STAFF REPORT LAND MANAGEMENT COMMITTEE

Land Management Committee Meeting, August 19, 2020 **Agenda Item 4**

Applicant: Western Mustang

Request: Conditional Use Permit for Large Solar Energy System

Background:
The applicant is proposing to construct a 74-megawatt (MW) alternating current (AC) solar generating facility in the Town of Gilman. The facility will have an East-West tracking solar panel system for off-site consumption. The power generated will be transmitted by a 34.5kV collection system to a substation to be developed as part of the Project. A pad-mounted step-up transformer within the project substation will increase voltage to match the nearby 161kV transmission line which will transmit the power to another substation/switching yard adjacent to the Project substation that will be developed, owned and operated by Dairyland Power Cooperative.

Additional facilities to be constructed include access roads to facilitate the erection and maintenance of the solar arrays and panels, temporary parking and an equipment laydown yard to be used during construction, and a fence surrounding the perimeter of the Project.

Issues Pertaining to the Request:

- The properties on which the use is proposed are located in Sections 3, 4, 5, 8, 9, & 10, T27N, R16W in the Town of Gilman. The properties are zoned General Rural and Primary Agriculture.
- Surrounding land uses are primarily agricultural (cultivated cropland, hay/pastureland) and residential. Project boundary is 1055 acres and the Project footprint is approximately 478.66 acres (45%).
- The proposed layout will occupy approximately 290 acres of Prime Farmland soils or Soils of Statewide Importance.
- Participating landowners of the project had the ability to negotiate regarding which portions of their property would be used for the project.
- Staff met the applicant on various properties to determine stream navigability and the projects conformity with the Pierce County Shoreland Ordinance.

Submittals:
Ranger Power submitted an application as well as numerous additional studies intended to provide additional detail or information. Submittals include:

Western Mustang Conditional Use Permit Application
Appendix A - Figures
Appendix B - Engineered Schematics
Appendix D - Cultural Resource Review Letter
Appendix E - Glare / Glint Study

Appendix F - Sound Report
Appendix G - Geotech Report
Appendix H - Vegetation Management Plan
Appendix I - Decommissioning Plan
Appendix J - Electro / Magnetic Frequency Study
Property Value Study

The following section summarizes portions of the applicant's submittals in an attempt to provide an overview of the materials and information submitted. Additional detail may be found in the full appendix, which may also be viewed at https://www.westernmustangsolar.com/

Description of Project Design:

- Major components of the Project include solar modules, racking, tracking system, inverters, transformers and a Project substation. The Project area includes approximately 20 panel array areas that are separately fenced with the panels, comprising a total area of 478.66 acres.

- There are many different PV module offerings to be evaluated and a selection will be made based on the most cost-effective option.

- Proposed Setbacks are:
  - □ Setback from Navigable Water – 35' (open-sided structure per Shoreland Ordinance 242-23A.(2))
  - □ Setback from 890th Ave. – 42' from ROW/ 75' from Centerline
  - □ Setback from 870th Ave. – 75' from Centerline
  - □ Setback from County Highway BB – 67' from ROW/100' from Centerline
  - □ Setback from State Highway 29 – 77' from ROW/132' from Centerline
  - □ Setback for Substation to any dwelling – 75'
  - □ Setback for Substation from any residential lot line – 50'

  - The applicant accepted the Town of Gilman's recommendation of a minimum one hundred fifty (150) foot setback to all above ground project components from nonparticipating residences, and at least a fifty (50) foot setback from property lines of nonparticipating residences (excluding fences and access roads), provided that non-participating landowners have the ability to waive the recommended setbacks.

Project Siting:

- The project area was evaluated based on topography, environmental concerns, land rights, willing landowner participation, and proximity to the point of interconnection to the existing Dairyland Power Cooperative transmission line.

Solar System Specifications:

- Typical modules are approximately 78"x39" and weigh approximately 50 lbs. They are mainly composed of nonmetallic materials such as silicon, mono- or poly-crystalline glass, composite film, plastic, and epoxies, with an anodized aluminum frame.

- Panels will be mounted on a steel racking frame that is positioned 3'-7' above grade with a +/- 60-degree range of motion driven by electric motors. The single axis tracking system is anticipated to be mounted on support posts driven or screwed in the ground with steel piles or helical piles. The piles will run north to south along the row to support each section of the steel structure.

- The horizontal tracker would be in its highest position during the morning and evening hours when the trackers are tilted at their maximum angle and would be a maximum of 10-12 feet above grade, and up to 4 feet above grade when tilted flat at mid-day. The variability in height is due to the panel configuration on the racking system.

- Panels will produce DC voltage which must be changed to AC voltage through inverters. The inverts will be spaced several hundred feet apart. Approximately 39 will be installed throughout the Project area.

Construction:

- Construction equipment will include: graders, bulldozers, excavators, forklifts, trailers, plows, trenchers, pile drivers and directional boring rigs. It is anticipated that most equipment will be initially delivered to the Project temporary laydown areas. Equipment will be transported from the laydown yard to the appropriate construction site, as needed.

- The site will receive an average of approximately five to seven box trucks a day throughout the delivery period and five to seven flatbed trucks a day during the pile driving period.

- The applicant may need to work with state and local authorities to obtain the applicable oversize-overweight permits. Access routes for vehicles which provide the most direct access and avoid cross traffic will be chosen. Roads that consist of higher capacity, four-lane divided highway will be used as much as possible.

- Construction activities are proposed to be conducted primarily during daylight hours, during off-peak times Monday through Friday not requiring additional site lighting. In the event additional lighting is needed, portable lighting and generators may be used. Smaller vehicles for personnel arriving onsite may continue through later hours if needed to maintain the construction schedule.

- Laydown areas will be established throughout the Project sites with main laydown areas being close to site entrances and secondary laydown as required in areas local to the performance of the construction work. These areas will be used to stockpile racking system components, PV modules, cable reels and other components until they are needed. Larger components such as inverters, transformers and substation equipment will be delivered directly to the final installed location wherever possible.

- Internal site roads will be 16 feet wide during construction and operation.

- Fencing will be used to surround and provide security to the photovoltaic panel areas will consist of deer exclusion fencing at a height of 7 feet. The Project substation will require a seven to eight-foot high chain link fence which may include barb wire at the top which will be 10 feet.

- Applicant will hire contractors to safely operate and maintain the facility. Facility will be remotely monitored 24/7. Maintenance activities will include mowing as needed to control weeds for invasive species.

Glare/Glint Study

- The glare study analyzes potential glare for landing paths at each airport for landing runways facing the general direction of the solar farm, for drivers of vehicles at a 5-ft (cars and small trucks) and 9-ft (semi-truck) viewing height on roadways adjacent to the Project, and for homes adjacent to the Project.

- Based on the solar array parameters provided, glare is not predicted to occur from the proposed Western Mustang Solar Project for planes landing on runways facing the general direction of the Project at (3) airports located within approximately 10 miles of the Project. Glare is not predicted for drivers of vehicles on roads adjacent to the project at either 5-ft or 9-ft viewing heights along any of the routes included in the analysis. Glare is also not predicted for any of the sensitive receptor/homesites provided by the client, all of which were located near the solar panel arrays.

**It should be noted that a ‘resting angle’ of 60 degrees was used for the panels in the analysis. If a resting angle of 0 degrees (panels facing straight up) is used in the analysis, the program moves the panels to 0 degrees instantly once the sun drops below 60 degrees in either direction. This results in the panels facing straight up during sunrise and sunset, under which conditions the program often predicts extensive green and yellow glare. Panels should therefore not be ‘rested’ in a 0- degree position when the sun is above the horizon.

Sound Study

- On May 28 and 29, 2019, a pre-construction ambient sound survey of the substation and solar array areas for the Ranger Western Mustang Project to quantify the existing acoustical environment. The background sound levels varied from 34 to 60 dBA for the varying sample locations and sample periods. The predominant sound source during the sampling was vehicular traffic.

- Sound analyses were completed for both an inverter skid and the transformer based on information provided by the equipment manufacturers. The maximum sound impact at the nearest residence to a solar inverter was calculated to be 48 dBA and a maximum sound impact from the transformer was calculated to be 32 dBA.

- The sound criteria for monitoring followed the PSC’s guidance on power plant siting. Sound levels from the proposed Project do not exceed 50 dBA during daytime hours and 45 dBA during nighttime hours, as defined by the PSC Standard.

- The impacts of the inverters and the substation on the nearby residences will not exceed these levels. This finding was further substantiated by computer modeling of the entire solar array.

- As the design of the facility progresses, Western Mustang will reevaluate the sound impact assessment and will update this report to verify compliance should any of the following occur:

  - Equipment sound level specifications for the invertor skid or transformer increase from the levels utilized in this analysis,
  - The minimum distance from an inverter skid to a residence decreases to less than 250 feet, or
  - The minimum distance from the substation transformer to the nearest NSA decreases to less than 1000 feet.

- A post-construction sound analysis and report will be completed following construction of the Project and commencement of operations. The purpose of the analysis will be to verify the findings and conclusions of this report.

Electro/Magnetic Frequency Study

- This study found that for the underground cables at 25-feet from the centerline, the magnetic field was below 5 milli-Gauss (mG), similar to that given off by a washing machine. Electric field intensity from the underground cables is not expected to result in an impact because it is canceled out due to the shielding by the metallic screen on the underground cables.

- In each scenario analyzed for the overhead lines, at 25 feet from the centerline, the magnetic field was below 46 milli-Gauss (mG) which is less than a typical microwave and the electric field was below 0.2 kV/m (a typical electric blanket gives off 0.25 kV/m).

- The Public Service Commission of Wisconsin has concluded that there is no correlation between magnetic fields and negative health effects.

Vegetation Management Plan

- During development and at the commencement of construction, site vegetation shall be evaluated to determine which areas will be mowed, left undisturbed or will require pre-seeding. Areas with limited vegetation due to past farming operations or disruption of native vegetation due to civil construction activities will be seeded and stabilized in a timely manner.

- Portions of the site that are currently vegetated and not utilized for the Project facilities or not impacted during construction will remain vegetated. These areas include most wetlands, forested lands, and other perimeter areas of the site.

- Where grading occurs on site, topsoil that is shallower than the graded area shall be stripped, stockpiled, and properly attended by BMPs until it is spread back over the cut / fill areas.

- Native compacted roads shall be created with existing in situ soils unless such soils are not suitable. In such cases a similar approach to aggregate road construction shall be employed.

- Cut/fill areas shall be finish graded and seeded within 14 days of completion of the cut/fill/grading activities.

- Erosion control devices will be maintained throughout grading and stabilization according to the Erosion Control and Storm Water Management Plan (SWMP) developed for the Project as part of the Water Resource Application for Project Permits (WRAPP) submitted to the Wisconsin DNR.

- At the general completion of the project, the site shall be inspected to ensure all disturbed areas still needing vegetation be addressed accordingly. Prior to final completion, the Project shall have established the necessary vegetative growth to allow for the Notice of Termination of the Stormwater or General permit.

Seed Bed Preparation and Seeding Procedures

- Prior to seeding areas may be tilled to reduce compaction and better prepare the seed bed. In lieu of deep tillage, specific species may be added to the seed mixes that are capable of alleviating compaction. Deep tillage will not be conducted in non-farmed wetlands.

- An adequate seed bed will be prepared using disc, field cultivator, or chisel plow (or equivalent) seedbed. Seedbed preparation will be based on seeding methods and species planted. Tillage and equipment operations related to seeding and mulching will be performed in a manner to minimize soil erosion.

Seed Mix

- The Project will utilize native species in the permanent seed mixtures. Species will be chosen that are appropriate for the area and solar installations. Seeds mixtures will meet state seeding rules and regulations and all seed will be noxious weed free and sourced from reputable seeding vendors.

- The project will utilize a diversity of plant species including grasses, sedges, forbs, cover crops, and companion vegetation. Specific varietals will be selected to provide better long-term health and self-sustainability.

- A definitive decision has not been made as to the design of the planting at this time and will be determined during the final engineering process.

- Seed will be applied uniformly at specified rates by drilling, broadcasting, or hydroseeding. Seed will be sown between ¼ and ½ inch deep based on method, species, soil type and available moisture-. Seeding activities will be suspended if conditions are such that equipment will cause significant rutting of the surface in the designated seeding areas.

Wetland Construction and Restoration Procedures

- No permanent wetland fill is proposed as part of the construction of the Project. The Project will require temporarily impacting wetlands due to placement of both panel facilities and access roads and existing contours will be maintained within wetlands.

- Access roads to be developed for the Project may require the placement of construction mats or the use of low ground pressure equipment which would result in temporary wetland impacts. Alternatively, construction activities within wetlands may be conducted during frozen ground conditions.

- Appropriate sediment barriers will be installed and maintained adjacent to wetlands and within workspace areas as necessary to minimize the potential for sediment runoff pursuant to the SWMP. Once revegetation is successful, sediment barriers will be permanently removed and disposed of properly.

- The seed mixes designed for the site will include a diversity of species including species such as sedges and rushes that are suitable for wetland conditions.

- The collection system will require crossing wetlands by either HDD or trench methods. These impacts will only be temporary in nature as the ground surface will be returned to pre-existing condition if trenching methods are utilized. Permits for the temporary impacts will be obtained from the US Army Corps of Engineers and the Wisconsin Dept. of Natural resources.

Vegetation Maintenance and Weed Control

- Once permanent vegetation has been established, mowing or hand pulling may be used to manage areas where invasive or noxious weeds occur. Mowing should be done at a raised height (>5") in order to target the invasive plants and to not damage the native species. Grazing may be considered to reduce vegetation height and reduce invasive broadleaf species on a seasonal basis.

- Spot-spraying should target only noxious/invasive weed species. Plantings that include both grasses and forbs should not be broadcast-sprayed.
- A rotation of haying/mowing, or spraying will be used to remove any unwanted trees/shrubs that may be present. Non-native planting areas may be hayed/mowed annually or as needed.
- The Project area does not contain sensitive wetlands including state or federally listed waterways, trout streams, fisheries, wilderness areas, recreational areas, sensitive resources of state or federal concern, or other areas of special natural resource interest.

Decommissioning Plan

- The expected lifetime of a utility-scale solar panel is approximately 30-40 years with an opportunity for a project lifetime of 50 years or more with equipment replacement and repowering.
- Depending on market conditions and project viability, the solar arrays may be retrofitted with updated components (e.g., panels, frame, tracking system, etc.) to extend the life of the project.
- In the event that the modules are not retrofitted, or at the end of the Project's useful life, the panels and associated components will be decommissioned and removed from the Project site.
- Decommissioning activities will begin within six months of the Project ceasing operation and are anticipated to be completed in twelve months. Monitoring and site restoration may extend beyond this period to ensure successful revegetation and rehabilitation.
- Foundations, steel piles, and electric cabling and conduit up to two feet (24 inches) below the soil surface will be removed. Components and cabling deeper than 24 inches below the surface will be left in place, except where specific contracts with landowners require removal to a greater depth.
- Access roads may be left in place if requested and/or agreed to by the landowner.
- Public roads damaged or modified during the decommissioning and reclamation process will be repaired to pre-existing conditions upon completion of the decommissioning phase.
- All recyclable materials, salvaged and non-salvage, will be recycled to the furthest extent possible. All other non-recyclable waste materials will be disposed of in accordance with state and federal law in an approved licensed solid waste facility.
- Depending on condition, the equipment may be sold for refurbishment and re-use. If not re-used, they will be salvaged or disposed of at an approved solid waste management facility.
- Cabling that is above a depth of two feet will be removed and salvaged, while cable greater than two feet in depth will remain in place, except where specific contracts with landowners require removal to a greater depth. The system will not interfere with future farming activities because of the depth. If, at the time of decommissioning, the salvage value of the underground cable exceeds the cost of extraction and restoration, the cables may be removed and salvaged.

- This decommissioning estimate assumes that all internal roads will be restored however, some landowners may wish their internal access roads to remain. Decommissioning activities include de-compacting of the access roads as needed.

- Areas of the Project that were previously utilized for agricultural purposes will be restored to their preconstruction condition and land use.

- Project areas that have been excavated and back filled will be re-graded. Disturbed areas will be seeded with appropriate vegetation or returned to crop production.

- Surface water conditions at the Project site will be reassessed prior to the decommissioning phase.

- The probability of a decommissioning event that would lead to abandonment or long-term interruption is extremely low during the first 15 to 20 years of the Project life and accordingly, the financial risk to decommission the Project is also extremely low. Therefore, it is suggested that Financial Assurances for the net estimated decommissioning costs should therefore take into account the reduced decommissioning risks early in the Project life. Western Mustang proposes to post decommissioning security in the form of a performance bond 15 years into the operation of the facility to cover the net estimated cost to decommission the Project which will be determined at that time.

Pierce County Zoning Ordinance §240-41D.(3):

- Large Solar Energy System is defined as, equipment which directly converts and then transfers or stores solar energy into usable forms of thermal or electrical energy which is intended for off-site consumption.

- Setbacks – Any portion of the SES shall not encroach within 10 feet of any property line or road right-of-way.
  - In developing the ordinance, staff recognized that a Large SES would require a Conditional Use Permit, which would allow for the imposition of greater setbacks to be conditioned when assessing the site of a proposed project and its impact on the public health safety and character of the area.

- Height – A SES shall not exceed 35 feet in height. Building-mounted SES may extend up to eight feet above the allowable building height. Exemptions may be granted by the Land Management Committee.
  - The applicant is proposing no structures greater than 35 feet.

- Glare – The SES shall be positioned so that the glare does not create any unsafe conditions.
  - The proposed design will not create unsafe conditions from glare. Glare is not predicted for any airports, drivers of vehicles on reads adjacent to the project, or for any sensitive receptor observation points such as homes that were evaluated for the analysis at any time of the day or any time of the year.

- Installer qualifications – All SES shall be installed by a North American Board of Certified Energy Practitioners (NABCEP) certified solar installer or other person qualified to perform such work.
  - Western Mustang will select an NABCEP Certified Solar Installer or other person qualified to perform the work.

- Code Compliance – A SES shall comply with all applicable State of Wisconsin electrical codes and the National Electrical Code.
  - Applicant will comply with all national electrical codes and Sate of Wisconsin electrical, Commercial Building and Uniform Dwelling codes.

- Utility Notification – A small SES that intends to connect to the electric utility shall not be permitted until evidence has been given that the utility company has been informed of the customer's intent to install an interconnected customer-owned generator. A copy of the final agreement shall be submitted to the Zoning Office.
  - Applicant has started the process and will provide final Generator Interconnection Agreement when available.

- Structural Integrity – The structure upon which the proposed SES is to be mounted shall have the structural integrity to carry the weight and wind loads of the SES.
  - Applicants confirms structural integrity (engineered schematics provided).

- Orderly Development – Upon issuance of a conditional use permit, all large SES shall notify the Public Service Commission of Wisconsin.
  - Applicants confirms that the Wisconsin Public Service Commission will be notified upon issuance of CUP.

Pierce County Zoning Ordinance §240-31 Landscape Buffers:

A. Purpose. These requirements are intended to reduce potential adverse impacts that a particular land use might have on occupants of adjacent properties, such as glare of lights, dust, litter and appearance. With vegetative screening, such adverse impacts will be lessened.

