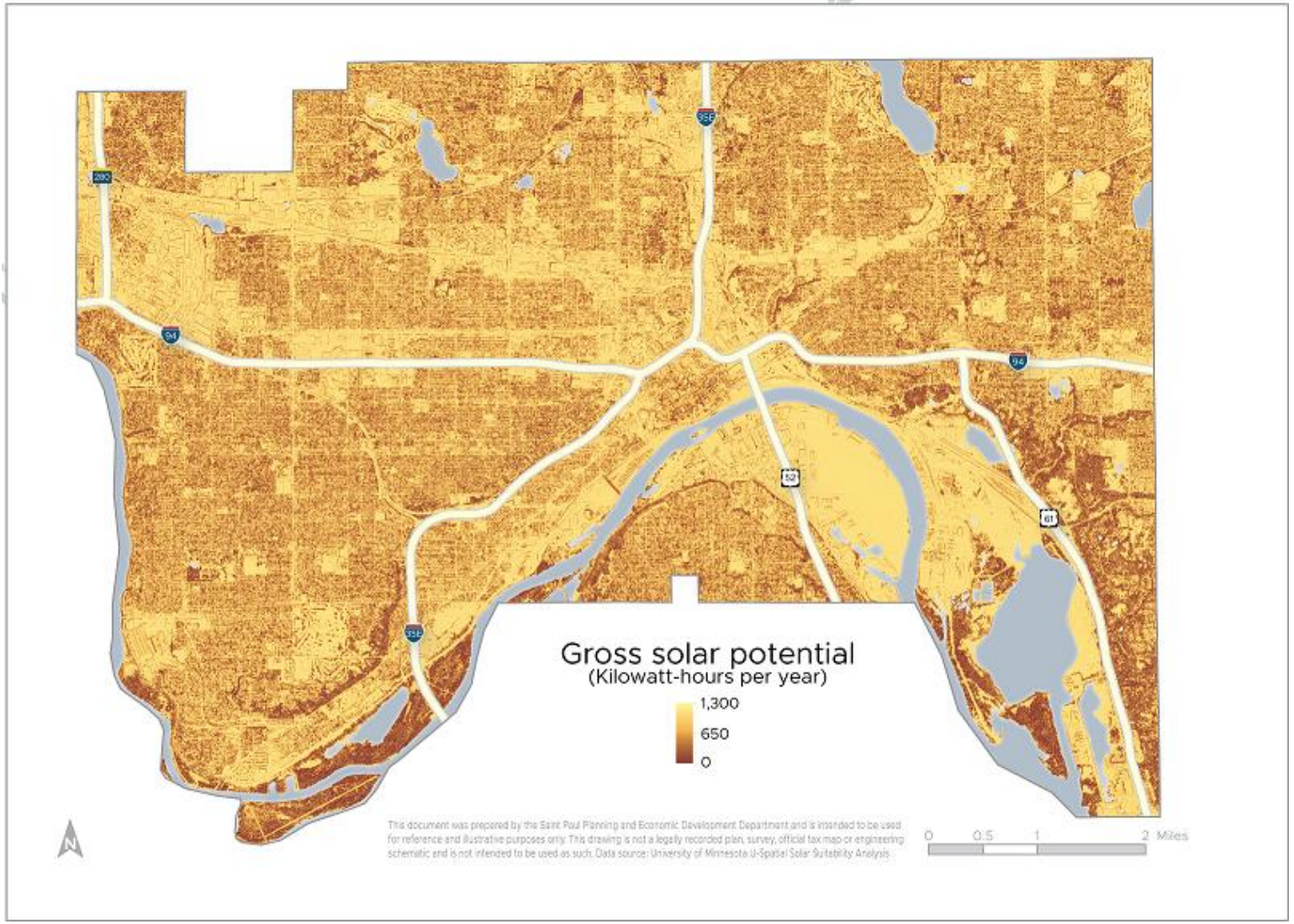
Capitol Lien 1010 N. Dale

1.5 kW roof-mounted

3 kW free-standing

Existing determination of similar use approved in 2011.

