Solar Ready University of Minnesota Guidelines

What is Solar Ready?

One of the largest barriers to the installation of solar energy systems is the traditional building design. Existing buildings were not built to be retrofitted with solar systems. Roof structure, building orientation, location of mechanical systems and other building design elements can often make the installation of solar energy systems more complicated and expensive than it would have been if these features were designed with solar in mind. Even new buildings often require substantial retrofits to take full advantage of the building's available solar resource, which is why new building solar ready guidelines are needed. [1]

With a few relatively easy changes, it is possible to build solar ready buildings with electrical and

mechanical features that help to streamline the integration of solar systems[2]. With a few relatively simple improvements in design and construction, solar systems can be installed with little, if any, structural modifications. For non-residential buildings, it is estimated that the addition of solar readiness could add approximately $5,000-$7,500 to construction costs, while retrofitting existing structures to incorporate solar readiness is estimated to cost $20-30,000 dollars. [3] This guide will focus primarily on the preparations for Photovoltaic (PV) solar systems because other forms of solar require additional costs and preparations.

Solar Ready guidelines are straightforward and focus upon the following general areas related to building design:

- Roof pitch and orientation
- Layout of roof vents, chimneys, etc., to prevent shading
- Roof load bearing specification
- Designated roof mounting points for PV array
- Installation of electrical conduit from main electrical panel location to roof
- Specification of main service panel and circuit breakers
- Space near the main electrical panel for PV inverters and other equipment

Early consideration of these guidelines will ensure the easy installation of future photovoltaic systems. [4]

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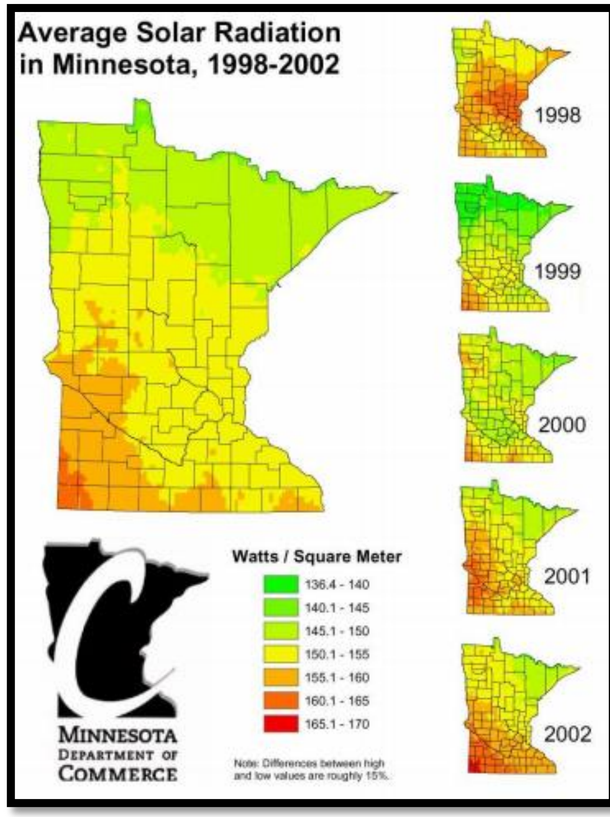
[1] Solar Ready Building Design Guidelines. (2010). Page 1.
[2] Recommendations for Building Solar Ready Homes Photovoltaic Systems. (2007). Executive Summary.
[3] Solar Ready Building Design Guidelines. (2010) Page 6.
[4] Recommendations for Building Solar Ready Homes Photovoltaic Systems. (2007). Executive Summary.

Minnesota Solar Resources



The Twin Cities are known for their harsh winters and warm, humid summers. However, Minnesota has an abundance of solar resources.[5] Despite the region's intense climatological extremes the total percentage of available sunshine is actually relatively consistent throughout the year. On average, the sky is clear or partly cloudy 58% of daylight hours annually.[6] It is true that from early November to late-January the region receives less than 9 hours of sunlight daily and the sky is overcast over 50% of the time. For this part of the year the solar resource in this region is minimal. However, the rest of the year receives ample daylight and 63% of the days are clear to partly cloudy resulting in an ample available solar resource. [7]

The amount of solar energy available is called "insolation." Insolation is measured in British thermal units (btu) per day per square foot of surface area (btu/day/sq.ft.). The insolation of different geographic locations have already been calculated which makes it possible to estimate and compare the amount of solar energy available at different locations during different times of year. Because the Twin Cities has significantly more solar energy available during the summer than during the winter, the region's annual average daily insolation compares favorably with other locations in the United States. [8] For example, the combined daily annual average insolation for horizontal and vertical surfaces at several major American cities, including Minneapolis/St. Paul can be seen below:

1. Denver 2,904 btu/day/sq.ft.
2. Los Angeles 2,753 btu/day/sq.ft.
3. Miami 2,415 btu/day/sq.ft.
4. **Minneapolis/Saint Paul 2,168 btu/day/sq.ft.**
5. Nashville 2,163 btu/day/sq.ft.
6. Washington 2,122 btu/day/sq.ft.
7. New York City 1,950 btu/day/sq.ft.
8. Seattle 1,913 btu/day/sq.ft. [9],

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[5] Solar Ready Building Design Guidelines. (2010). Page 4

[6] Minnesota Climatology Working Group, State Climatology Office- DNR Waters and University of Minnesota. 30 years of data from 1970-2000. Http://climate.umn.edu/doc/twin_cities/twin_cities.htm

[7] Architectural Graphic Standards, 10th ed., John Ray Hoke, Jr., Ed., 2000. John Wiley & Sons

[8] Solar Ready Building Design Guidelines. (2010). Page 4

[9] J.D. Balcomb et al., Passive Solar Design Handbook, Vol. 3, 1983. American Energy Society, Inc., Boulder

Site Planning

To define the site requirements for Photovoltaic and/or Solar Thermal System, the following documentation will be needed:

1. A site survey showing topography and site features for the property and surroundings.
2. Documentation of any regulatory requirements that may pertain to the site. [10]

When evaluating the potential for solar ready construction it is also important consider both the size and orientation of the prospective building sites as well as impacts of existing buildings or vegetation on the site and on nearby properties. [11]

Further, a solar-ready building needs to anticipate the eventual installation of a solar system. The addition of solar generation to a building may require conditional use permits or design review with city agencies or city commissions. The city standards may limit the installation of solar systems on the front of the building. A solar ready building will, if possible, minimize or eliminate the need for additional permits or review through initial design. An increasing number of Minnesota cites, including Minneapolis and Saint Paul, have adopted solar zoning standards or are considering such standards. Cities in the 7-county metropolitan Twin Cities region are required to complete new comprehensive plans by 2018; these plans by state law must include an element for protection and development of access to direct sunlight for solar energy systems. [12] Review development association covenants for restrictions that may need to be addressed. While the solar array may not be part of the initial phase of construction, inform interested parties of this possibility and illustrate with suitable graphics.

General Site Guidelines[13]

For general site guidelines, please refer to NREL's Solar Ready Building Design Guidelines: http://www.nrel.gov/docs/fy10osti/46078.pdf. This guide can be used to plan the design of new solar ready buildings. The document outlines the factors that must be considered in order to minimize costs and maximize the solar production potential of a site. Some of the guidelines included in this guide include:

- *Avoid Shading:* [14] Shading will negatively affect the ability of a site to harness the solar resource. When shade falls on a PV panel, that portion of the panel is no longer able to collect the high-energy beam radiation from the sun. NREL suggests using a sun path calculator, such as the Solar Pathfinder™, to assess shading at the site. In addition future construction and landscaping should be planned to avoid shading which can adversely affecting the solar panel in the future.

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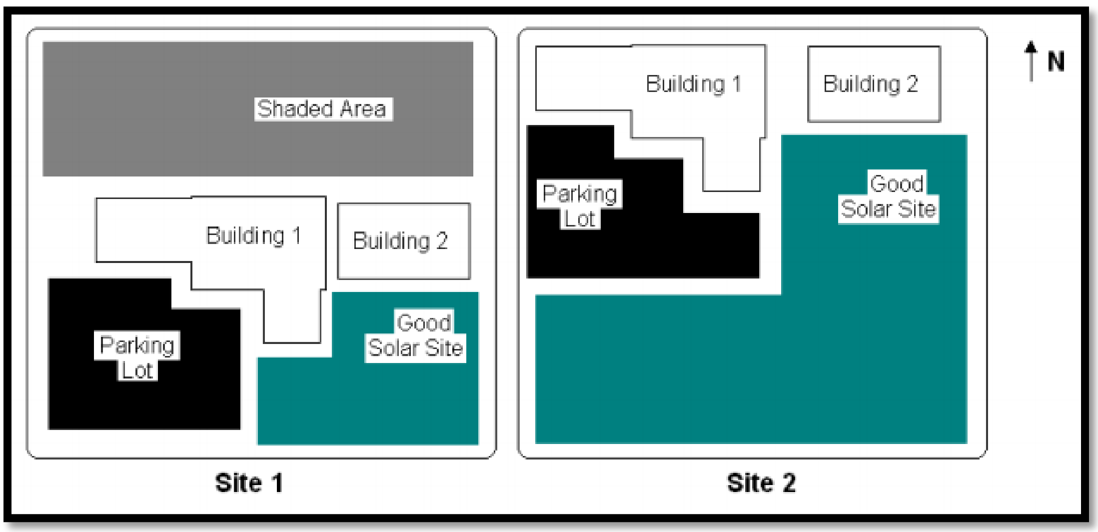
[10] Solar Ready Building Design Guidelines. (2010). Page 7
[11] Solar Ready Building Design Guidelines. (2010). Page 7
[12] See the Metropolitan Council website, http://www.metrocouncil.org/Handbook/Plan-Elements/Resilience.aspx
[13] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009).
[14] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 7

- *Zoning Laws:* [15] It is important to know local zoning laws and how they impact the installation of solar panels. For example, sites located within historical districts or covered by a homeowners association may be subject to additional restrictions. These and other laws can have a significant impact on the design and development of solar ready buildings.