B. Applicability. Landscape buffer requirements shall only apply to proposed uses in cases where a commercial or industrial use abuts a residential or agricultural district; where a utility use requiring a land use permit abuts any district; or such landscape buffer is required by a provision in this chapter.

C. General requirements.
   1. Landscape buffers shall be located in such manner that principal buildings and outdoor storage areas associated with the proposed use are screened as viewed from the vantage point of the principal structures on affected adjoining lots.
   2. Landscape buffers may be located in an area devoted to meeting minimum side or rear yard requirements.
   3. Landscape buffers, when required, shall be established on a lot at the time of the lot's development or at the time the use of the lot is changed to a use which requires a landscape buffer.
   4. Landscape buffers shall be provided on each lot as required by this section independent of existing landscape buffers on adjoining lots.
   5. Installation and maintenance of the required landscape buffers shall be the responsibility of the owner of the lot.
   6. Existing woody plants which meet the requirements listed in Subsection D may be used to meet the landscape buffer requirements.

D. Landscape buffer tree requirements. Landscape buffers, at the time of establishment, shall meet the design specifications on file in the Zoning Office as approved and incorporated into this chapter.

Land Management Minimum Landscaping Policy adopted February 7, 2007:

- Screening – Vegetation, earthen berms and or fencing shall be placed between nonresidential development and adjacent properties so as to render the development as visually unobtrusive, as is practical, from adjacent properties or from public view. Native vegetation should be utilized whenever practical. Vegetated screening buffers shall be maintained in good condition.
- Power and orientation of light fixture – No exterior light fixture may be placed or orientated so that the lighting element or associated convex lens is visible from an adjacent lot line, ordinary high-water mark line or public road right-of-way easement line.

Pierce County Zoning Ordinance §240-41E(3) Utility Facilities:

- Electrical substations shall be enclosed by a chain-link fence at least 10 feet high. Such structures shall additionally be located at least 75 feet from a dwelling unit and 50 feet from any residential lot line.

Town Recommendation

- The Town of Gilman recommended approval of this request on March 11, 2020. Recommended Conditions were included as attachment #2; concerns raised by the applicant included as attachment #1. The Town noted a Concern/Suggested Condition – Review legal requirements.

  The Town of Gilman believes the following conditions are needed for the proposed project to be consistent with the objectives and goals of the town, and to be in the public interest. The complete documents (Attachments #1 and #2) are included in the LMC's packet, as well as a review document which combined the two attachments. Staff has summarized the Town Recommendation and the applicant's response for this report which are:

1. Planning Phase

Upon request from the Local Governments, the Owner/Operator should provide proposed plans for construction of the project and proposed equipment haul routes.

2. Preconstruction Schedule

The Owner/Operator should provide the Local Governments relevant site plans, including the erosion control plan, construction timelines, and other relevant construction information, at least seventy-five (75) days prior to the start of construction, to allow the Local Governments an opportunity to review and comment on construction information. The construction team should meet with County staff and Town representatives at a mutually agreeable date not less than forty-five (45) days prior to the start of constructions. The Owner/Operator should identify a project contact to the Local Governments on its behalf, for compliance and complaints, if any.

3. Construction Hours

Should be limited to daylight hours, not earlier than 7am and not later than 7pm Monday-Friday.

Applicant Response (summarized) -
Construction hours should be limited to daylight hours between 7am-7pm Monday through Saturday. Ranger may work outside these construction hours in the event of unforeseen weather conditions or other exigent circumstances requiring work outside these hours to meet contractual deadlines,

provided that Ranger give Pierce County reasonable notice that it needs to work outside normal hours.

4. Use of Roads (summarized)
The Owner/Operator should agree to minimize the use of Town roads when practicable and shall seek to obtain all permits typically required of others, such as driveway permits and rights-of-way crossing permits. To the extent practicable, the heaviest vehicles and traffic will be limited to Hwy. 29 and County BB and that the primary constriction staging areas be near that intersection.

Applicants Response (summarized) -
Western Mustang accepts the request to minimize traffic on town roads.

5. Road Repair Obligations (summarized)
Owner/Operator should engage a professional engineer to prepare and "Initial Condition" report on all roads to be used during construction. The same firm should be engaged to prepare a post-construction condition report on the same roads. These reports will serve as the basis for future discussions and decisions about needed post-construction repairs. The Owner/Operator should issue a Request for Proposals for road maintenance and restoration services during construction to a list of contractors which should include local contractors familiar with conditions in the project area. Throughout the construction of the project, all parties should work cooperatively to maintain public road infrastructure in a safe condition for passage by the public. Within 60 days of satisfactory completion of all work specified in the Final Repair Plan, the County and the Town should provide Owner/Operator with a letter stating acceptance of satisfaction with work performed.

Applicant Response
As an alternative to this condition Western Mustang proposes entering into a separate Road Use Agreement with the Pierce County Highway department or other local road authority, who are the permitting officials and local experts on road issues. Western Mustang is also amenable to entering into an identical Road Use Agreement with the Town of Gilman to address town roads. In addition, Western Mustang proposes the following revision:

"Western Mustang Solar, LLC should repair any damage to roads or drainage systems caused by the project or project activity, ~~to as good or better than the condition they were in prior to construction~~ to a condition at least as good as the pre-construction condition, as documented in the initial Evaluation."

6. Drainage Infrastructure (summarized)
If drainage infrastructure or systems are damaged by any cause connected with the project, the Owner/Operator should restore the drainage infrastructure or system to pre-existing condition or better.

Applicants Response
Damage to drainage infrastructure on the parcels participating in the project is addressed by Western Mustang's land agreement with the project landowners. Western Mustang proposes the following revision:

"If drainage infrastructure or systems on non-participating properties are damaged by any cause connected with the project, Western Mustang Solar, LLC shall restore the drainage infrastructure or system to ~~pre-existing condition or better~~ a condition at least as good as the pre-construction condition."

7. Revenue Questions/School Payment Impacts (summarized)
The Owner/Operator has agreed, as part of the application, to pay any monies lost as a result of the removal of some property in the Township from the local property tax role directly to Spring Valley and CVTC schools. The town asks that those payments include any future amounts resulting from referendum or tax rate changes, and an annual 2% increase as well.

In the event that the shared revenue payments payable to the Town and County are eliminated by the Legislature, the Owner/Operator should reimburse the Town at the rate of $1,666.66 per installed megawatt and the County at the rate of $2,333.33 per installed megawatt.

Applicants Response (summarized)
This condition does not meet the standard set by Wisconsin law governing Conditional Use permits or those for restrictions on the installation or use of solar energy systems. Nevertheless, Western Mustang agreed as part of its CUP application to replace and revenues for Spring Valley Schools that are lost as a result of property collection declines due to the Project. Western Mustang can voluntarily accept a 1.5% escalator, as reflected in the following revision:

> "In the future event that Pierce County is no longer able to collect property taxes in the approximate amount of $6,600, Western Mustang Solar herby agrees to pay such portions of property tax that would have otherwise been distributed to the Spring Valley Public School and Chippewa Valley Technical College (CVTC) directly to the Spring Valley Public School and CVTC, in the amounts of $2,700/year and $300/year, respectively, with a 1.5% per year escalator, during the useful life of the Project."

Western Mustang feels the condition regarding the Utility Aid Shared Revenue Payment is unclear as stated and should be modified as follows:

> "If a change in law results in the elimination or reduction of the Utility Shared Revenue program, the elimination or reduction of the generator license fee (under Wis. Stat. §76.28 and §76.29), and the land used by the Project is not returned to the applicable taxing jurisdiction's property tax rolls, which result in tax payments to the County in an amount less than what was previously being received through the Utility Shared Revenue program, then Western Mustang will compensate County and Local Units of Government for the difference between the lost property tax revenue and the previous payments received by County and Local Units of Government, up to the amount of the Project's prior year's generator license fee (under Wis. Stat. §76.28 and §76.29)."

8. Assurances (summarized)
Gilman Township asks that the developer reimburse the town for the legal fees to date (approx. $1,200). In lieu of the compensation the members of the Plan Commission have not received for the substantial time invested, the town also asks for a donation, in an amount reflective of the work, be made to area charities and non-profits.

The developer should deposit one of the following assurances (a) an additional One Hundred and Fifty Thousand Dollars ($150,000); (b) post a Bond in said amount; or (c) provide a Letter of Credit in said amount with or to Pierce Count and the Town of Gilman. This assurance should be in place prior to construction beginning. Said assurance shall remain in place through the project's operations.

Applicants Response -
Western Mustang voluntarily agrees to compensate the Township $1,200 for legal fees. The condition requesting that Western Mustang provide a donation to local charities does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. However, western Mustang is amenable to providing a donation to local charities provided those donation amounts are at its sole distraction. No justification was provided to support the need for the $150,000 requested bond. Accordingly, this condition does not meet the standard set by Wisconsin law for restrictions on the installation or use of solar energy systems and it should be removed.

9. Assurances in Support of Decommissioning
The Owner/Operator should deposit Five Hundred Thousand Dollars ($500,000), post in a bond in said amount, or provide a Letter of Credit ("The Decommissioning Assurance") in said amount with or to Pierce County and the Town of Gilman, prior to the start of the project's construction. This amount should be increased (doubled) 15 years after construction is complete. This is necessary to protect the Town, County, and land owners from potentially incurring those costs should market forces changes unpredictably.

10. Decommissioning requirements
All physical improvements, materials, and equipment related to solar energy generation, both surface and subsurface components, should be removed in their entirety. The soil grade should also be restored follow disturbance caused in the removal process. Perimeter fencing should be removed and recycled or reused. Where the current or future landowner prefers to retain the fencing, these portions of fence could be left in place.

All access roads should be removed, including any geotextile material beneath the roads and granular material. The exception to removal of the access roads and associated culverts or their related material would be upon written request from the current or future landowner to leave all or a portion of these facilities in place for use by that landowner. Access roads should be removed within areas that were previously used for agricultural purposes and topsoil should be redistributed to provide substantially similar growing media as was present within the areas prior to site disturbance.
If decommissioning is triggered for a portion, but not the entire Solar Facility, then the Owner/Operator should commence and complete decommissioning, in accordance with the decommissioning plan, for the applicable portion of the Solar Facility. The remaining portion of the Solar Facility would continue to be subject to the decommissioning plan.

Applicant Response -
Some project land owners have expressed a desire to avoid or minimize disturbance of their land during restoration and have stated they prefer that project infrastructure remain in the ground below a depth of 24 inches as it will not interfere with agricultural activity. Western Mustang requests that subsurface component removal be restricted to a depth of 24 inches to be consistent with landowner agreements.

11. Power Purchase Agreement
The Owner/Operator should have executed a power purchase agreement with a third-party providing for the sale of a minimum of 80% of the Solar Facility's anticipated generation capacity for not less than 10 years from commencement of operation/construction.

Applicant Response –
The Power Purchase Agreement execution requirement does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. The condition is too restrictive and conflicts with the preference for project ownership of many Wisconsin utility companies. While Western Mustang will not move forward without buyer of the power, that buyer may choose to own the project rather than enter into a power purchase agreement. Ranger respectfully requests this proposed condition be removed.

12. Insurance (summarized)
The Owner/Operator should at all times maintain a broad general liability insurance policy commensurate with industry standards and be provided to the Local Governments upon request.

13. Setbacks (summarized)
Ideally, the language contained in the attached document from the APA would be the preferred outcome from the Township perspective. Short of this preferred standard, the Town believes these to be the minimum acceptable setbacks:

The project should incorporate a minimum one hundred fifty (150) foot setback to all above ground project components from nonparticipating residences, and at least a fifty (50) foot setback from property lines of nonparticipating residences (excluding fences and access roads).

The project should maintain a minimum setback to all above ground project components (excluding fences and access roads) from water if deemed "navigable" by the Wisconsin Department of Natural Resources at a distance required by the appropriate State regulatory authority, or 35 feet, whichever is greater. If not deemed "navigable", a minimum twenty (20) foot setback should be maintained to all above ground project components.

Property Boundaries: The project should maintain a fifty (50) foot setback from property lines of nonparticipating land owners to all above ground project components (excluding fences and access roads), with no minimum setback from property lines of participating landowners.

For nonparticipating landowners whose property is bounded on two or more sides by property owned by a participating landowner on which the final design will include above ground components (excluding fences and access roads), the project should incorporate a minimum two hundred (200) foot setback to all above ground project components from the nonparticipating landowner's residence, and at least a fifty (50) foot setback from the nonparticipating landowner's property line (excluding fences and access roads), for those parcels containing the residence and for those shared boundaries within four hundred (400) feet of the residence.

State Highway 29: The project should maintain a seventy (70) foot setback from the end of the right-of-way or one hundred forty (140) feet from the center of the traveled portion of the road to all above ground project components (excluding fences and access roads), whichever is greater.

County Road BB: The project should maintain a seventy (70) foot setback from the end of the right-of-way or one hundred (100) feet from the center of the traveled portion of the road to all above ground project components (excluding fences and access roads), whichever is greater.

Applicant Response -
This condition does not meet the standard set by Wisconsin law. Western Mustang's application complies with the ten (10) foot setback required by the Pierce County solar ordinance, §240-41 D.(3)(b). Nevertheless, Western Mustang accepts the recommendation for setbacks from residences of nonparticipants and property lines of nonparticipating landowners, provided that non-participating landowners have the option to waive the recommended setbacks that exceed the Pierce County solar ordinance requiring a 10-foot setback from property lines.

14. Equipment Height
The height of the project's equipment should be no higher than the twelve (12) foot maximum panel height (with the exception of the project substation), which is to be measured at the apex when the tracker is at its maximum tilt in early morning or late evening.

Applicant Response (summarized) -
Western Mustang proposes this condition be changed from 12 feet in height to 15 feet in height.

15. Vegetation/Vegetative Barriers (summarized)
Under-Panel and Inter-Row Ground Cover – Perennial vegetation mix comprised of a native grass species will be planted under the panels and between rows. Soils should be planted and maintained for the duration of operation to prevent erosion, manage runoff, and improve soil. Seeds should include a mix of grasses and wildflowers. Blooming shrubs could be used in buffer areas as appropriate for visual screening. Seed mixes and maintenance practices should be consistent with recommendations may by qualified natural resource professionals. Owner/Operator should implement and annual vegetation management regimen which will consist of mowing as necessary and selective practices to control noxious weeds, including but not limited to the minimized use of approved herbicides (preferably OMRI approved). The Owner/Operator should explore the use of grazing animals such as sheep for its annual vegetation management regimen.

Applicant Response -
This condition does not meet the standard set by Wisconsin law. Nevertheless, Western Mustang can accept a request to use native grass species. Western Mustang will endeavor to use native grass species as much as possible for vegetative cover under the panel arrays and in between panel rows; however, some non-native species are well-adaptive to the area and have a higher probability of success. Accordingly, Western Mustang proposes modifying the first sentence of this condition as follows:

> "Perennial vegetation mix comprised of native and non-native grass species will be planted under the panels and between rows."

Western Mustang also proposes that "Blooming shrubs could be used in buffer areas as appropriate for visual screening" be removed from this condition. Western Mustang proposes to submit a landscape plan after final design is complete and prior to construction.

16. Vegetative Buffer (summarized)
A continuous vegetative buffer should be present and maintained at all times around the perimeter of the exterior of the fencing where occupants of neighboring nonparticipating residential properties and nonparticipating farm residences can see directly into the project area under panels or around equipment fences. Additional visual transition vegetation plantings should be discussed and agreed upon on a case by case basis with the individual nonparticipating landowners. A minimum 50-foot vegetative buffer (consistent of existing trees and vegetation) should be maintained. If there is no existing vegetation or if the existing vegetation is inadequate to serve as a buffer, a triple row of trees and shrubs should be planted on approximately 10- foot centers in the 25 feet immediately adjacent to the security fence. New plantings of trees and shrubs should be approximately 4-6 feet in height at time of planting. In addition, pine seedlings should be installed in the remaining 25 feet of the 50-foot buffer. The Owner/Operator should maintain any areas between fence line and property boundaries that are not being actively farmed by participating landowner with prairie grass (pollinator habitat, comprised of long stem grass and flowering plants).

The Owner/Operator should agree to create and maintain an appropriate vegetative buffer designed to prevent or minimize erosion around drainage ditches.

The developer should submit a financial guarantee in the form of a bond, letter of credit, or cash deposit equal to one hundred twenty-five (125) percent of the costs to meet the ground cover and buffer standards. The financial guarantee should remain in effect until ground cover and buffers are sufficiently established.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law, and could block sunlight needed to produce electricity. Western Mustang is amenable to providing, at its option, a Vegetative Buffer Plan, including vegetation of reasonable height and density, to owners of non-participating neighboring properties on which an inhabited residence is located and which do not experience a buffering effect from existing vegetation or land forms, if requested.

17. Wildlife corridors and other related concerns (summarized)
The developer should identify an access corridor for wildlife to navigate through the Solar Facility. Areas between fencing should be kept open to allow for the movement of migratory animals and other wildlife. The Developer/Owner/Operator to continue to research the "Lake Effect" that has been described related to large arrays of panels and it's impacts on migratory birds.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law. The quilt block pattern layout and the fence line breaks across the site plan provide ample connectivity for larger wildlife passage.

18. Tree Removal (summarized)
Large-scale removal of mature trees in the project area should be strongly discouraged. No removal of trees in the road rights-of-way should be permitted unless trees are in the right-of-way of a participating property or unless permission to remove trees is obtained from the town board. The Developer/Owner/Operator should promote a tree planting program with residents of the Town.

Applicant Response (summarized) -

This condition does not meet the standard set by Wisconsin law. Western Mustang can accept a request to consider voluntary support for a tree planting program.

19. Testing Soil and Groundwater (summarized)
The Owner/Operator should be responsible to provide a current written list of all chemicals used for maintenance, etc. The Owner/Operator should permit and fund post-construction environmental studies that include periodic monitoring of soil and of wells and drinking water supplies for any and all chemical residue. Random soil and water testing should be performed on a yearly basis.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law. The use of pesticides and/or herbicides will be significantly less than currently used within and near the project area. Similarly, cleaning of the solar panels will rarely be required because precipitation will clean the panels.

20. Additional Environmental Concerns (summarized)
The Owner/Operator should buy the described Mono Crystalline Modules from a manufacturer with a combined score of 85 or higher on the SILICON VALLEY TOXICS COALITION Solar -Scorecard found here http://www.solarscorecard.com/2018-19/2018-19-SVTC-Solar-Scorecard.pdf.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law. Nevertheless, Western Mustang can accept a revised condition requiring the project to be constructed with Tier 1 solar panels.

21. Fencing (summarized)
The Owner/Operator should install deer fencing around the solar equipment at the height of seven (7) feet or a height mandated by electrical code to mitigate changes to the aesthetics of agricultural landscape and to prevent larger animals from gaining access to solar equipment and to allow the safe passage of small mammals. The project's substation fence may utilize chain link and barbed wire, as required by electrical code. No fence should cross a "navigable" waterway.

22. Aesthetics
The Owner/Operator should maintain all facilities in a manner to preserve the aesthetics of all facilities including, but not limited to, not allowing equipment or fencing to deteriorate or remain in a state of disrepair within view of the public or adjoining land owners.