Solar access in Saint Paul



Wind Turbine Buyer's Guide

Turbine	In Business (Yrs.)	In Production (Yrs.)	Warranty (Yrs.)	Rotor Swept Area ($Ft.^2$)	Rotor Diameter (Ft.)	Tower-Top Weight (Lbs.)	Certification	Rated Power @ 11 m/s (kW)	AEO @ 5 m/s (kWh)	Est. Annual Energy Output (AEO in kWh) for Wind Speeds 8 mph	9 mph	10 mph	11 mph	12 mph	13 mph	14 mph	AEO Source	RPM @ Rated Power	Governing System	Governing Wind Speed (mph)	Cost (Turbine & Controls)
Bergey Excel 1 bergey.com	38	15	5	53	8.2	75	—	1.00	1,110	420	610	840	1,180	1,400	1,710	2,040	Mfr.: Windcad	490	Furling	29	$4,595
Luminous Whisper 200 luminousrenewable.com	8	6	2	64	9	66	IEC-61400	0.99	2,052	871	1,231	1,629	2,048	2,473	2,890	3,291	Mfr.	1200	Furling, dump	31	3,291
Pika T 701 pika-energy.com	6	1	5	76	9.8	93	Power Cert. in process[2]	1.50	2,420	700	1,250	1,800	2,350	2,900	3,500	4,100	Mfr.	400	Stall	53.7	6,675
Xzeres Skystream 3.7 xzeres.com	5	2	5	117	12	170	AWEA 9.1	2.10	3,420	989	1,740	2,576	3,282	4,115	4,962	5,814	Mfr.	330	Dynamic brake	27	Call
Luminous Whisper 500 luminousrenewable.com	8	6	2	177	15	154	—	3.10	5,568	2,309	3,286	4,386	5,572	6,803	8,042	9,256	Mfr.	800	Furling, dump	31	7,296
Luminous Whisper 500+ luminousrenewable.com	8	6	2	177	15	154	—	3.15	5,846	2,424	3,450	4,605	5,850	7,143	8,445	9,718	Mfr.	650	Furling, dump	31	8,040
Luminous Windistar 4500 luminousrenewable.com	2	2	2	177	15	249	In process	4.31	7,800	2,724	4,800	6,900	7,800	9,600	12,000	14,400	Mfr.	450	Furling, dump	31	9,466
Weaver 5 weaverwindenergy.com	5	1	5	210	16.3	821	In process	3.85	3,857 – 4,897	1,647 – 2,096	2,312 – 3,033	2,945 – 4,085	3,496 – 5,172	3,944 – 6,213	4,290 – 7,142	4,546 – 7,919	Mfr.	260	Active furling	50	38,576 – 62,190
Bergey Excel 6 bergey.com	38	3	5	325	20.2	772	AWEA 9.1	5.50	9,920	3,963	5,582	7,470	9,536	11,667	13,850	16,325	Mfr.: Windcad	400	Furling	31 – 45	21,995
Ventera VT-10 venterawind.com	10	7.5	5	380	22	580	In process	9.30	12,772	5,037	7,218	8,957	11,625	13,924	17,599	20,836	Mfr.	280	Blade pitching	28	24,000
Bergey Excel 10 bergey.com	38	32	10	414	23	1,200	AWEA 9.1	8.90	13,800	4,924	7,124	9,850	13,026	16,499	20,248	24,712	Mfr.: Windcad	400	Furling	31 – 45	31,770
Bergey Excel R bergey.com	38	32	10	414	23	1,200	—	7.50	13,800	4,549	6,723	9,292	12,114	15,008	17,922	21,125	Mfr.: Windcad	400	Furling	31 – 45	26,870
Xzeres 442SR xzeres.com	5	4	10 turbine, 5 controller	442	23.6	1,600	AWEA 9.1	9.17	15,329	4,990	8,583	12,630	16,017	19,958	23,984	27,997	Mfr.	150	Dynamic brake	26	Call
Wind Turbine Industries Jacobs 31-20 wind-turbine.net	29	30	5	755	31	2,000	Certified Power	12.00	16,630	5,100 – 7,800	7,450 – 11,375	10,420 – 15,900	13,900 – 21,225	17,742 – 2,7075	21,950 – 33,470	26,250 – 38,950	Mfr.	175 – 185	Blade pitching, furling	30 – 45	53,550
Osiris 10 osirisenergy-usa.com	8	6	5	797	31.8	1,870	AWEA 9.1, IEC 61400-2	10.00	23,704	8,250	13,929	18,824	22,740	27,530	31,340	35,734	Mfr.	120	Passive & active pitch	20	27,500
Eocycle 25 eocycle.com	14	5	2, with 5 ext.	1,347	41.3	4,960	In process	23.00	37,229	11,230	18,992	25,625	34,160	44,471	53,775	64,700	Mfr.	90	Stall, active yaw	56	81,000
Endurance Wind Power E-3120 endurancewindpower.com	8	6	5	3,120	63	8,800	Certified Power[1, 2]	56.80	116,935	41,516	65,214	88,913	112,611	137,334	162,289	186,458	Mfr.	42	Stall control, air brakes	56	215,000
Northern Power NPS-100C-24 northernpower.com	41	16 (NPS100)	2	4,867	78.74	15,300	—	90.20	196,000	80,000	113,000	150,000	189,000	228,000	267,000	305,000	Mfr.	50	Stall control	56	365,000

[1]AWEA standards do not cover turbines this size—only up to 2,153 $ft.^2$ (200 m^2). [2]The turbine power curve has been certified to industry standards by a nationally recognized testing facility.