- *Solar Collector Placement:*[16] The roof of a building is often the best site for a PV system because roofs are typically un-shaded and out of the way. However, consider all possible locations when identifying potential solar system sites.

- *Site Orientation:*[17] The orientation of a site can determine whether a solar system is feasible or not. By placing the buildings on a site with solar resource and shading in mind, the area available for solar panels can be greatly increased. For example, the image below shows how where site



layout changes solar potential.

- *Roof Obstructions:* [18] Maximize the size of unobstructed roof top area. Large contiguous areas are ideal.

- *Roof Types:* [19] The type of roof installed when a building is built will affect solar installation costs. In addition, the quality, and warranty of the roof can also affect ease of a solar install.[20]

- *Roof Load:* [21] If the solar system is to be located on the roof of a building the roof must be designed to accommodate the additional weight of the PV system.

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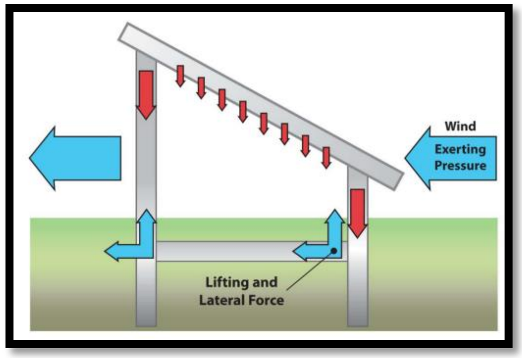
[15] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 8
[16] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Pages 8-9
[17] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 9
[18] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 10
[19] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 10
[20] Another important feature of roof types is roof pitch. The ideal pitch for a PV system in Minnesota is between 35-37º. *Source:* Solar Ready Building Design Guidelines. (2010). Page 15
[21] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 11

Wind Load:[22] Roof structures should also be designed to accommodate the dynamic loads that results from wind blowing on solar collectors. The wind load is dependent upon the building location, wind conditions, collector orientation, height exposure category, topography of the surroundings, and the roof zone placement of the solar collectors.



- *Panel Mounting:* [23] There are different types of mounts available depending on whether the panels are mounted on the ground, a flat roof, a slanted roof, a wall, a pole, or elsewhere. If the proper wind and loading analysis has been done on a solar system, the appropriate mounts can be chosen and installed at the time of the building construction.

- *Electrical Panel Location:* [24] Because the PV system needs to be connected to the electrical system of the building, the electrical panel should be in a convenient location to connect to the PV array. The electrical panel must have sufficiently large amperage rating to accommodate the PV energy as well as grid energy. Provide wall space approximately 3' by 3' for the inverter and an AC disconnect as close as possible to the solar array and next to the main service panel. A clear floor area 3' wide is required in front of the equipment.

- *Grid Inter-connection:* [25] The grid inter-connection rules are different in every state, and sometimes even vary by city. Connection requirements also vary based upon the type of grid the building connects to and which utility serves it. The compensation scheme is also dependent on the servicing utility. The rules and regulations associated with the grid inter-connection can be very specific, so it is important that the rules are fully understood for your location.

- *Wiring Schematic:* [26] The PV system will require conduit to go from the PV array to various electrical components. Making sure there is adequate space for the BOS near the electrical panel is an easy step that can be taken during the building design phase and that will streamline installation at a later time.

- *Consider Special Loads:* [27]If there are auxiliary systems that require uninterrupted power (i.e., security systems, fire alarms) consider available storage options. In the event of a power outage, the storage system would feed power to the system for a pre-determined amount of time. Emergency call centers, fire and police departments, schools, and emergency shelters are often good candidates for battery-supported PV systems.

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[22] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 12
[23] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 14
[24] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 24
[25] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Pages 24-25
[26] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Pages 25-26
[27] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Pages 26-27

- *Sizing the System:* [28] When a building is being prepared for a solar installation, it is important to know the size of the proposed system so that all the correct preparations can be made. The size of the system will depend on the solar resource of the proposed location. Typically, PV systems are designed only to provide a portion of the energy usage required by a site.

- *Access:* [29] On a flat roof application, a stairway with roof access is sufficient. Guardrails at the roof edge may also be needed.

For the full set of guidelines published by NREL please refer to: http://www.nrel.gov/docs/fy10osti/46078.pdf.

Work Cited

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[28] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Pages 27-28
[29] Solar Ready Buildings Planning Guide. National Renewable Energy Laboratory (2009). Page 13