23. Local Emergency Services Coordination and Public Safety (summarized)
Owner/Operator should require during construction and operation that all contractors on the site meet all state, federal, and industry best practice standards for employee and public safety.
Owner/Operator should request meetings with site area Emergency Response agencies to provide project and facility familiarization and confirm the access roads to the interior areas of the project are sufficient for emergency needs.

It has been practice on other similarly sized projects for local emergency services to receive new specialized equipment and a yearly fund contribution for ongoing training and other needs to be sure they are prepared to respond as needed. The Town recommends a $10,000 yearly contribution from the Owner/Operator to a fund that local emergency services can use for those ongoing needs. This is in keeping with other similar projects.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law. Ranger respectfully requests that this proposed condition be removed. Western Mustang will offer training to local emergency services to familiarize them with the project and any unique safety considerations.

24. Good Neighbor Agreements (summarized)
The developer should pursue agreements where it is most warranted in an effort to indeed be a "good neighbor". Based on the limited demonstrated impacts, dollar amounts in the 5-12% of assessed value to mitigate the potential impacts for those landowners who are in very close proximity.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law. However, Western Mustang can accept a request to enter into Good Neighbor agreements.

25. Informational Area/Kiosk for visitors to the area (summarized)
The Developer/Owner/Operator to build a road side visitors' station/kiosk with parking for a handful of vehicles and use this space to educate visitors about the project, how it is beneficial to the greater good, and to highlight local attractions and resources. The Town is open to discussing the long-term logistics for how to manage this.

Applicant Response (summarized) -
This condition does not meet the standard set by Wisconsin law and should be removed.

Other Studies/Information

Staff reviewed several additional studies relating to solar energy systems (studies are attached), including:

Planning for Utility Scale Solar Energy Facilities, Planning Advisory Series – Sept/Oct 2019, American Planning Association.

- Establishing such a solar facility use may take an existing agricultural or forestry operation out of production, and resuming such operations in the future will be a challenge. Land with significant topography, active agricultural land, or forests is more challenging to restore.
- For a solar facility, the site will need to be graded in places and revegetated to stabilize the soil. That vegetation typically needs to be managed (e.g., by mowing, herbicide use, or sheep grazing) over a long period of time. This prolonged vegetation management can change the natural characteristics of the soil, making restoration of the site for future agricultural use more difficult. While native plants, pollinator plants, and grazing options exist and are continually being explored, there are logistical issues with all of them, from soil quality impacts to compatibility of animals with the solar equipment.
- The impact of utility-scale solar facilities is typically negligible on neighboring property values. This can be a significant concern of adjacent residents, but negative impacts to property values are rarely demonstrated.

- Recommended setbacks are 150-feet from property lines and road rights-of-way. As well as a minimum 50-foot vegetative buffer shall be maintained. If there is no existing vegetation or if the existing vegetation is inadequate to serve as a buffer, a triple row of trees and shrubs will be planted on approximately 10-foot centers in the 25 feet immediately adjacent to the security fence. New plantings of trees and shrubs shall be approximately 6 feet in height at time of planting. In addition, pine seedlings will be installed in the remaining 25 feet of the 50-foot buffer. Ancillary project facilities may be included in the buffer.
- Minimum Development Standards:
  a. No solar facility shall be located within a reasonable radius of an existing or permitted solar facility, airport, or municipal boundary.
  b. The minimum setback from property lines shall be a reasonable distance (e.g., at least 100 feet) and correlated with the buffer requirement.
  c. The facilities, including fencing, shall be significantly screened from the ground-level view of adjacent properties by a buffer zone of a reasonable distance extending from the property line that shall be landscaped with plant materials consisting of an evergreen and deciduous mix (as approved by staff), except to the extent that existing vegetation or natural landforms on the site provide such screening as determined by the zoning administrator. In the event that existing vegetation or landforms providing the screening are disturbed, new plantings shall be provided which accomplish the same. Opaque architectural fencing may be used to supplement other screening methods but shall not be the primary method.
  d. The design of support buildings and related structures shall use materials, colors, textures, screening, and landscaping that will blend the facilities to the natural setting and surrounding structures.
  e. Maximum height of primary structures and accessory buildings shall be a reasonable height as measured from the finished grade at the base of the structure to its highest point, including appurtenances (e.g., 15 feet). The board of supervisors may approve a greater height based upon the demonstration of a significant need where the impacts of increased height are mitigated.
  f. All solar facilities must meet or exceed the standards and regulations of the Federal Aviation Administration (FAA), State Corporation Commission (SCC) or equivalent, and any other agency of the local, state, or federal government with the authority to regulate such facilities that are in force at the time of the application.
  g. To ensure the structural integrity of the solar facility, the owner shall ensure that it is designed and maintained in compliance with standards contained in applicable local, state, and federal building codes and regulations that were in force at the time of the permit approval.
  h. The facilities shall be enclosed by security fencing on the interior of the buffer area (not to be seen by other properties) of a reasonable height. A performance bond reflecting the costs of anticipated fence maintenance shall be posted and maintained. Failure to maintain the security fencing shall result in revocation of the use permit and the facility's decommissioning.
  i. Ground cover on the site shall be native vegetation and maintained in accordance with established performance measures or permit conditions.
  j. Lighting shall use fixtures as approved by the municipality to minimize off-site glare and shall be the minimum necessary for safety and security purposes. Any exceptions shall be enumerated on the concept plan and approved by the zoning administrator.
  k. No facility shall produce glare that would constitute a nuisance to the public.
  l. Any equipment or situations on the project site that are determined to be unsafe must be corrected within 30 days of citation of the unsafe condition.

m. Any other condition added by the planning commission or governing body as part of a permit approval.

Study of Acoustic and EMF Levels from Solar Photovoltaic Projects
Prepared for: Massachusetts Clean Energy Center
Prepared by: Peter H. Guldberg, INCE, CCM, Tech Environmental, Inc.

- Any sound from the PV array and equipment was inaudible at set back distances of 50 to 150 feet from the boundary. Inverters generate more sound. At 150 feet from the inverter pad, sound levels approached background levels.

- At the utility scale sites, electric field levels along the fenced PV array boundary and inverters, and at the locations set back 50 to 150 feet from the boundary, were not elevated above background levels.

- Magnetic field levels at the locations 50 to 150 feet from the fenced array boundary were not elevated above background levels. There are significant magnetic fields at locations a few feet from these utility-scale inverters. At a distance of 150 feet from the inverters, these fields drop back to very low levels, and in many cases to background levels.

An Exploration of Property-Value Impacts Near Utility-Scale Solar Installations
Policy Research Project (PRP), LBJ School of Public Affairs,
The University of Texas at Austin, May 2018.

- Results from our survey of residential home assessors show that the majority of respondents believe that proximity to a solar installation has either no impact or a positive impact on home values. However, variation in responses by size of the facility, distance from the home, and the assessor's experience assessing near such an installation previously, all impacted those estimates. Regression analyses suggest that closer proximity to an installation is associated with more negative estimates of property value impacts, as is larger installation size. Prior experience assessing near a solar installation, by contrast, was associated with more conservative estimates of impact. Meanwhile, the median and mode of all estimates of impact was zero, suggesting negative estimates from a few respondents were pulling down the mean. Additionally, the survey results indicate that respondents believe some features of solar installations may be associated with positive impacts. These include a location on land that previously had an unappealing use, or the presence of trees or other visual barriers around the array. Meanwhile, features such as being located on land that previously had an appealing use and higher installations are expected to have a negative impact, according to the respondents.

Recommendation:

The Land Management Committee will need to make a determination as to whether the proposed use at the proposed location would be contrary to the public interest and whether it would be detrimental or injurious to the public health, public safety or character of the surrounding area.

Additionally, Wis. Stats. 66.0401(1m) **Authority to Restrict Systems Limited**, states:

No political subdivision may place any restriction, either directly or in effect on the installation or use of a solar energy system…unless the restriction satisfies one of the following conditions:
(a) Serves to preserve or protect the public health or safety.
(b) Does not significantly increase the cost of the system or significantly decrease its efficiency.
(c) Allows for an alternative system of comparable cost and efficiency.

(4) Local procedure.
(b) "A political subdivision shall make a record of its decision making on an application for approval, including a recording of any public hearing, copies of documents submitted at any public hearing, and copies of any other documents provided to the political subdivision in connection with the application for approval."
(d) "A political subdivision shall base its decision on an application for approval on written findings of fact that are supported by the evidence in the record…"

Staff recognizes that the applicant has agreed to many of the Town of Gilman recommended conditions. Not all of the recommended conditions (agreed to and not agreed to by the applicant) can be part of this Conditional Use Permit. Staff is hopeful that the applicant will honor the commitments made to the Town even if this Conditional Use Permit does not require them.

Staff recommends that the Land Management Committee determine whether the proposed use at the proposed location would be contrary to the public interest and whether it would be detrimental or injurious to public health, public safety, or the character of the surrounding area. If found to be not contrary to the above, staff recommends the Land Management Committee approve this conditional use permit for a Large Solar Energy System with the following conditions:

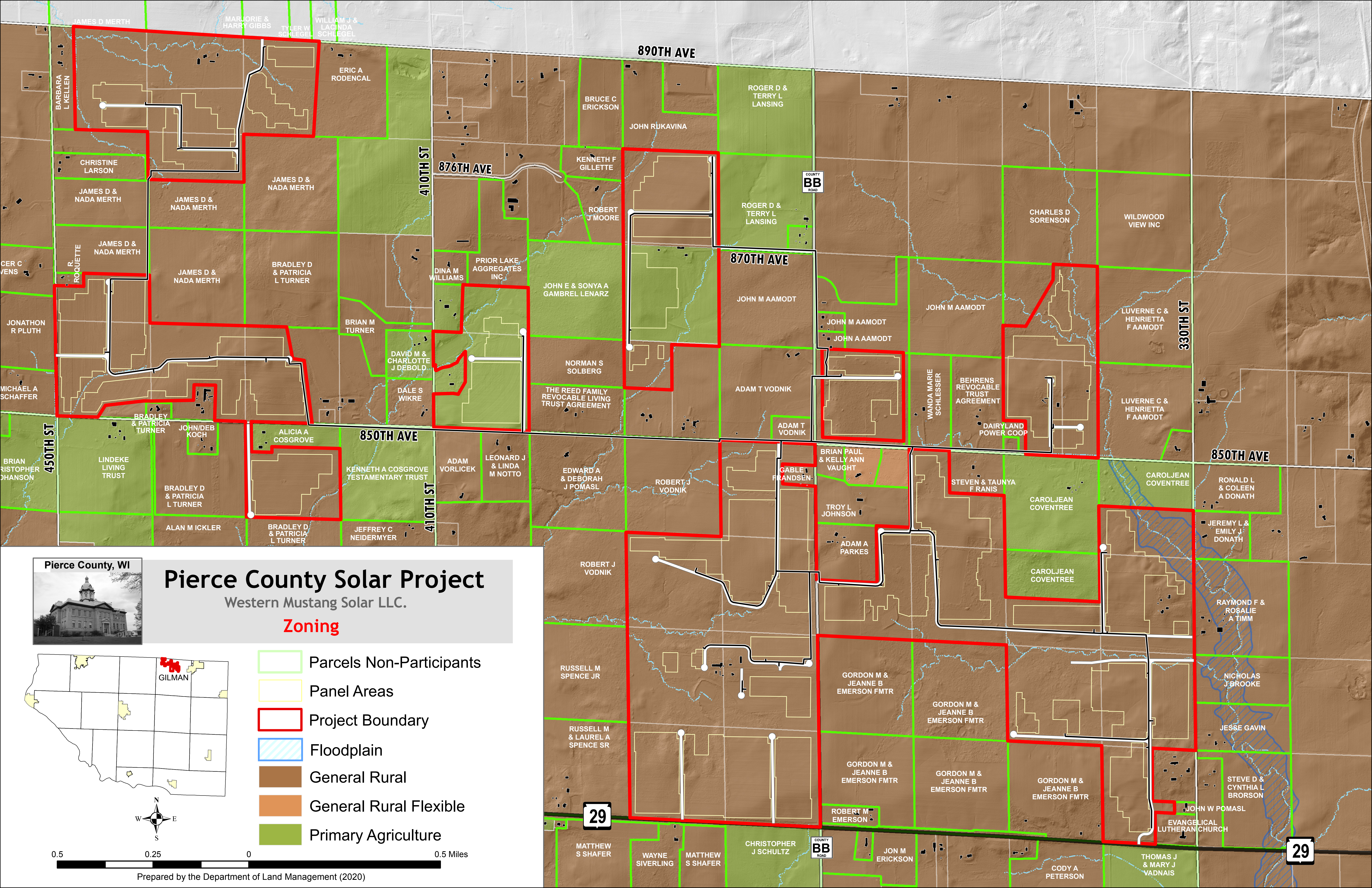
1. The owner or operator shall construct, maintain, and operate the facility in compliance with the submitted plan (and/or as described in their response to town recommendations) unless modified by a condition of this permit.
2. Inverters shall be setback a minimum of 300 feet from any nonparticipating land owners lot line.
3. A minimum 50-foot vegetative buffer (consisting of existing trees and vegetation) shall be maintained between the facility and adjacent nonparticipating properties and road right-of-ways. If existing vegetation is inadequate to serve as a buffer, new plantings of trees, shrubs and grasses shall be established. The majority of the vegetated buffer shall have a minimum height of the project exterior fence. Initial plantings shall render the facility visually unobtrusive from adjacent properties and public view. Vegetative buffer may be waived/modified with the consent of the adjacent property owner. Notice of consent shall be submitted to the Zoning Office.
4. The project shall be setback a minimum one hundred fifty (150) feet to all above ground project components from nonparticipating residences, at least one hundred (100) feet from property lines of nonparticipating properties (excluding fences and access roads), and sixty-seven (67) feet from all road rights-of-way. Property line setback may be waived/modified with consent of adjacent property owner (no less than 10 feet). Notice of consent shall be submitted to Zoning Office.
5. The applicant shall enter into road agreements with the Pierce County Highway Department if deemed necessary by the Highway Commissioner, as well as with the Town of Gilman.
6. A Vegetative Management Plan shall be developed for the site and it shall be reviewed for approved by the Land Management Committee. The applicant shall work with the Land Conservation Department in developing the Plan. The Plan shall include trees and shrubs, seed mixes, vegetation maintenance, and weed controls for the vegetative buffer, facility construction as well as facility operations.
7. Construction main laydown areas shall be located at least 1320 feet from any nonparticipating residence. Secondary laydown areas shall be at least 500 feet from nonparticipating residences.
8. Construction hours shall be daylight hours, not earlier than 7am and not later than 7pm Monday through Saturday.

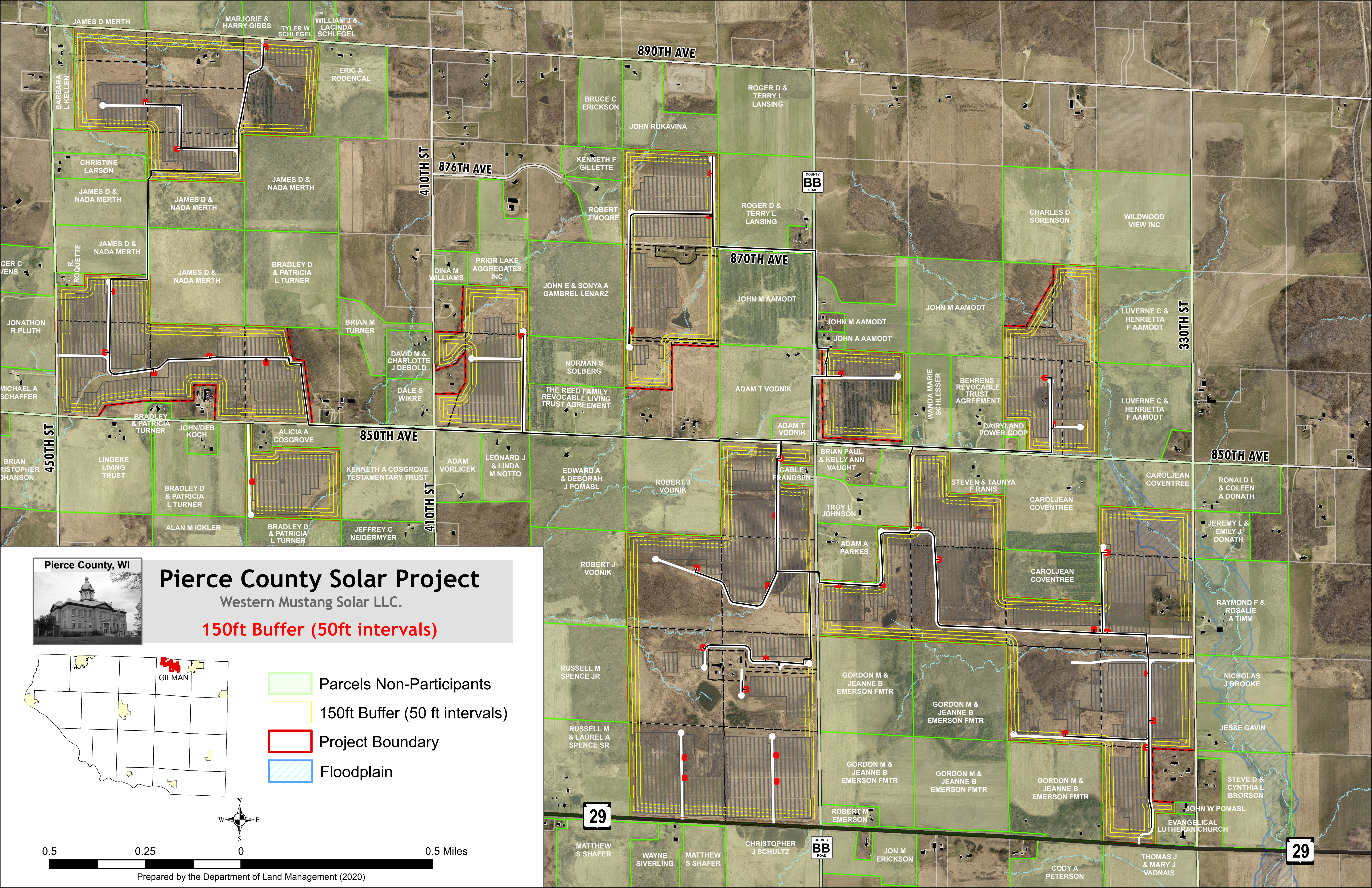
9. The applicant shall submit a construction management plan which includes delivery routes, parking areas, laydown areas, noise mitigation and dust suppression methods prior any site disturbance.
10. A final grading plan shall be submitted to the Zoning Office prior to any site disturbance.
11. A post construction sound analysis shall be conducted as described in the application.
12. The Applicant shall submit a decommissioning plan to the County for approval. The purpose of the decommissioning plan is to specify the procedure by which the Applicant or its successor would remove the Solar Facility after the end of its useful life.
13. The decommissioning plan shall include a decommissioning cost estimate prepared by a State licensed professional engineer. The cost estimate shall provide the gross estimated cost to decommission the Solar Facility in accordance with the decommissioning plan and these conditions. The decommissioning cost estimate shall not include any estimates or offsets for the resale or salvage values of the Solar Facility equipment and materials.
14. Applicant shall provide decommissioning security in one of the two following alternatives to the Pierce County Corporation Counsel for approval:
    a. Letter of Credit or other acceptable assurance for the full decommissioning cost.
    b. Tiered Security, such as:
        i. 10 percent of the decommissioning cost estimate to be deposited in a cash escrow reasonably acceptable to the County; and
        ii. 10 percent of the decommissioning cost estimate in the form of a letter of credit or other acceptable assurance with the amount of the financial assurance increasing by an additional 10 percent in years 2-9 after commencement of operation of the facility.
        iii. In the tenth year after operation, the Applicant will have increased the value of the financial assurance to 100 percent of the decommissioning cost estimate. At such time, the Applicant may be entitled to a return of the 10 percent cash escrow.
15. The maximum height of the project's equipment shall be fifteen (15) feet (with the exception of the project substation).
16. Panels shall have a resting angle of 60 degrees.
17. The Owner/Operator should install deer fencing around the solar equipment at the height of seven (7) feet unless electrical code mandates a different height. No fence should cross a "navigable" waterway.
18. All lighting shall comply with Land Management Department Minimum Landscaping Policy.
19. No structures shall be placed or land disturbed in the Floodplain.
20. A signed copy of the interconnection agreement shall be submitted to the Zoning Office.
21. Any unforeseen erosion issues shall be addressed to the satisfaction of the County.
22. Applicants shall coordinate with emergency services staff to provide materials, education and/or training to the departments serving the property with emergency services.
23. If drainage infrastructure or systems on non-participating properties are damaged by any cause connected with the project, Western Mustang Solar, LLC shall restore the drainage infrastructure or system to a condition at least as good as the pre-construction condition.
24. The applicant shall at all times during construction and operation of the project maintain a broad general liability insurance policy commensurate with industry standards. Certificates of insurance shall be provided to the County and Town of Gilman upon request.
25. The post-construction sound analysis results shall be submitted to the Zoning Office.
26. Substation shall be enclosed by a chain-link fence at least 10 feet high.

The Land Management Committee should also consider conditions the following conditions which were recommended by the Town of Gilman:

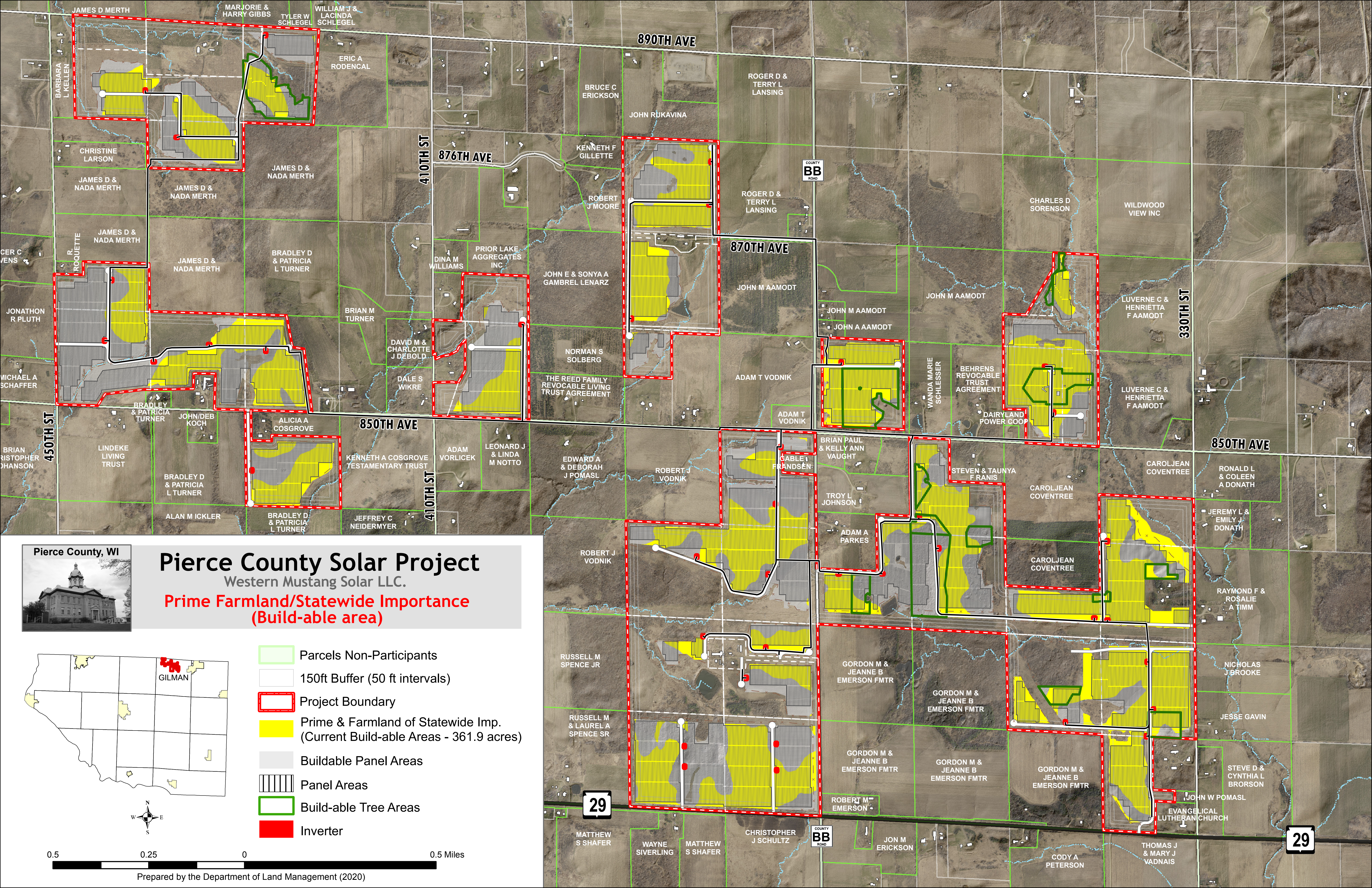
- The applicant shall buy the described Mono Crystalline Modules from a manufacturer with a combined score of 85 or higher on the Silicon Valley Toxics Coalition Solar Scorecard.
- The shall provide financial assurance for the construction of the project in the amount of One Hundred and Fifty Thousand Dollars ($150,000) to Pierce Count and the Town of Gilman.
- The shall keep and provide a list of all chemicals used for maintenance, etc. (e.g. pesticides, herbicides, cleaners) including quantity and frequency of application of each. Applicant shall monitor soil, wells and drinking water supplies for any and all chemical residue annually.
- The applicant shall provide the Pierce County and the Town of Gilman relevant site plans, including erosion control plan, construction timelines, and other relevant construction information, at least seventy-five (75) days prior to the start of construction, to allow the Local Governments an opportunity to review and comment on construction information. The construction team should meet with County staff and Town representatives at a mutually agreeable date not less than forty-five (45) days prior to the start of constructions.

Submitted By: Brad Roy, Zoning Administrator


Pierce County, WI
Pierce County Solar Project
Western Mustang Solar LLC.
Zoning
Parcels Non-Participants
Panel Areas
Project Boundary
Floodplain
General Rural
General Rural Flexible
Primary Agriculture
GILMAN
N
S
E
W
0.5
0.25
0
0.5 Miles
Prepared by the Department of Land Management (2020)
890TH AVE
876TH AVE
870TH AVE
850TH AVE
410TH ST
330TH ST
450TH ST
BB
29
JAMES D MERTH
MARJORIE & HARRY GIBBS
TYLER W SCHLEGEL
WILLIAM J & LACINDA SCHLEGEL
ERIC A RODENCAL
BARBARA L KELLEN
CHRISTINE LARSON
JAMES D & NADA MERTH
BRUCE C ERICKSON
JOHN RUKAVINA
ROGER D & TERRY L LANSING
KENNETH F GILLETTE
ROBERT J MOORE
CHARLES D SORENSON
WILDWOOD VIEW INC
BRADLEY D & PATRICIA L TURNER
R. ROQUETTE
PRIOR LAKE AGGREGATES INC
DINA M WILLIAMS
JOHN E & SONYA A GAMBREL LENARZ
JOHN M AAMODT
JOHN A AAMODT
LUVERNE C & HENRIETTA F AAMODT
JONATHON R PLUTH
BRIAN M TURNER
DAVID M & CHARLOTTE J DEBOLD
DALE S WIKRE
NORMAN S SOLBERG
THE REED FAMILY REVOCABLE LIVING TRUST AGREEMENT
ADAM T VODNIK
WANDA MARIE SCHLESSER
BEHRENS REVOCABLE TRUST AGREEMENT
DAIRYLAND POWER COOP
MICHAEL A SCHAFFER
JOHN/DEB KOCH
ALICIA A COSGROVE
BRIAN CHRISTOPHER JOHANSON
LINDEKE LIVING TRUST
KENNETH A COSGROVE TESTAMENTARY TRUST
ADAM VORLICEK
LEONARD J & LINDA M NOTTO
EDWARD A & DEBORAH J POMASL
ROBERT J VODNIK
GABLE FRANDSEN
BRIAN PAUL & KELLY ANN VAUGHT
STEVEN & TAUNYA F RANIS
CAROLJEAN COVENTREE
RONALD L & COLEEN A DONATH
ALAN M ICKLER
JEFFREY C NEIDERMYER
TROY L JOHNSON
ADAM A PARKES
JEREMY L & EMILY J DONATH
RAYMOND F & ROSALIE A TIMM
RUSSELL M SPENCE JR
GORDON M & JEANNE B EMERSON FMTR
NICHOLAS J BROOKE
RUSSELL M & LAUREL A SPENCE SR
JESSE GAVIN
STEVE D & CYNTHIA L BRORSON
JOHN W POMASL
ROBERT M EMERSON
EVANGELICAL LUTHERAN CHURCH
MATTHEW S SHAFER
WAYNE SIVERLING
CHRISTOPHER J SCHULTZ
JON M ERICKSON
CODY A PETERSON
THOMAS J & MARY J VADNAIS



Pierce County, WI
Pierce County Solar Project
Western Mustang Solar LLC.
150ft Buffer (50ft intervals)
GILMAN
Parcels Non-Participants
150ft Buffer (50 ft intervals)
Project Boundary
Floodplain
N
W
E
S
0.5
0.25
0
0.5 Miles
Prepared by the Department of Land Management (2020)
890TH AVE
876TH AVE
870TH AVE
850TH AVE
410TH ST
450TH ST
330TH ST
COUNTY BB ROAD
29
JAMES D MERTH
MARJORIE & HARRY GIBBS
TYLER W SCHLEGEL
WILLIAM J & LACINDA SCHLEGEL
ERIC A RODENCAL
BARBARA L KELLEN
BRUCE C ERICKSON
JOHN RUKAVINA
ROGER D & TERRY L LANSING
CHRISTINE LARSON
JAMES D & NADA MERTH
KENNETH F GILLETTE
ROBERT J MOORE
CHARLES D SORENSON
WILDWOOD VIEW INC
R. ROQUETTE
BRADLEY D & PATRICIA L TURNER
PRIOR LAKE AGGREGATES INC
DINA M WILLIAMS
JOHN E & SONYA A GAMBREL LENARZ
JOHN M AAMODT
JOHN A AAMODT
LUVERNE C & HENRIETTA F AAMODT
JONATHON R PLUTH
BRIAN M TURNER
DAVID M & CHARLOTTE J DEBOLD
NORMAN S SOLBERG
THE REED FAMILY REVOCABLE LIVING TRUST AGREEMENT
ADAM T VODNIK
WANDA MARIE SCHLESSER
BEHRENS REVOCABLE TRUST AGREEMENT
MICHAEL A SCHAFFER
DALE S WIKRE
DAIRYLAND POWER COOP
BRADLEY & PATRICIA TURNER
JOHN/DEB KOCH
ALICIA A COSGROVE
BRIAN PAUL & KELLY ANN VAUGHT
GABLE FRANDSEN
BRIAN RISTOPHER OHANSON
LINDEKE LIVING TRUST
KENNETH A COSGROVE TESTAMENTARY TRUST
ADAM VORLICEK
LEONARD J & LINDA M NOTTO
EDWARD A & DEBORAH J POMASL
ROBERT J VODNIK
STEVEN & TAUNYA F RANIS
CAROLJEAN COVENTREE
RONALD L & COLEEN A DONATH
TROY L JOHNSON
JEREMY L & EMILY J DONATH
ALAN M ICKLER
JEFFREY C NEIDERMYER
ADAM A PARKES
RAYMOND F & ROSALIE A TIMM
RUSSELL M SPENCE JR
GORDON M & JEANNE B EMERSON FMTR
NICHOLAS J BROOKE
RUSSELL M & LAUREL A SPENCE SR
JESSE GAVIN
STEVE D & CYNTHIA L BRORSON
ROBERT M EMERSON
JOHN W POMASL
EVANGELICAL LUTHERAN CHURCH
MATTHEW S SHAFER
WAYNE SIVERLING
CHRISTOPHER J SCHULTZ
JON M ERICKSON
CODY A PETERSON
THOMAS J & MARY J VADNAIS



Pierce County Solar Project
Western Mustang Solar LLC.
Prime Farmland/Statewide Importance
(Build-able area)
Pierce County, WI
GILMAN
Parcels Non-Participants
150ft Buffer (50 ft intervals)
Project Boundary
Prime & Farmland of Statewide Imp.
(Current Build-able Areas - 361.9 acres)
Buildable Panel Areas
Panel Areas
Build-able Tree Areas
Inverter
0.5
0.25
0
0.5 Miles
N
W
E
S
Prepared by the Department of Land Management (2020)
890TH AVE
876TH AVE
870TH AVE
850TH AVE
410TH ST
450TH ST
330TH ST
COUNTY BB ROAD
29
JAMES D MERTH
MARJORIE & HARRY GIBBS
TYLER W SCHLEGEL
WILLIAM J & LACINDA SCHLEGEL
ERIC A RODENCAL
BARBARA L KELLEN
CHRISTINE LARSON
JAMES D & NADA MERTH
BRUCE C ERICKSON
JOHN RUKAVINA
ROGER D & TERRY L LANSING
KENNETH F GILLETTE
ROBERT J MOORE
CHARLES D SORENSON
WILDWOOD VIEW INC
R. ROQUETTE
BRADLEY D & PATRICIA L TURNER
DINA M WILLIAMS
PRIOR LAKE AGGREGATES INC
JOHN E & SONYA A GAMBREL LENARZ
JOHN M AAMODT
JOHN A AAMODT
LUVERNE C & HENRIETTA F AAMODT
JONATHON R PLUTH
BRIAN M TURNER
DAVID M & CHARLOTTE J DEBOLD
NORMAN S SOLBERG
MICHAEL A SCHAFFER
DALE S WIKRE
THE REED FAMILY REVOCABLE LIVING TRUST AGREEMENT
ADAM T VODNIK
WANDA MARIE SCHLESSER
BEHRENS REVOCABLE TRUST AGREEMENT
DAIRYLAND POWER COOP
JOHN/DEB KOCH
ALICIA A COSGROVE
BRIAN CHRISTOPHER JOHANSON
LINDEKE LIVING TRUST
KENNETH A COSGROVE TESTAMENTARY TRUST
ADAM VORLICEK
LEONARD J & LINDA M NOTTO
EDWARD A & DEBORAH J POMASL
ROBERT J VODNIK
GABLE FRANDSEN
BRIAN PAUL & KELLY ANN VAUGHT
STEVEN & TAUNYA F RANIS
CAROLJEAN COVENTREE
RONALD L & COLEEN A DONATH
ALAN M ICKLER
JEFFREY C NEIDERMYER
TROY L JOHNSON
ADAM A PARKES
JEREMY L & EMILY J DONATH
RAYMOND F & ROSALIE A TIMM
RUSSELL M SPENCE JR
RUSSELL M & LAUREL A SPENCE SR
GORDON M & JEANNE B EMERSON FMTR
NICHOLAS J BROOKE
JESSE GAVIN
STEVE D & CYNTHIA L BRORSON
JOHN W POMASL
ROBERT M EMERSON
EVANGELICAL LUTHERAN CHURCH
MATTHEW S SHAFER
WAYNE SIVERLING
CHRISTOPHER J SCHULTZ
JON M ERICKSON
CODY A PETERSON
THOMAS J & MARY J VADNAIS

PIERCE COUNTY WISCONSIN
DEPARTMENT OF LAND MANAGEMENT & RECORDS
Zoning: 715/273-6747
Planning: 715/273-6746 Fax: 715/273-6864

Pierce County Courthouse
414 W. Main Street, P.O. BOX 647
Ellsworth, Wisconsin 54011
www.co.pierce.wi.us

Town Recommendation Form

Request: _X_ **Conditional Use Permit** ____ **Plat Approval – Concept, Preliminary, Final (Circle One)**

____ **Map Amendment - (Rezone)** ____ **Other-** ________

Applicant/Agent:

Name Western Mustang Solar, LLC

Site Address (if applicable) *Please see full list of parcel IDs in the attached application

Property Description: ____ ¼ of the ____ ¼, or Gov. Lot # ____ Section ____, T ____ N, R ____ W,

Lot ____, Block ____, Subdivision ________ Town of ________

Parcel # ____ - ____ - ____ Alternate Parcel # ________

Zoning District ________ Acreage ____

A town recommendation is required as part of the application for a rezone (map amendment) or a conditional use permit. This recommendation is necessary whether a town has adopted a comprehensive plan or has not. Pierce County will seek to further each Town's planning goals when considering the establishment of conditionally permitted uses and when considering approval of a request for a rezone/map amendment.

Pierce County will consider adherence to applicable goals, objectives, and policies, of an adopted or amended town comprehensive plan to be consistent with the "public interest" for decisions relating to that Town. In cases where an adopted plan gives guidance regarding the establishment of a proposed conditional use, the specific portion of the plan relating to the request should be referenced. If a town plan is silent regarding the establishment of a proposed use, or a town has not adopted a comprehensive plan, the recommendation will be advisory in nature.

Pierce County will approve re-zonings (map amendments) within a given town only when the proposed amendment is consistent with that town's comprehensive plan. The specific portion of the plan which supports the rezone request should be referenced. It should be noted that if a town's comprehensive plan is silent on a proposed rezone, approval cannot be granted unless consistency is achieved through plan amendment. In cases where a town has not adopted a comprehensive plan, a rezoning request will be considered based upon its consistency with the Pierce County Comprehensive Plan. In such cases, a town's recommendation regarding the proposed rezone will be used to assist the Land Management Committee in evaluating applicable goal statements.

Questions regarding the need for a Town Recommendation and its generation or use should be directed to Land Management Department Staff at (715) 273-6746.

Town Recommendation: _X_ Approval ____ Denial

Justification/PlanReference: Please refer to attachment 1 and 2

Concerns/Suggested Conditions: Review legal requirements.

Please attach additional information as necessary.

Town Chair Signature: Michael W [signature] **Meeting Date:** March 11, 2020

Attachment 2

Town of Gilman recommended conditions for approval of the Western Mustang Solar, LLC Conditional Use Permit Application

The Town believes the following conditions need to be met for this project to move forward in a manner consistent with the objectives and goals of the town, and to ultimately be in the public interest.

These recommendations are based on the best evidence available from other similar projects, consultations with other local government officials, feedback from residents, and the recommendations from the American Planning Association's Planning Advisory Service. The relevant documents are included as attachments. The Town of Gilman strongly encourages the County to consider these documents as it develops or amends the ordinances(s) related to Utility Scale Solar. Of particular interest would be the document from the APA.

At the final Town public hearing on March 9th, the developer and a resident raised additional concerns. Rather than amend our recommendations, the Plan Commission chose to simply attach them for the county to review and consider at their discretion.

The term Owner/Operator is understood to refer to Ranger Power and/or any entity the project is ultimately sold to. All conditions applied to this permit need to be adhered to by any entity who is ultimately the builder, owner, or operator of the proposed project for the life of the project. The term Developer refers specifically to Ranger Power.

The term Town represents the Town of Gilman.

The term County represents Pierce County

The term Parties refers to all of the above.

The Town Of Gilman recommends approval of this application with these conditions:

Planning Phase. Upon request from a Local Government, the Owner/Operator should provide proposed plans for above ground facilities and below ground facilities of the project and proposed equipment haul routes.

Pre-Construction Schedule. The Owner/Operator should provide the Local Governments relevant site plans, including the erosion control plan, construction timelines, and other relevant construction information, at least seventy-five (75) days prior to the start of construction, to allow the Local Governments an opportunity to review and comment on construction information. The construction team should meet with County staff and Town representatives at a mutually agreeable date not less than forty-five (45) days prior to the start of construction. The Owner/Operator should identify a project contact to the Local Governments on its behalf, for compliance and complaints, if any.

Construction Hours. Should be limited to daylight hours, not earlier than 7am and not later than 7pm Monday-Friday.

Use of Roads. The project Owner/Operator and its successors, assigns, contractors, agents and representatives will use public roads as part of the construction, operation, maintenance and repair of the project. The Owner/Operator should agree to minimize the use of Town roads when practicable. The Owner/Operator should agree that it shall seek and obtain all permits typically required of others, such as driveway permits and rights-of-way crossing permits. The Town asks that, to the extent practicable, the Owner/Operator keep the heaviest vehicles and traffic to Hwy.29 and County BB and that the primary construction staging areas be near that intersection. The Town roads most impacted by construction will likely include the above plus 330th, 410th, 450th streets and 850th and 890th Avenues. The town asks that to the extent practicable the Owner/Operator minimize traffic on these Town roads.

Road Repair Obligations. Following issuance of a permit to proceed with construction, Owner/Operator should engage a professional engineer to prepare an "Initial Condition" report on all roads to be used during construction. The same engineering firm should be engaged to prepare a post-construction road condition report on the same roads. These reports will serve as the basis for future discussions and decisions about needed post-construction repairs. The Owner/Operator should issue a Request for Proposals for road maintenance and restoration services during construction to a list of contractors which should include local contractors familiar with conditions in the project area. Throughout the construction of the project, all parties should work cooperatively to maintain public road infrastructure in a safe condition for passage by the public. During the ongoing construction of the project, the Owner/Operator, at its expense, should repair any significant damage to roads due to any cause connected with the project. In the event a hazardous road condition exists that presents a safety hazard to the public use of the road and is not promptly repaired by Owner/Operator within three (3) days after receipt of notice of the hazardous condition, the applicable road authority may make emergency road repairs, or order emergency road repairs to be performed by qualified contractors, and the Owner/Operator should promptly reimburse the road authority for reasonable emergency road repairs.

At or near the end of Project construction, the Owner/Operator should prepare and provide to the Local Governments a Post Construction Road Condition Report. The Post Construction Roads Report would be the basis for preparation of the Final Roads and Drainage Restoration Plan. The Plan should be provided to the Parties. The

Owner/Operator should repair any damage to roads or drainage systems due to any cause connected with the project, to as good or better than the condition they were in prior to construction, as documented in the Initial Evaluation. If no objections to the Final Repairs Plan are stated by the Parties within 30 days of receipt, the Owner/Operator, at its expense, should commence work to the items set forth in the Final Repairs Plan. The Parties should rely upon the Initial Evaluation for purposes of determining the type of repair required. Weather permitting, the final road repairs obligations should be completed to the reasonable satisfaction of the Local Governments within 120 days of no frost condition, after the completion of construction of the project or as mutually agreed upon by the Parties. Road repairs as set forth in the Final Repairs Plan should include restoration of original condition of ditches, slopes, embankments or fills within the right-of-way unless special circumstances dictate otherwise, and specific approval has been requested by the Owner/Operator and granted by the Local Governments. Within 60 days of satisfactory completion of all work specified in the Final Repair Plan, the County and the Town should provide Owner/Operator with a letter stating acceptance of satisfaction with work performed.

Disputes. Should a dispute arise between the Parties on whether the Final Repairs Plan adequately and completely describes repairs needed, the Parties should agree that a final determination would be made by an independent civil engineer licensed in Wisconsin and selected by mutual agreement.

Drainage Infrastructure. If drainage infrastructure or systems are damaged by any cause connected with the project, the Owner/Operator should restore the drainage infrastructure or system to pre-existing condition or better. Pre-existing condition should mean the flow capacity existing immediately prior to the project commencing construction. The Owner/Operator should be responsible for all expenses related to repairs, relocations, reconfigurations and replacements of drainage infrastructure and systems that are damaged as a direct result of the project.

Revenue Questions/School Payment Impacts. The Owner/Operator has agreed, as part of the application, to pay any monies lost as a result of the removal of some property in the Township from the local property tax role directly to Spring Valley and CVTC schools. The town asks that those payments include any future amounts resulting from referendum or tax rate changes, and an annual 2% increase as well.

In the event that the shared revenue payments payable to the Town and the County are eliminated by the Legislature, the Owner/Operator should reimburse the Town at the rate of $1,666.66 per installed megawatt and the County at the rate of $2,333.33 per installed megawatt. The Owner/Operators obligation to make such payments should be suspended if the State adopts or implements a new mechanism to replace the Utility Aid Shared Revenue payments, to the extent that the new payment system provides payments equal or greater than the payments produced under the Utility Aid Shared Revenue formula.

Assurances. It has been standard practice on other such projects for the developer to provide an escrow account or bond for the Township to cover the costs associated with the Conditional Use Permit review process. That did not occur in this case. Gilman Township asks that the developer reimburse the town for the legal fees to date (approx. $1200). In lieu of the compensation the members of the Plan Commission have not received for the substantial time invested, the town also asks for a donation, in an amount reflective of the work, be made to area charities and non-profits including Spring Valley Seniors Staying Put, the SV Stagehands, and the Spring Valley Community Cancer Fund.

It is also standard practice for the Town and County to have some protections during the construction and operational phases of a project to minimize risk to the local governments. The developer should deposit one of the following assurances (a) an additional One Hundred and Fifty Thousand Dollars ($150,000); (b) post a Bond in said amount; or (c) provide a Letter of Credit in said amount with or to Pierce County and the Town of Gilman. This assurance should be in place prior to construction beginning. Said assurance shall remain in place through the project's operations.

Assurances in Support of Decommissioning. The Owner/Operator should deposit Five Hundred Thousand Dollars ($500,000), post a Bond in said amount, or provide a Letter of Credit ("The Decommissioning Assurance") in said amount with or to Pierce County and the Town Of Gilman, prior to the start of the project's construction. This amount should be increased (doubled) 15 years after construction is complete. This is necessary to protect the Town, County, and land owners from potentially incurring those costs should market forces change unpredictably.

Decommissioning requirements. All physical improvements, materials, and equipment related to solar energy generation, both surface and subsurface components, should be removed in their entirety. The soil grade should also be restored following disturbance caused in the removal process. Perimeter fencing should be removed and recycled or reused. Where the current or future landowner prefers to retain the fencing, these portions of fence could be left in place.

All access roads should be removed, including any geotextile material beneath the roads and granular material. The exception to removal of the access roads and associated culverts or their related material would be upon written request from the current or future landowner to leave all or a portion of these facilities in place for use by that landowner. Access roads should be removed within areas that were previously used for agricultural purposes and topsoil should be redistributed to provide substantially similar growing media as was present within the areas prior to site disturbance.

If decommissioning is triggered for a portion, but not the entire Solar Facility, then the Owner/Operator should commence and complete decommissioning, in accordance with the decommissioning plan, for the applicable portion of the Solar Facility. The remaining portion of the Solar Facility would continue to be subject to the decommissioning plan.

Power Purchase Agreement. The Owner/Operator should have executed a power purchase agreement with a third-party providing for the sale of a minimum of 80% of the Solar Facility's anticipated generation capacity for not less than 10 years from commencement of operation/construction.

Insurance. The Owner/Operator should at all times during construction and operation of the project maintain a broad general liability insurance policy commensurate with industry standards. Certificates of insurance would be provided to the Local Governments upon request.

Setbacks. Ideally, the language contained in the attached document from the APA would be the preferred outcome from the Township perspective. We were unable to find another example that adhered to these setbacks, but they seem reasonable for installations of this scale. Short of this preferred standard, the Town believes these to be the minimum acceptable setbacks:

The project should incorporate a minimum one hundred fifty (150) foot setback to all above ground project components from nonparticipating residences, and at least a fifty (50) foot setback from property lines of non-participating residences (excluding fences and access roads).

The project should maintain a minimum setback to all above ground project components (excluding fences and access roads) from water if deemed "navigable" by the Wisconsin Department of Natural Resources at a distance required by the appropriate State regulatory authority, or 35 feet, whichever is greater. If not deemed "navigable", a minimum twenty (20) foot setback should be maintained to all above ground project components.

Property Boundaries: The project should maintain a fifty (50) foot setback from property lines of non-participating land owners to all above ground project components (excluding fences and access roads), with no minimum setback from property lines of participating landowners.

For non-participating landowners whose property is bounded on two or more sides by property owned by a participating landowner on which the final design will include above ground components (excluding fences and access roads), the project should incorporate a minimum two hundred (200) foot setback to all above ground project components from the non-participating landowner's residence, and at least a fifty (50) foot setback from the non-participating landowner's property line (excluding fences and access roads), for those parcels containing the residence and for those shared boundaries within four hundred (400) feet of the residence.

State Highway 29: The project should maintain a seventy (70) foot setback from the end of the Right of Way or one hundred forty (140) feet from the center of the traveled portion of the road to all above ground project components (excluding fences and access roads), whichever is greater.

County Road BB: The project should maintain a seventy (70) foot setback from the end of the Right of Way or one hundred (100) feet from the center of the traveled portion of the road to all above ground project components (excluding fences and access roads), whichever is greater.

It is understood by the township that the professionals at the County have greater experience with these issues related to setbacks, particular to the roads in question. We are more concerned with protecting neighboring property owners through the above appropriate setbacks.

Equipment Height. The height of the project's equipment should be no higher than the twelve (12) foot maximum panel height (with the exception of the project substation), which is to be measured at the apex when the tracker is at its maximum tilt in early morning or late evening.

Vegetation/Vegetative Barriers:

- **Under-Panel and Inter-Row Ground Cover.** Perennial vegetation mix comprised of a native grass species will be planted under the panels and between rows. Soils should be planted and maintained for the duration of operation in perennial vegetation to prevent erosion, manage run off, and improve soil. Seeds should include a mix of grasses and wildflowers, ideally native to the region that would result in a short stature prairie with a diversity of forbs or flowering plants that bloom throughout the growing season. Blooming shrubs could be used in buffer areas as appropriate for visual screening. Seed mixes and maintenance practices should be consistent with recommendations made by qualified natural resource professionals such as those from the Wisconsin Department of Natural Resources, County Soil and Water Conservation District, Land and Water Conservation Department or Natural Resource Conservation Service. In order to control potential invasive and/or noxious weed species which have the potential to impact neighboring properties, the Owner/Operator should implement an annual vegetation management regimen which will consist of mowing as necessary and selective practices to control noxious weeds, including but not limited to the minimized use of approved herbicides (preferably OMRI approved).

- The Owner/Operator should explore the use of grazing animals such as sheep for its annual vegetation management regimen. There is a good deal of evidence to indicate this is a cost conscious and effective strategy for vegetation management on utility scale solar farms. The Owner/Operator should follow a Natural Resource Conservation Service-Wisconsin prescribed grazing plan to implement and manage grazing pressure.

The Vegetative Buffer:

A continuous vegetative buffer should be present and maintained at all times around the perimeter of the exterior of the fencing where occupants of neighboring non-participating residential properties and non-participating farm residences can see directly into the project area under panels or around equipment fences. Additional visual transition vegetative plantings should be discussed and agreed upon on a case by case basis with the individual non-participating landowners. A minimum 50-foot vegetative buffer (consisting of existing trees and vegetation) should be maintained. If there is no existing vegetation or if the existing vegetation is inadequate to serve as a buffer, a triple row of trees and shrubs should be planted on approximately 10-foot centers in the 25 feet immediately adjacent to the security fence. New plantings of trees and shrubs should be approximately 4- 6 feet in height at time of planting. In addition, pine seedlings should be installed in the remaining 25 feet of the 50-foot buffer. The Owner/Operator should maintain any areas between fence line and property boundaries that are not being actively farmed by participating landowner with prairie grass (pollinator habitat, comprised of long stem grass and flowering plants). This should again be done in consultation with conservation professionals.

The Owner/Operator should agree to create and maintain an appropriate vegetative buffer designed to prevent or minimize erosion around drainage ditches.

The developer should submit a financial guarantee in the form of a bond, letter of credit, or cash deposit equal to one hundred twenty-five (125) percent of the costs to meet the ground cover and buffer standards. The financial guarantee should remain in effect until ground cover and buffers are sufficiently established.

Wildlife corridors and other related concerns. The Developer should identify an access corridor for wildlife to navigate through the Solar Facility. The proposed wildlife corridor should be shown on the site plan submitted to the County. Areas between fencing should be kept open to allow for the movement of migratory animals and other wildlife. Appropriate NRCS and/or DNR biologists should be consulted. There is a real opportunity for cooperation between the developer, landowners, and conservation agency staff to create a truly beneficial project that includes habitat for wildlife and residents. The Town strongly encourages all involved to pursue these important goals. The Town would also like for the Developer/Owner/Operator to continue to research the "Lake Effect" that has been described related to large arrays of panels and it's impacts on migratory birds. There is some mixed information on this potential concern, but it warrants some serious consideration as the project design and the industry continue to evolve.

Tree Removal. Large-scale removal of mature trees in the project area should be strongly discouraged, especially diverse hardwoods native to the area. No removal of trees in the road rights-of-way should be permitted unless trees are in the right-of-way of a participating property or unless permission to remove trees is obtained from the town board.

To offset some of the tree loss likely to occur, the Town recommends that the Developer/Owner/Operator promote a tree planting program with residents of the Town. An example might be for them to purchase inexpensive seedlings, through a program like the Pierce County Land Conservation Department Tree Program, and make them available to town residents.

Testing of soil and groundwater. The Owner/Operator should be responsible to provide a current written list of all chemicals used for maintenance, etc. (e.g. pesticides, herbicides, cleaners). This list should include quantity and frequency of application of each of these chemicals. The Owner/Operator should permit and fund post-construction environmental studies deemed appropriate. Studies should include periodic monitoring of soil and of wells and drinking water supplies for any and all chemical residue. At a minimum, random soil and water testing should be performed on a yearly basis.

Additional Environmental Concerns. Because the environment, and the concerns for how to integrate solar energy responsibly, are way bigger than Gilman Township or Pierce County, the

Town has this recommendation as well. The Owner/Operator should buy the described Mono Crystalline Modules from a manufacturer with a combined score of 85 or higher on the SILICON VALLEY TOXICS COALITION Solar Scorecard found here http://www.solarscorecard.com/2018-19/2018-19-SVTC-Solar-Scorecard.pdf. The Score Card rates manufacturers on their full lifecycle commitment to responsibility. One of the referenced representative panels in the application is from a manufacturer with a score of 100 on the latest Score Card, so this does not seem like an unreasonable recommendation. The other panel has a current score of 0 and a previous score of 16. The Town feels sourcing from such a manufacturer would be unacceptable and inconsistent with the stated environmental objectives.

Fencing. The Owner/Operator should install deer fencing around the solar equipment at the height of seven (7) feet or a height mandated by electrical code to mitigate changes to the aesthetics of agricultural landscape and to prevent larger animals from gaining access to solar equipment. In the event of a conflict between a height of seven (7) feet and a height mandated by code, the height mandated by the code should control.

The fencing specified for the project should have openings large enough to allow the safe passage of small mammals.

The project should include areas where larger wildlife such as deer will have crossings or passage at locations where wildlife trails are located, along stream and drainage corridors, and at other locations as needed. See above Wildlife Corridors.

The project's substation fence may utilize chain link and barbed wire, as required by electrical code.

No fence should cross a "navigable" waterway.

Aesthetics. The Owner/Operator should maintain all facilities in a manner to preserve the aesthetics of all facilities including, but not limited to, not allowing equipment or fencing to deteriorate or remain in a state of disrepair within view of the public or adjoining land owners.

Local Emergency Services Coordination and Public Safety. Owner/Operator should require during construction and operation that all contractors on the site meet all state, federal and industry best practice standards for employee and public safety. Owner/Operator should request meetings with site area Emergency Response agencies to provide project and facility familiarization and establish communication channels. This consultation should include confirming the access roads to the interior areas of the project are sufficient for emergency needs.

It has been practice on other similarly sized projects for local emergency services to receive new specialized equipment and a yearly fund contribution for ongoing training and other needs to be sure they are prepared to respond as needed. The Town has communicated with the emergency response professionals in our area and asked what they might need specific to this project. They do not see an immediate equipment need, but do see the need for a fund for continued training and any needs that arise in time. The Town recommends a $10,000 yearly contribution from the Owner/Operator to a fund that local emergency services can use for those ongoing needs. This is in keeping with other similar projects.

"**Good Neighbor Agreements".** The subject of agreements between the developer and some non-participating landowners who are bordered by the project has been raised at each of the public hearings. The Town has looked at all the available evidence and information related to potential property value impacts, as well as potential quality of life issues, and what the short history of utility scale solar can show us.

There are "studies" that show significant impacts, but tend to be surveys of real estate professionals asking for their opinion on the subject. The limited evidence that exists of actual before and after values/sales seems to indicate much more modest and very localized impacts. The following quote is straight from the previously referenced American Planning Association's Planning Advisory Service PAS Memo: "The impact of utility-scale solar facilities is typically negligible on neighboring property values. This can be a significant concern of adjacent residents, but negative impacts to property values are rarely demonstrated and are usually directly addressed by applicants as part of their project submittal."

The standard practice for addressing this concern seems to be a negotiated agreement between the developer and those landowners who closely border the project, i.e. installations on two or more sides, within so many feet, etc. Since these agreements are negotiated privately with the individual landowners, there is very limited information as to what they might contain, and there is likely some variation accounting for the individually unique situations.

Based on what we have been able to identify as good evidence, the Town believes the developer should pursue these types of agreements where it is most warranted in an effort to indeed be a "good neighbor". Based on the limited demonstrated impacts, dollar amounts in the 5-12% of assessed value seem to be appropriate to mitigate the potential impacts for those landowners who are in very close proximity.

The Town also acknowledges the difficulty in defining and mandating such a thing, so we ask for all the parties to work together to reach a "reasonable" solution based on "substantial evidence" as the conditional use permit process requires.

Informational Area/Kiosk for visitors to the area. The final recommendation from the Town is a request for the Developer/Owner/Operator to build a road side visitors station/kiosk with parking for a handful of vehicles and use this space to educate visitors about the project, how it is beneficial to the greater good, and to highlight local attractions and resources. One of the installation areas along Hwy. 29 seems like a good fit. The Town is open to discussing the long-term logistics for how to manage this.

Referenced Documents

https://www.planning.org/pas/memo/2019/sep/

See PDF's for Jefferson County Joint Development Agreement and Iowa County Local Operating Contract

http://www.sheridantwp.com/Portals/38/Permits/ENTIRE%20Ordinance%2003-30-18.pdf
(Relevant part is section 14-22)

http://www.concordwisconsin.org/files/solar/Town_of_Concord_Solar_Farm_Resolution.pdf

http://www.solarscorecard.com/2018-19/2018-19-SVTC-Solar-Scorecard.pdf

Attachment 1

March 11, 2020

Mike Traynor
Board Member, Town of Gilman
W3616 770th Ave.
Spring Valley, WI 54767

Dear Mr. Traynor,

Ranger Power (Ranger) would like to thank the Town of Gilman Planning Commission for recommending approval of the Conditional Use Permit (CUP) for Western Mustang Solar, LLC (the Project) and appreciates the opportunity it was given to address the recommended CUP conditions at the public meeting of the Town of Gilman Planning Commission on March 9, 2020. Ranger would like to register objections to certain conditions and provide comments on several others ahead of the Gilman Town Board's consideration of them at its March 11, 2020 meeting.

Ranger's review of the conditions and its objections and comments are guided by Wisconsin law. As the Plan Commission may know, Wisconsin law provides that so long as an applicant meets the requirements specified in the Pierce County ordinance, Pierce County is required to grant the permit application.

> (b) 1. If an applicant for a conditional use permit meets or agrees to meet all of the requirements and conditions specified in the county ordinance or those imposed by the county zoning board, the county shall grant the conditional use permit. Any condition imposed must be related to the purpose of the ordinance and be based on substantial evidence.
>
> 2. The requirements and conditions described under subd. 1. must be reasonable and, to the extent practicable, measurable and may include conditions such as the permit's duration, transfer, or renewal. The applicant must demonstrate that the application and all requirements and conditions established by the county relating to the conditional use are or shall be satisfied, both of which must be supported by *substantial evidence.* The county's decision to approve or deny the permit must be supported by *substantial evidence*.

Wis. Stat. § 59.69(5e)(emphasis added).

Furthermore, Wisconsin law protects the right to develop solar energy, and in doing so, prohibits towns and counties from placing unnecessary burdens on solar development. In particular, it states, that

> No political subdivision may place any restriction, either directly or in effect, on the installation or use of a solar energy system, as defined in s. 13.48(2)(h)1.g., ... unless the restriction satisfies one of the following conditions:
>
> (a) Serves to preserve or protect the public health or safety.
>
> (b) Does not significantly increase the cost of the system or significantly decrease its efficiency.
>
> (c) Allows for an alternative system of comparable cost and efficiency.

Although Ranger believes many of the CUP conditions fail to meet the legal standards provided above, it accepts several of the conditions in an effort to demonstrate its commitment to the community and cooperating with the Town of Gilman where possible. Accordingly, Ranger respectfully requests that the Town of Gilman recommend approval of the CUP application with the following edits, deletions and modifications.

Ranger Objections and Comments

1. The term Owner/Operator should be edited to be "Western Mustang Solar, LLC" rather than Ranger Power. Ranger Power is the developer of the Western Mustang project, while Western Mustang Solar, LLC is the long-term owner and operator.

2. **Construction Hours –** Western Mustang accepts this condition provided the work days are expanded to include Saturdays and an exception to the 7 a.m. to 7 p.m. work hours limit is added for exigent circumstances after notice to Pierce County. Although not anticipated, in the event of unforeseen weather conditions or other events preventing project construction during normal hours, the Project may need the ability to request to operate outside of these construction hours to meet contract deadlines. Ranger Power requests the following language be added:

   Construction hours should be limited to daylight hours between 7am-7pm Monday through Saturday. Ranger will make all reasonable efforts to limit construction activity to 7am-7pm, Monday through Saturday. Ranger may work outside these construction hours in the event of unforeseen weather conditions or other exigent circumstances requiring work outside these hours to meet contractual deadlines, provided that Ranger gives Pierce County reasonable notice that it needs to work outside normal hours.

3. **Use of Roads –** Western Mustang accepts the request to minimize traffic on town roads and will make efforts to do so. However, Western Mustang wants to clarify that the use of these public roads is unavoidable due to project location and design.

4. **Road Repair Obligations –** As an alternative to this condition Western Mustang proposes entering into a separate Road Use Agreement with the Pierce County Highway department or other local road authority, who are the permitting officials and local experts on road issues. Western Mustang is also amenable to entering into an identical Road Use Agreement with the Town of Gilman to address town roads. In addition, Western Mustang requests the following revision:

   "The Owner/Operator should repair any damage to roads or drainage systems caused by the project or project activity, ~~to as good or better than the condition they were in prior to construction~~ to a condition at least as good as the pre-construction condition, as documented in the Initial Evaluation"

5. **Drainage Infrastructure –** Damage to drainage infrastructure on the parcels participating in the project is addressed by Western Mustang's land agreement with the project landowners. This condition should therefore be limited to damage to drainage infrastructure on non-participating property. Western Mustang proposes the following revision:

   "If drainage infrastructure or systems on non-participating properties are damaged by any cause connected with the project, the Owner/Operator shall restore the drainage infrastructure or system to ~~pre-existing condition or better~~ a condition at least as good as the pre-construction condition."

6. **Revenue Questions/School Payment Impacts** –
    a. This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. Nevertheless, Western Mustang agreed as part of its CUP application to replace any revenues for Spring Valley Schools that are lost as a result of property collection declines due to the Project. Western Mustang can voluntarily accept a 1.5% escalator, as reflected in the following revision:

       "In the future event that Pierce County is no longer able to collect property taxes in the approximate amount of $6,600, Western Mustang Solar hereby agrees to pay such portions of property tax that would have otherwise been distributed to the Spring Valley Public School and Chippewa Valley Technical College (CVTC) directly to the Spring Valley Public School and CVTC, in the amounts of $2,700/year and $300/year, respectively, with a 1.5% per year escalator, during the useful life of the Project."

    b. The condition requesting an additional monetary commitment to community schools not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. Western Mustang would entertain a request to consider such a voluntary commitment.

    c. Western Mustang feels the condition regarding the Utility Aid Shared Revenue Payment is unclear as stated and should be modified as follows:

       "If a change in law results in the elimination or reduction of the Utility Shared Revenue program, the elimination or reduction of the generator license fee (under Wis. Stat. § 76.28 and §76.29), and the land used by the Project is not returned to the applicable taxing jurisdiction's property tax rolls, which result in tax payments to the County in an amount less than what was previously being received through the Utility Shared Revenue program, then Western Mustang will compensate County and Local Units of Government for the difference between the lost property tax revenue and the previous payments received by County and Local Units of Government, up to the amount of the Project's prior year's generator license fee (under Wis. Stat. § 76.28 and §76.29)"

7. **Assurances** – Western Mustang voluntarily agrees to compensate the Township $1,200 for legal fees. The condition requesting that Western Mustang provide a donation to local charities does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. However, Western Mustang is amenable to providing a donation to local charities provided those donation amounts are at its sole discretion. No justification was provided to support the need for the $150,000 requested bond. Accordingly, this condition does not meet the standard set by Wisconsin law for restrictions on the installation or use of solar energy systems and it should be removed.

8. **Decommissioning requirements** – Some project landowners have expressed a desire to avoid or minimize disturbance of their land during restoration and have stated they prefer that project infrastructure remain in the ground below a depth of 24 inches as it will not interfere with agricultural activity. Western Mustang requests that subsurface component removal be restricted to a depth of 24 inches to be consistent with landowner agreements.

9. **Power Purchase Agreement –** The Power Purchase Agreement execution requirement does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. The condition is too restrictive and conflicts with the preferences for project ownership of many Wisconsin utility companies. While Western Mustang will not move forward without a buyer of the power, that buyer may choose to own the project rather than enter into a power purchase agreement. Ranger respectfully requests that this proposed condition be removed.

10. **Setbacks –** The setback conditions do not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. Western Mustang's application complies with the ten (10) foot setback required by the Pierce County solar ordinance, § 240-41 D. (3)(b). Nevertheless, Western Mustang accepts the recommendation for setbacks from residences of nonparticipants and property lines of nonparticipating landowners, provided that non-participating landowners have the option to waive the recommended setbacks that exceed the Pierce County solar ordinance requiring a 10 foot setback from property lines.

11. **Equipment height –** Western Mustang proposes this condition be changed from 12 feet in height to 15 feet in height. A 15 -foot height limit would still comply with Pierce County's height and solar ordinances, which allow structures up to 35 feet tall. Pierce Co. Code §§ 240-29 A; 240-41 D (3)(b).

12. **Vegetation/Vegetative Barriers – Under-Panel and Inter-Row Ground Cover. -** This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. Nevertheless, Western Mustang can accept a request to use native grass species. Western Mustang will endeavor to use native grass species as much as possible for vegetative cover under the panel arrays and in between panel rows; however, some non-native species are well-adapted to the area and have a higher probability of success. Accordingly, Western Mustang proposes modifying the first sentence of this condition as follows:

    "Perennial vegetation mix comprised of native and non-native grass species will be planted under the panels and between rows."

    Western Mustang also proposes that "Blooming shrubs could be used in buffer areas as appropriate for visual screening" be removed from this condition. Western Mustang proposes to submit a landscape plan after final design is complete and prior to construction.

13. **The Vegetative Buffer –** The Vegetative Buffer condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems, because it would significantly increase the cost of the project, is not needed for public health, is not reasonable or supported by substantial evidence, and could block sunlight needed to produce electricity. This condition should accordingly be removed. Western Mustang is amenable to providing, at its option, a Vegetative Buffer Plan, including vegetation of reasonable height and density, to owners of non-participating neighboring properties on which an inhabited residence is located and which do not experience a buffering effect from existing vegetation or land forms, if requested. The plan will be presented to the owners of said properties for them to provide reasonable comments and request reasonable revisions. Those requests and Western Mustang's updated Vegetative Buffer Plan will be provided to Pierce County for review and approval of a final Vegetative Buffer Plan.

14. **Wildlife Corridors and related concerns** –This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems, because it is not reasonable and is not supported by substantial evidence. The quilt block pattern of the Western Mustang layout presented in the CUP application as well as the existing fence line breaks across the site plan provide ample connectivity for larger wildlife passage. Placement of additional "corridors" of sufficient width to provide large wildlife passage within panel blocks as shown on the preliminary plan would be an onerous condition to the project and would require the loss of land that may jeopardize the viability of the project.

15. **Tree Removal** – The condition recommending the establishment of a tree planting program does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. Ranger will also need to remove some mature trees from private property in order to build the project. Western Mustang can accept a request to consider voluntary support for a tree planting program.

16. **Testing of Soil and Groundwater** – This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems, because it is not related to the purpose of the conditional use permit ordinances, is not supported by substantial evidence, and would significantly increase the costs of the project over its useful life. The vegetative cover planted with the footprint of the Western Mustang project will be primarily native, slow-growing species instead of cash crops needing protection from pests. As such, the use of pesticides and/or herbicides will be significantly less than currently used within and near the project area. Similarly, cleaning of the solar panels will rarely be required because precipitation will clean the panels and the use of cleaners, if required at all, will be exceedingly rare.

17. **Additional Environmental Concerns** – This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. Nevertheless, Western Mustang can accept a revised condition requiring the project to be constructed with Tier 1 solar panels.

18. **Local Emergency Services Coordination and Public Safety** – Ranger is committed to public safety and promoting a safe work environment. Ranger complies with all state, federal, and local safety regulations in addition to industry standards to promote safety. The request for a $10,000 annual fee for local emergency services does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems because it is too costly and is not reasonable or supported by substantial evidence. Ranger respectfully requests that this proposed condition be removed. The Western Mustang project will not result in increased fire risk justifying ongoing training. Western Mustang will offer training to local emergency services to familiarize them with the project and any unique safety considerations.

19. **Good Neighbor Agreements** – This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems. However, Western Mustang can accept a request to enter into Good Neighbor agreements.

Ranger Power has submitted a property value study that examined sales of property adjacent to eight existing solar projects in rural and suburban communities, most of which were in the Midwest. It states, in relevant part:

> "With regard to their impact on nearby property values, our studies of facilities of various sizes demonstrate that there is no measurable and consistent difference in property values for properties adjacent to solar farms when compared to similar properties locationally

> removed from their influence. This is supported by our interviews with local real estate brokers who have stated there is no difference in price, marketing periods or demand for the homes directly adjacent to solar farm facilities in Michigan, Illinois, Indiana, Minnesota, North Carolina, and Virginia." CohnReznick Property Value Impact Study, Andrew R. Lines and Patricia L. McGarr, p. 4 (2019).

This study examined actual land sales adjacent to solar installations in rural areas similar to Western Mustang, and is therefore based on facts and information, not personal opinion or speculation, directly pertaining to the requirements needed to obtain a conditional use permit, and that reasonable people would accept in support of a conclusion. See Wis. Stat. § 59.69(g)(2). The study is "substantial evidence" under Wis. Stat. § § 59.69(5e) that shows Western Mustang will have no adverse impact on neighboring property values and that the CUP application should be approved as submitted. Substantial evidence establishing an impact on property values has not been presented.

20. **Informational Area/Kiosk for visitors to the area.** – This condition does not meet the standard set by Wisconsin law governing Conditional Use Permits or those for restrictions on the installation or use of solar energy systems and should be removed.

We look forward to discussing these issues in greater detail during the March 11, 2020 Gilman Town Board meeting. Thank you in advance for your consideration.

Respectfully submitted,

Rosanne Koneval

Rosanne Koneval
Ranger Power

cc: Bill Emerson, Gilman Town Board
Becky Manley, Gilman Town Clerk
Tom Manley, Chair, Town of Gilman Plan Commission

Application for Conditional Use Permit
Western Mustang Solar, LLC
Pierce County, WI

WESTERN MUSTANG SOLAR
A RANGER POWER PROJECT

December 6, 2019

Table of Contents

1.0 NAME AND CONTACT INFORMATION OF THE APPLICANT, OWNER AND INSTALLER 1.4
2.0 LEGAL DESCRIPTION AND ADDRESS OF THE SITE 2.5
2.1 PROJECT AREA 2.5
2.2 PARTICIPATING PARCELS 2.6
3.0 DESCRIPTION OF THE SCOPE OF WORK 3.7
3.1 COUNTY ORDINANCE STANDARDS 3.8
3.2 DESCRIPTION OF PRELIMINARY SOLAR DESIGN 3.9
3.3 PROJECT SITING 3.9
3.4 EXPECTED PROJECT LIFESPAN 3.12
3.5 SUMMARY OF DECOMMISSIONING PLAN 3.12
3.6 REGULATORY PERMITS AND APPROVALS 3.13
4.0 SOLAR SYSTEM SPECIFICATIONS 4.13
4.1 TECHNICAL CHARACTERISTICS OF PANELS 4.13
4.2 TECHNICAL CHARACTERISTICS OF PANEL SUPPORTS 4.13
4.3 TECHNICAL CHARACTERISTICS OF INVERTERS 4.14
4.4 TECHNICAL CHARACTERISTICS OF COLLECTOR CIRCUITS 4.14
4.5 CONSTRUCTION OF PROJECT 4.15
4.5.1 Types of Construction Equipment / Delivery Vehicles 4.15
4.5.2 Gross Weight of Vehicles 4.16
4.5.3 Probable routes for Delivery of Equipment / Heavy and Oversized Equipment 4.16
4.5.4 Roads most likely to be affected by construction and materials delivery 4.16
4.5.5 Duration of typical traffic disturbance / time of day 4.17
4.5.6 Laydown areas 4.18
4.5.7 Internal Access Roads 4.18
4.5.8 Project Fencing 4.18
4.5.9 Construction Site Lighting 4.19
4.6 PRELIMINARY CONSTRUCTION SEQUENCE 4.19
4.7 OPERATION AND MAINTENANCE 4.20
5.0 SITE LAYOUT 5.20
6.0 INSTALLERS QUALIFICATIONS 6.21
7.0 UTILITY NOTIFICATION 7.21
8.0 ALL ADDITIONAL INFORMATION REQUIRED FOR A LAND USE PERMIT 8.22
9.0 ADDITIONAL APPLICATION REQUIREMENTS FOR A LARGE SES 9.22
9.1 SURROUNDING PROPERTY USES 9.22
9.2 PERCENTAGE OF LAND COVERAGE BY THE SES. 9.22
9.3 EFFECTS OF THE PROPOSED PROJECT ON COUNTY / TOWNSHIP BUDGETS AND BENEFITS TO THE COMMUNITY 9.22
9.4 CONSISTENCY WITH LOCAL COMPREHENSIVE PLANS AND COMMUNITY ENGAGEMENT 9.23

9.5 PROJECT CONSISTENCY WITH TOWN OF GILMAN COMPREHENSIVE PLAN 9.24
9.5.1 Utilities and Community Facilities: 9.24
9.5.2 Land Use 9.25
9.5.3 Economic Development 9.26
9.6 PROJECT CONSISTENCY WITH PIERCE COUNTY COMPREHENSIVE PLAN 9.26
9.6.1 Agricultural Resources 9.26
9.6.2 Natural Resources 9.27
9.6.3 Economic Development 9.28
9.6.4 Countywide Policies -- Use of Renewable Energy Systems 9.28
9.7 COMMUNITY ENGAGEMENT SUMMARY 9.28
9.8 WETLAND AND WATERWAY STUDIES 9.29
9.9 CULTURAL RESOURCES 9.30
9.10 ENDANGERED SPECIES 9.30
9.11 EROSION CONTROL AND STORM WATER MANAGEMENT PLAN 9.31
9.12 SUMMARY OF GLARE / GLINT STUDY 9.31
9.13 SUMMARY OF SOUND STUDY 9.31
9.14 ESTIMATE OF MAGNETIC PROFILE CREATED BY COLLECTOR CIRCUITS 9.31

LIST OF TABLES

TABLE 2.1-1 PROJECT LOCATION 2.5
TABLE 2.2-1 PARTICIPATING PARCELS 2.6
TABLE 5.0-1 SETBACKS 5.21
TABLE 9.3-1 ESTIMATE OF REVENUE 9.22

LIST OF APPENDICES

APPENDIX A FIGURES
APPENDIX B ENGINEERED SCHEMATICS
APPENDIX C WETLAND / WATERWAY DELINEATION REPORT
APPENDIX D CULTURAL RESOURCE REVIEW LETTER
APPENDIX E GLARE / GLINT STUDY
APPENDIX F PRE-CONSTRUCTION SOUND REPORT
APPENDIX G PRELIMINARY GEOTECHNICAL REPORT
APPENDIX H VEGETATION MANAGEMENT PLAN
APPENDIX I DECOMISSIONING PLAN
APPENDIX J ELECTRO / MAGNETIC FREQUENCEY STUDY
APPENDIX K VISUAL SIMULATIONS

Abbreviations

AC	Alternating Current
CTH	County Trunk Highway
DC	Direct current
ER	Endangered Resources
HDD	Horizontal Directional Drilling
MW	Megawatts
NABCEP	North American Board of Certified Energy Practitioners
NHI	Natural Heritage Inventory
NSA	Nearest sound sensitive area
Project	Western Mustang Solar, LLC Project
PSC	Public Service Commission (of Wisconsin)
ROW	Right-of-Ways
SES	Solar Energy System
STH	State Trunk Highway
USH	U.S. Highway
WRAPP	Water Resource Application for Project Permits
Western Mustang	Western Mustang Solar, LLC
WisDOT	Wisconsin Department of Transportation

1.0 NAME AND CONTACT INFORMATION OF THE APPLICANT, OWNER AND INSTALLER

This Section 1.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[1]

Applicant and Owner:

Name:	Western Mustang Solar, LLC
Address:	20 Jay Street, Suite 900
	Brooklyn, New York, 11201
Phone:	(917) 608-3569
Representative:	Rosanne Koneval, Director - Development
Email:	rosanne@rangerpower.com

Installer

An installer has not yet been selected at this time but will be selected during the final design stages of the project.

Agent:

Name:	Stantec Consulting Services Inc.
Address:	209 Commerce Parkway
	Cottage Grove, Wisconsin 53527
Phone:	608-830-2013
Representative:	Brian Karczewski, Senior Associate
Email:	brian.karczewski@stantec.com

The applicant is Western Mustang Solar, LLC, which will own and operate the Project. Western Mustang Solar, LLC, is a Delaware limited liability company.

Ranger Power LLC develops the project on behalf of Western Mustang Solar, LLC. Ranger Power is a utility-scale solar development company focused on bringing cost-effective clean renewable energy projects and jobs to the Midwest region. Ranger Power's team of experienced developers and renewable energy specialists have successfully developed early-, mid-, and late-stage solar projects throughout the country. Collectively, the Ranger Power team has worked on over 3,500 MW of renewable energy projects and currently has approximately 3 GW under development.

2.0 LEGAL DESCRIPTION AND ADDRESS OF THE SITE

This Section 2.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[2]

2.1 PROJECT AREA

The proposed Project is located in the Town of Gilman in Pierce County, Wisconsin. Table 2.1-1 further describes the location of the Project Area.

TABLE 2.1-1 PROJECT LOCATION

County	Town	Township (North)	Range (West)	Sections
Pierce	Gilman	27	16	3, 4, 5, 8, 9, and 10

The Project boundary is 1,055 acres in size before consideration of siting restrictions, with the project footprint being approximately 478.66 acres. The Project footprint constitutes approximately 45 percent of the total Project Boundary. These figures are based on currently available technology and the precise project footprint number will be only be known when the final design is produced. The final design will be comparable to the acreage listed here and significantly less than the 1,055 leased acres. Figure 1 provided in Appendix A depicts the general Project location within the state, Figure 2 shows the total Project area with an aerial photography base map. Figure 3 is a site layout of the proposed Project facilities.

The Project boundary was designed taking into consideration the following:

- Location of Project facilities (panels, access roads, substation)
- Location of land under contract
- Public roads utilized for construction and maintenance
- Current setbacks per County and Township zoning (Refer to Section 5.0 for a listing of setbacks incorporated into the preliminary design)
- Approximate zone of shadow/sound impact of panels

The Project is situated on multiple parcels of land with seventeen property owners. Western Mustang possesses signed landowner agreements for the parcels currently proposed to host panels, access roads, substation, laydown yard, transformers, junction boxes and the collection system. The Project will require permits from town, county and state departments of transportation to allow partial placement of the collection system in public road rights-of-way ("ROW").

2.2 PARTICIPATING PARCELS

Table 2.2.1 provides a list of participating parcels for the Project.

TABLE 2.2-1 PARTICIPATING PARCELS

Owner	Landowner	Parcel ID
Behrens	Scott C. & Valerie J. Behrens	010-01010-0800
Behrens	Scott C. & Valerie J. Behrens	010-01025-0500
Behrens	Scott C. & Valerie J. Behrens	010-01025-0200
Behrens	Scott C. & Valerie J. Behrens	010-010-250-410
Solberg	Norman S. Solberg	010-01012-0610
Lenarz	John & Sonya Gambrel-Lenarz	010-01012-0500
MarShan Farms, LLC	Mary I. & Shane Lucking	0100-1009-1000
MarShan Farms, LLC	Mary I. & Shane Lucking	0100-1010-0100
MarShan Farms, LLC	Mary I. & Shane Lucking	0100-1010-0120
Verges	Phillip G. & Judith A. Verges	0100-1012-0200
Verges	Phillip G. & Judith A. Verges	010-01012-0100
Nord Family Trust	Jeanette M. Leonard	010-01009-0600
Mattison	Jerry E. and Dianne J. Mattison	010-01023-0100
Mattison	Jerry E. and Dianne J. Mattison	010-01022-0900
Mattison	Jerry E. and Dianne J. Mattison	010-01022-0700
Yang	Mai Yang	010-01024-0100
Yang	Mai Yang	010-01024-0200
Mason	James L. and Sandra K. Mason	010-01026-0310
Mason	James L. and Sandra K. Mason	010-01025-1000
Mason	James L. and Sandra K. Mason	010-01026-0100
Dangeur	Nicholas J. & Sonja K. Thompson	010-01024-0700
Dangeur	Nicholas J. & Sonja K. Thompson	010-01024-1000
Dangeur	Nicholas J. & Sonja K. Thompson	010-01025-0100
Rush River	Nils A. and Jennifer E. Rahm	010-01013-0500
Rush River	Nils A. and Jennifer E. Rahm	010-01013-0900
Rush River	Nils A. and Jennifer E. Rahm	010-01013-0700
Rush River	Nils A. and Jennifer E. Rahm	010-01013-0200
Turner	Bradley D. & Patricia Turner	010-01014-0900
Turner	Bradley D. & Patricia Turner, Eric S. & Linda Turner	010-01014-0600
Turner	Bradley D. & Patricia Turner, Eric S. & Linda Turner	010-01014-0300
Turner	Bradley D. & Patricia Turner, Eric S. & Linda Turner	010-01014-0500

Owner	Landowner	Parcel ID
Turner	Bradley D. & Patricia Turner, Eric S. & Linda Turner	010-01019-0900
Wayne & Anita Spence Family Trust	Mark Spence	010-01024-0400
Spence	Russell M. Spence, Jr.	010-01024-0300

3.0 DESCRIPTION OF THE SCOPE OF WORK

This Section 3.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[3]

Western Mustang is proposing to construct, install, operate and maintain a 74-megawatt (MW) alternating current (AC) solar energy generating facility known as the Western Mustang Solar, LLC Project ("Project") to be located within the Town of Gilman, Pierce County, Wisconsin. The Project will consist of an east-west tracking solar panel system and associated facilities, with a generating capacity of approximately 74 MW AC. The Project will be a large solar energy system (SES) which directly converts and then transfers solar energy into usable forms of electrical energy intended for offsite consumption.

The power generated by the Project will be transmitted by a 34.5 kV collection system to a substation which will be developed as part of the Project. A pad-mounted step-up transformer within the Project substation will increase the voltage to match the nearby 161 kV transmission line which will then transmit the power to another substation / switching yard adjacent to the Project substation that will be developed, owned and operated by Dairyland Power Cooperative. Additional Project facilities to be constructed within the Project footprint include access roads to facilitate the erection and maintenance of the solar arrays and panels, temporary parking and an equipment laydown yard to be used during construction, and a fence surrounding the perimeter of the Project.

The Project will create significant environmental, social, and economic benefits, including new local jobs during construction, new local long-term jobs, utility aid payments, annual pollution reductions, and substantial contributions towards meeting Wisconsin's renewable energy goals.

The Project is seeking a recommendation from Gilman Township and approval from Pierce County for a conditional use permit to be valid throughout the useful life of the Project in accordance with the Pierce County ordinance.

The figures and information contained in this application are estimates based on desktop and field analyses performed to date. They are subject to change based on final siting of the solar arrays and associated facilities, and the ultimate procurement of Project equipment.

3.1 COUNTY ORDINANCE STANDARDS

Pierce County has established Zoning Code § 240-41 D (3)(b) [1-8] which lists eight standard requirements for large SES.

These standards include the following:

1. Setbacks. Any portion of the SES shall not encroach within 10 feet of any property line or road right-of- way.

   Western Mustang confirms that no portion of the SES proposed shall encroach within 10 feet of any property line or road right-of-way. The final design of the project will maintain these setbacks. Reference Section 5 for a listing of setbacks incorporated into the preliminary design.

2. Height Restrictions. A SES shall not exceed 35 feet in height.

   Western Mustang confirms that no portion of the proposed SES shall exceed 35 feet in height. Please reference Section 4.0 for technical characteristics of the SES.

3. Glare. The SES shall be positioned so that the glare does not create any unsafe conditions.

   The proposed design for Western Mustang will not create unsafe conditions from glare. Glare is not predicted for any airports, drivers of vehicles on roads adjacent to the project, or for any sensitive receptor observation points such as homes that were evaluated for the analysis at any time of the day or any time of the year. See Section 9.12 for discussion regarding the glare analysis performed for the Project.

4. Installer. All SES shall be installed by a North American Board of Certified Energy Practitioners (NABCEP) Certified Solar Installer or other person qualified to perform such work.

   An installer has not yet been selected at this time. Western Mustang will select an NABCEP Certified Solar Installer or other person/firm qualified to perform the work. See Section 6.0 for discussion regarding Installer certification and qualifications.

5. Code Compliance. A SES shall comply with all applicable State of Wisconsin electrical codes and the National Electrical Code. A SES that will connect to a commercial structure or multi-unit dwelling shall comply with the State of Wisconsin Commercial Building Code, when necessary; other applicable SES shall comply with the Uniform Dwelling Code.

   Western Mustang will comply with all national electrical codes and State of Wisconsin electrical Commercial Building, and Uniform Dwelling Codes. See Section 4.0 for discussion regarding technical characteristics of the SES.

6. Utility Notification. A small SES that intends to connect to the electric utility shall not be permitted until evidence has been given that the utility company has been informed of the customer's intent to install an interconnected customer-owned generator. A copy of the final agreement shall be submitted to the Zoning Office.

   Western Mustang is in the MISO Interconnection Queue J801 and in the DPP-2017-August West Cluster. Western Mustang shall provide the Zoning Office with the final Generator Interconnection Agreement when available.

7. Structural Integrity. The structure upon which the proposed SES is to be mounted shall have the structural integrity to carry the weight and wind loads of the SES.

   Western Mustang confirms that the structure upon which the proposed SES is to be mounted shall have the structural integrity to carry the weight and wind loads of the SES. See Section 4.2 for discussion regarding technical characteristics of the panel supports.

8. Orderly Development. Upon issuance of a Conditional Use Permit, all Large SES shall notify the Public Service Commission of Wisconsin.

   Western Mustang confirms that the Wisconsin Public Service Commission will be notified upon issuance of a Conditional Use Permit from Pierce County.

3.2 DESCRIPTION OF PRELIMINARY SOLAR DESIGN

The full Project nameplate capacity of 74 MW AC can be achieved with the single axis tracking systems proposed for the Project. At the time of construction several PV module offerings from different suppliers will be evaluated and a selection will be made based on the most cost-effective option. The technologies that may be considered are polycrystalline, monocrystalline and bi-facial PV modules, and the final supply of modules may contain a mix of several similar wattages. PV modules produced by a wide range of manufacturers are under consideration for the Project, including Canadian Solar, Hanwha Qcells, JA Solar, Jinko, Longi, Risen, SunPower, and Trina. The models selected will comply with all county ordinance requirements.

Major components of the Project include solar modules, racking, tracking system, inverters, transformers and a Project substation. Detailed description of each of these components is provided in Section 4.0. The Project area includes approximately twenty panel array areas that are separately fenced with the panels comprising a total area of 478.66 acres.

3.3 PROJECT SITING

Western Mustang identified Wisconsin as a promising potential market for solar farms in 2017, due to the low number of such facilities in the state at that time and the need for new, clean electricity generation. One of the most significant factors enabling solar development in this region has been the dramatic decline in the cost of large solar systems, due to a combination of improving technology, equipment and installation methods.

Wisconsin has an aging fleet of fossil-fuel power plants, many of which are scheduled to come offline over the next several years according to announcements by large utilities. Solar is one of the lowest cost forms of new energy generation for the region, with low operating costs and no fuel costs.

Western Mustang initiated a preliminary site review to identify potential locations for development of a solar facility based on the following siting criteria:

Phase I

The first phase of assessment eliminates areas of poor resource or other siting flaws as described below.

- Transmission and Injection Capacity – nearby electric transmission infrastructure is necessary to connect a project to the power grid. A project substation and additional transmission lines are often necessary, however the cost required to connect a project to the grid increases with the distance over which project-specific transmission must be built.
- With respect to the grid analysis, Western Mustang looks for injection points where the existing electrical infrastructure is robust. This way, Western Mustang minimizes the interconnection facility costs and network upgrades frequently attributed to new generating facilities. In addition, Western Mustang prioritizes projects where land is available adjacent to the point of interconnection, to minimize the length of high voltage transmission generation tie lines and the number of structures that support them. At Western Mustang Solar, the projected cost to interconnect the project to the transmission system is expected to be less than $5M. The project will not require any additional upgrades to the transmission system to inject its power. The project substation will be located adjacent to an existing 161kV transmission line, minimizing the need for additional high voltage infrastructure.

Phase II

The second phase of assessment is a more focused evaluation of land availability in the areas identified as feasible in Phase I.

- Land use – large tracts of open land must be available to support the responsible siting of solar panels. Undeveloped, vacant land is ideally suited for solar farms. The Project area consists primarily of open land with gently rolling topography, thus providing suitable conditions for siting a solar facility. Wooded areas are present within the Project area and have been avoided to the extent practicable.
- Community – Western Mustang values working with communities that welcome solar projects and responsible economic development opportunities. Western Mustang places great importance on community-supported projects. In order to be a good neighbor, it is important that the project start on the right foot by being transparent and being in

constant communication with the public. The Western Mustang team engages local landowners, neighboring landowners, municipal leaders, and state legislators early on in its development process. Gilman Township and Pierce County expressed positive feedback after the Project was announced.

- Potential host landowners – Prospective landowners are visited to gauge interest in hosting project facilities. Prospective landowners in Gilman Township expressed interest and support of the Project.
- Environmental concerns – A site suitability tool was run to screen for environmental factors including, but not limited to, wetlands, waterways, trees, critical habitat, endangered species and animals, and hydric soils. The Project areas selected showed few environmental factors, and, those factors identified can be avoided by placement of the solar PV array.
  - Cultural and Historic Resources - Archaeological, cultural, and historical resources were considered during the site selection and Project design. The areas selected will not impact known archaeological, cultural, or historical resources.
  - Constructability – Topography (elevation and slope), as well as soils and subsurface geology are reviewed at a desktop level. Detailed field analyses are performed later in the development process.
  - Road infrastructure – Highways and roads within the proposed project area are reviewed for compatibility with large construction vehicles and delivery trucks. Main highways feeding into the area from major ports or rails are also considered for delivery of panels and other components.
  - With respect to suitability of available land, solar farms are best sited on tracts that are relatively flat or with a slight southern incline. The use of cleared land minimizes impacts from shading and the need to remove trees. It also significantly reduces the likelihood that sensitive flora or fauna inhabit the area. As stated above, the Project area consists primarily of open land with gently rolling topography. Some wooded areas are present within the Project area and have been avoided to the extent practicable.
  - With respect to receptiveness of the community, Western Mustang places great importance on community-supported projects. In order to be a good neighbor, it is important that the project start on the right foot by being transparent and being in constant communication with the public. The Western Mustang team engages local landowners, neighboring landowners, municipal leaders, and state legislators early on in its development process. Prospective landowners expressed interest and support of the Project. Gilman Township and Pierce County expressed positive feedback after the Project was announced.

The Town of Gilman and Pierce County both operate under a Comprehensive Plan and Pierce County administers an ordinance regulating Large SES. Section 3.1 provides a description of the Projects conformance with Pierce County Large SES ordinances and Section 9.4 provides discussion regarding the Project's consistency with local comprehensive plans.

The Project Area proposed within this application was evaluated based on topography, environmental concerns, land rights, willing landowner participation, and proximity to the point of interconnection to the existing Dairyland Power Cooperative 161kV transmission line that bisects the area.

3.4 EXPECTED PROJECT LIFESPAN

The expected useful life of the Project is approximately 30-40 years. All lease agreements have been negotiated to allow for that term of operation. Western Mustang understands that the value of a solar farm lies in its operation and anticipates a premium level of operation and maintenance service throughout its life. Based upon the needs of the marketplace, the community, the landowners, and Western Mustang, it is anticipated there will be an opportunity to extend the Project life beyond 40 years. The lease agreements would allow for a maximum operating period of 40 years; an extension beyond 40 years would require approval from landowners in the form of new land agreements as well as local approval.

3.5 SUMMARY OF DECOMMISSIONING PLAN

The expected lifetime of a utility-scale solar panel is approximately 30-40 years with an opportunity for a longer project lifetime with equipment replacement and repowering. Depending on market conditions and Project viability, the solar arrays may be retrofitted with updated components (e.g., panels, frame, tracking system, etc.) to extend the life of the project.

At the end of the Project's useful life, the Project would cease operation. At that time, the facilities would be decommissioned and dismantled, and the site restored to its preconstruction condition. Farmland could be used again for agricultural purposes with no anticipated long-term loss of soil productivity. Components of the solar facility that have resale value may be sold in the wholesale market. Components with no resale value will be salvaged and sold as scrap for recycling or disposed of at an approved offsite licensed solid waste disposal facility (landfill). The detailed decommissioning plan developed for the Project is included in Appendix I.

Western Mustang will be responsible for decommissioning the Project and associated facilities and has included an obligation to decommission the Project components in the Project's solar lease and easement agreements with participating landowners. Western Mustang will post decommissioning security 15 years into the operation of the facility to cover the net estimated cost to decommission the Project.

3.6 REGULATORY PERMITS AND APPROVALS

The necessary federal, state, and local permits and approvals will be obtained before commencing construction activities. In addition, the PSC will be notified upon receipt of the Conditional Use Permit from Pierce County.

4.0 SOLAR SYSTEM SPECIFICATIONS

This Section 4.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[4]

4.1 TECHNICAL CHARACTERISTICS OF PANELS

Western Mustang is considering the Jinko Eagle HC 72M 365-385-watt modules or similar model for the Project. Each module assembly (with frame) typically has a total weight of approximately 50 pounds. Typical modules are approximately 78 inches by 39 inches in size and are mainly comprised of non-metallic materials such as silicon, mono- or poly-crystalline glass, composite film, plastic, and epoxies, with an anodized aluminum frame. Final panel selection cannot be made at this time due to the ever-changing nature of the technology. Panel selection will be made during final design. Western Mustang will commit to follow up with the County when a specific panel type is selected. Refer to Appendix B for specification sheets of example panel types that may be considered for the Project.

4.2 TECHNICAL CHARACTERISTICS OF PANEL SUPPORTS

In accordance with Pierce County Zoning Ordinance Chapter 240: Zoning § 240-41D (3)(b)[7] the structure upon which the proposed SES is to be mounted shall have the structural integrity to carry the weight and wind loads of the SES.

The solar panels will be mounted on a steel racking frame that is positioned three to seven feet from the finished ground with a +\- 60-degree range of motion (single axis tracking) driven by electric motors. The single axis tracking system is anticipated to be mounted on support posts driven or screwed into the ground with steel piles or helical piles. The horizontal tracker would be in its highest position during the morning and evening hours when the trackers are tilted at their maximum angle and would be a maximum of 10 to 12 feet above the ground surface. The bottom edge of the modules will be a minimum of one foot above grade at maximum tilt, and up to four feet above grade when tilted flat at mid-day.

In summary:

- Approximate height of tracker rotation shaft – 3 to 7 feet.
- Minimum tracker height (module edge to ground at maximum tilt) – 2 to 4 feet.
- Maximum tracker height (module edge to ground at maximum tilt) – 10 to 12 feet.

- Range of tracking angle - +/-60 degrees.

The variability in height is due to the panel configuration on the racking system. Some systems are designed with a single row of panels arranged in a portrait configuration relative to a viewer east or west of the row. The long axis of the panels would be perpendicular to the axis of the tracking system. The panels would be approximately four feet above grade when tilted flat at mid-day in this design. A racking system with a two-portrait design may also be selected. This system holds two panels in portrait configuration with an axis that is perpendicular to the tracker. The two-portrait configuration requires taller piles and results in a taller overall system, but also provides for wider aisles. Racking system design will be selected prior to construction.

In the case of extreme weather conditions, Western Mustang has reviewed the closest weather station's climate history, as verified by the Solar America Board for Codes and Standards. Potential tracking technologies will be assessed in the context of other project attributes, such as resource forecast and expected operating profile. The final selection could assume an operating scenario where equipment can operate in the most extreme heat and cold, or potentially pause tracking operation until these conditions pass.

The complete tracker system will be arranged into rows of individual trackers with an estimated length of 270 feet for three strings and 183 feet for two strings. Both three and two string trackers would be 6.7 feet in width when the panels are horizontal with gaps placed between sections or groups of sections to allow for maintenance personnel to access the whole site. The piles will run north to south along the row to support each section of the steel structure and will likely include an integrated cable management solution in order to support the insulated copper DC string cabling which interconnects each of the PV modules.

4.3 TECHNICAL CHARACTERISTICS OF INVERTERS

The Project facility will consist of solar panels producing DC voltage which must be changed to AC voltage through a series of inverters. The inverters will be spaced several hundred feet apart from each other. Approximately 39 inverters will be installed throughout the Project area (subject to final site design). A manufacturer brochure of an inverter which is used for the basis of the preliminary design included with this submission is provided in Appendix B. The inverters are typically part of a skid assembly with the inverter and the assembly being mounted on a driven pile foundation.

4.4 TECHNICAL CHARACTERISTICS OF COLLECTOR CIRCUITS

In accordance with Pierce County Zoning Ordinance Chapter 240: Zoning § 240-41D (3)(b)[4] the SES will be developed in compliance with all applicable State of Wisconsin electrical codes, the National Electrical Code, and State of Wisconsin Commercial Building Code.

The preliminary design assumes the conductor will be aluminum. Insulation: 35kV TRXLPE, 100% insulation, (1/6, 1/3 and 2/3 concentric neutral depending on wire size), PVC Jacket overall. Cables are MV-105. Final specifications will be determined during the detailed engineering phase.

The collection system will either be buried at a depth of 36 inches to the top of the cables or will be enclosed within a conduit and buried at a depth of 24 inches. The trench for the cable will be one foot wide. Where multiple cables are installed parallel to each other, the cable separation will be two feet apart, therefore the width of the trench will vary depending on the number of circuits within the trench

Methods of Installation of the collection system within uplands may include vibratory plow, or direct trenching. Underground horizontal directional drilling (HDD) or direct trenching will be utilized in environmentally sensitive areas, such as wetlands and waterways. If direct trenching is used, the pre-existing surface contours will be reestablished once work is complete. In addition, there are several underground HDD drilling areas that will be used to cross roadways (under County Trunk Highway (CTH) BB, 410th St., and 850th Avenue).

4.5 CONSTRUCTION OF PROJECT

4.5.1 Types of Construction Equipment / Delivery Vehicles

Construction equipment will include the following: graders, bulldozers, excavators, forklifts, trailers, plows, trenchers, pile drivers and directional boring rigs. It is anticipated that most equipment will be initially delivered to the Project temporary laydown areas. Equipment will be transported from the laydown yard to the appropriate construction site, as needed.

Additional deliveries of construction materials and components will be made directly to the construction sites. The materials and delivery vehicles include the following:

- Culvert sections and road fabric (flatbed semis);
- Reinforced steel for foundation, anchor bolts and padmount transformers (flatbed semis);
- Ready-mixed concrete at the substation only (traditional ready-mix trucks);
- Large equipment and main substation main transformer (heavy/oversize load tractor trailers); and
- Fiber optic spools, electrical cable and electrical conductors (lowboy or flatbed semis).

Except for the main power transformer, vehicles used for delivery will be standard over-the-road semitrucks and flatbed trailers having standard turning radius and ground clearance.

4.5.2 Gross Weight of Vehicles

Vehicles used for transporting Project components will consist of legal load (80,000lb or less) over-the-road flatbed and box trucks, other than the oversize load delivery vehicle used for the main step-up transformer for the Project substation.

The site will receive an average of approximately five to seven box trucks (modules) a day throughout the module delivery period and five to seven flatbed trucks a day (inverters, piles, racking, misc.) during the pile driving period. The shipping weight of the main transformer will be approximately 317,550 lb and may be transported via rail to the nearest railyard or via barge to the nearest port and then using special multi-axle trucking as necessary to the site. If there becomes a need for a larger vehicle, Western Mustang's construction contractor will work with state and local authorities to obtain the applicable oversize-overweight permits.

4.5.3 Probable routes for Delivery of Equipment / Heavy and Oversized Equipment

The most suitable access to the Project site will be via I-94 to United States Highway (USH) 63 approximately 0.75-mile west of the site. The Project site may be accessed from USH 63 by State Trunk Highway (STH) 29 on the south boundary of the site, 890th Avenue on the north boundary or 850th Avenue which bisects the Project site. Roads traversing the site north to south include County Highway BB, 220th Street/Viking View Road, 330th Street and 410th Street. Access routes for vehicles arriving at the site that provide the most direct access and avoid cross traffic will be chosen. Furthermore, roads that consist of higher capacity, four-lane divided highway will be used as much as possible.

Final routes for equipment have not been chosen at this time although most loads will approach the Project area via STH 29 and 890th Avenue from the west, and County Highway BB from the south. Although some highways are listed as 'high-clearance' or 'oversize-over weight', these ratings do not remove the requirement for application for a permit for a load which exceeds the standard limits for size and weight. Additionally, the lack of a 'high-clearance' or 'oversize-over weight' rating does not preclude a highway from use for loads which exceed state limits. Finally, temporary restrictions are placed on many roads during Spring thaw and Winter Frozen Road Period. The WisDOT Oversize-Overweight Permit section will be contacted for additional information when specific loads and routes are known.

4.5.4 Roads most likely to be affected by construction and materials delivery

The area roads are primarily hot-mix asphalt pavement. The roads serve the general traveling public, area agriculture industry traffic, and local vehicle traffic. Each possible route considered for delivery and transportation of construction materials will be evaluated individually for potential mitigation requirements prior to construction. To determine the sub-surface load bearing capacities of local roads, past maintenance requirements are often an accurate indicator of future performance.

In general, except for entrance/exit locations, haul vehicles that have axle and wheel loads similar to standard highway vehicles should not have an adverse impact on bridges and structures that have been designed for modern highway loadings. This would apply to State and County Trunk Highways and other major roadways that have been designed for and routinely carry this type of traffic. Also, this would apply to minor roads with newer structures designed in accordance with current codes. Driveway locations may reveal localized roadway deficiencies due to the increased stresses of vehicle braking, turning, and accelerating. Minor roads with older and smaller structures would require investigation and evaluation of individual structures.

Vehicles used for transporting Project components will consist of legal load (80,000lb or less) over-the-road flatbed and box trucks except for the delivery of the main step-up transformer for the Project substation. Western Mustang's construction contractor will work with state and local authorities to obtain the applicable oversize-overweight permits.

Road damage during the construction phase of the Project is unlikely. Vehicles used for transporting Project components will consist primarily of legal load over-the-road flatbed and box trucks. Prior to commencement of construction, a survey of road conditions within routes used for the Project will be performed. If necessary, roads will be video-taped both before and after construction and assessed by an independent consultant acceptable to Western Mustang. If direct damage results from the Project traffic loads, it will be repaired and returned to conditions mutually agreed upon by the affected jurisdictions as determined by the pre-construction survey. Alternatively, Western Mustang and the affected jurisdictions may agree on a rate of compensation directly caused by and related to the Project traffic. Deliveries to Project sites will be compliant with statutory heavy-haul axle loading requirements.

4.5.5 Duration of typical traffic disturbance / time of day

Road use during construction for materials delivery will include USH 63, STH 29, CTH BB, 850th Avenue and 890th Avenue. Section 4.5.3 discusses how each road will be used during the construction phase.

The Project is in a rural area and thus general traffic congestion will be limited. During construction little to no interference with local traffic patterns is anticipated and closures of state, county or local town roads are not planned. Most of the work and transportation activities will occur during low volume and off-peak times. Signage will be posted during construction to notify local traffic of construction vehicles entering and exiting the roadway and presence of workers.

The first phase of construction will include delivery of earth-moving equipment. Delivery trucks will bring steel posts, racks and solar modules, followed by equipment and personnel to install them. This will be followed by installation of the electrical system which will be installed by trenching equipment as described in Section 4.4. Construction activities will be conducted primarily during daylight hours, during off-peak times Monday through Friday. Smaller vehicles for personnel arriving on-site may continue through later hours if needed to maintain the Project's construction schedule.

4.5.6 Laydown areas

As construction progresses, the solar panels and other equipment will generally be delivered directly to the installation locations in a standard over-the-road truck. Forklifts are used to unload pallets from the truck and place the pallets throughout the site. Some equipment will be delivered to the laydown area and then distributed as needed.

The laydown areas will be established throughout the Project sites with main laydown areas being close to site entrances and secondary laydown as required in areas local to the performance of the construction work. The specific location of the laydown areas within Project sites will be established during the detailed design and construction planning of the Project. These areas will be used to stockpile racking system components, PV modules, cable reels, and other components until they are needed. Larger components such as inverters, transformers and substation equipment will be delivered directly to the final installed location wherever possible.

4.5.7 Internal Access Roads

Internal site roads will be 16 feet wide during construction and operation of the facility. Construction matting may be used to a limited extent during construction in areas with soil strength limitations for construction vehicles that will be traversed a minimum number of times (i.e. one or two times). In these areas, the existing soil surface will remain intact, planted in perennial vegetation and maintained for operation and maintenance once construction is completed. Most internal access roads are anticipated to remain as the existing soil surface. Vegetation will be maintained on these roads throughout the life of the Project

If areas are identified as having soil strength limitations to support construction vehicles where vehicle traffic will be more frequent (i.e. site approaches), aggregate materials may be used. In these areas, topsoil will be stripped and stored for use during reclamation. Geotextile matting will be installed prior to placement of aggregate to prevent mixing with native subsoil. The aggregate would be maintained for the life of the Project. During decommissioning at the end of the Project's life, these areas will be restored by removing the aggregate, decompacting the soil if required, restoring the topsoil and either seeding to permanent perennial vegetation or returning the area to agricultural production.

4.5.8 Project Fencing

The fence that will be used to surround and provide security to the photovoltaic panel areas will consist of deer exclusion fencing at a height as required by electrical code and/or local and state ordinance. The Project substation will require a seven to eight-foot high chain link fence which may include barb wire at the top which will be 10 feet as stipulated by the Pierce County Zoning Ordinance. Each fenced area will have at least one secured entrance gate. A typical of the fence design that could be used for the Project is included in Appendix B.

4.5.9 Construction Site Lighting

Construction is planned to be conducted during daylight hours and therefore not require additional site lighting. In the event that site lighting is needed to accommodate safe working conditions for construction, portable lighting and generators may be used as needed.

4.6 PRELIMINARY CONSTRUCTION SEQUENCE

The following provides a description of the staging and construction sequence for the Project:

- Stabilize construction entrances and exits;
- Receive security fencing and gate materials;
- Install perimeter security fencing and gates;
- Remove vegetation in areas of construction and perform limited and localized grading as needed for transformer substation;
- Develop the staging and lay-down areas for receiving of construction materials and equipment, storage of the construction materials and equipment containers, location of construction trailers and parking for personnel and construction-related vehicles;
- Survey and stake the access roads and panel locations;
- Develop the access roads (limited grading is anticipated as roads will be constructed at grade when possible);
- Delivery of equipment, including piles and potentially helical piers, aluminum supports/mounting structures, tracking systems and inverters. Because the Project will be constructed in blocks and multiple blocks will be constructed simultaneously as well as over time, deliveries will continue over time in advance of construction of the blocks;
- Install driven piles or helical piers for a given block;
- Install aluminum supports/mounting structures on to piles for a given block;
- Install inverter pads for a given block;
- Install tracking systems for a given block;
- Delivery of PV modules and collection system equipment;
- Install solar PV modules;
- Install collection system by means of trenching and directional drilling;
- Electrical testing and equipment inspections for each block and the collection system;
- Receive materials and equipment for step-up transformer substation;

- Install step-up transformer substation and connect collection system to transformer substation;
- Electrical testing and equipment inspections of transformer substation and connections to substation;
- Install and inspect tie-in to DPC substation;
- Conduct interconnection inspections and testing and Project commissioning;
- Vacate and restore staging and lay-down areas. De-compact the subsoil, with windrowed topsoil re-distributed and de-compacted again as needed; and
- Reseed and revegetate disturbed areas if needed consistent with revegetation and restoration plan.

The duration of construction for this project is estimated to be 12-18 months.

4.7 OPERATION AND MAINTENANCE

Western Mustang will hire and train contractors to safely operate and maintain the facility. All equipment including the substation will be monitored by Western Mustang Solar and its contractors. All services will comply with all federal, state, and local laws. The facility will be remotely monitored 24/7. Maintenance activities will include mowing as needed to control weeds or invasive species. Western Mustang may locate an operations and maintenance building within the Project area that will be of a Conex box type construction. A Conex box is a steel container of varying sizes. The placement of the structure on the site will be in conformance with all local and state building codes.

5.0 SITE LAYOUT

This Section 5.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[5]

Major components of the Project include solar modules, racking, tracking system, inverters, transformers and a Project substation. Detailed description of each of these components is provided in Section 4.0. The Project area includes approximately twenty panel array areas that are separately fenced with the panels comprising a total area of 478.66 acres. A Preliminary Site Layout is provided as Figure 3 in Appendix A.

The setbacks considered as part of the project design are provided in Table 5.0-1.

TABLE 5.0-1 SETBACKS

Setback Description	Setback Value
Setback from Navigable Waterways	35 feet[1]
Setback from 890th Ave [Town Road]	42 feet from edge of ROW / 75 feet from Centerline
Setback from Bee Road (870th Ave) [Town Road]	75 feet from Centerline of Road
Setback from BB Highway [County Highway]	67 feet from edge of ROW / 100 feet from Centerline
Setback from State Highway 29 [State Highway]	77 feet from edge of ROW / 132 feet from Centerline
Minimum Setback from any Road ROW	10 feet
Minimum Setback from any Property Line	10 feet
Setback for Substation to any dwellings	75 feet
Setback for Substation from any residential lot line	50 feet

6.0 INSTALLERS QUALIFICATIONS

This Section 6.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[6]

An installer has not yet been selected at this time. Western Mustang will select an NABCEP Certified Solar Installer or other person/firm qualified to perform the work. Upon selection of an installer, the installer's qualifications and signature certifying that the SES will be installed in compliance with this section and all other applicable codes will be provided to the County.

7.0 UTILITY NOTIFICATION

This Section 7.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[7]

Western Mustang is in the MISO Interconnection Queue J801 and in the DPP-2017-August West Cluster. Western Mustang completed Phase I of the MISO Definitive Planning Phase (DPP) on October 24, 2019. The report showed no ERIS or NRIS Network Upgrades and the estimated cost for interconnection was $3.4M for a new three-ring bus to be constructed by Dairyland Power Cooperative. MISO kicked off the Phase II study on October 29, 2019, and Western Mustang expects to see results and a draft report in January 2020. The current MISO schedule shows the DPP Phase III being completed on August 25, 2020, and our final Generator Interconnection Agreement being executed in January 2021. Western Mustang shall provide the Zoning Office with the final Generator Interconnection Agreement.

[1] As per discussions with Brad Roy, Pierce County, Department of Land Management and Records

8.0 ALL ADDITIONAL INFORMATION REQUIRED FOR A LAND USE PERMIT

This Section 8.0 addresses Pierce County Zoning Code § 240-41 D (3)(d)[3]

Information required for a Land Use Permit includes identification of the property owner, property location, description of the proposed project, a description of the structures to be constructed, setback distances from lot lines and road ways, driveways, easements, floodplains, location of existing structures, and a plot plan. All of these items have been provided within this application.

9.0 ADDITIONAL APPLICATION REQUIREMENTS FOR A LARGE SES

This Section 9.1 addresses Pierce County Zoning Code § 240-41 D (3)(e)

9.1 SURROUNDING PROPERTY USES

This Section 9.1 addresses Pierce County Zoning Code § 240-41 D (3)(e)[1]

The property surrounding the Project is primarily used for agricultural purposes and consists of cultivated cropland, hay/pastureland, and rural residential.

9.2 PERCENTAGE OF LAND COVERAGE BY THE SES.

This Section 9.2 addresses Pierce County Zoning Code § 240-41 D (3)(e)[2]

The Project boundary is 1,055 acres in size before consideration of siting restrictions, with the project footprint being approximately 478.66 acres. The Project footprint constitutes approximately 45 percent of the total Project Boundary. These figures are based on currently available technology and the precise project footprint number will be only be known when the final design is produced. The final design will be comparable to the acreage listed here and significantly less than the 1,055 leased acres.

9.3 EFFECTS OF THE PROPOSED PROJECT ON COUNTY / TOWNSHIP BUDGETS AND BENEFITS TO THE COMMUNITY

The impacts to the local government budgets will be positive. Western Mustang has committed to replacing any revenues for Spring Valley Schools that are lost as a result of property tax collection declines due to the Project.

The Wisconsin Shared Revenue Utility Aid Program administered by the Department of Revenue provides for a capacity-based payment to be distributed annually to the communities hosting an electric generating facility. As proposed, the 74MW solar project would be eligible for the standard generator payment, as well as a payment for energy derived from an "alternative energy source."

In aggregate, the Western Mustang Solar Project will provide an estimated $296,000 in annual payments through the State of Wisconsin Shared Revenue Utility Aid program. Modern PV solar facilities are expected to have useful lives in excess of 30 years. A conservative estimate of 25 years of shared revenue would result in $7,400,000 to Pierce County and the Town of Gilman for hosting the Project.

From this aggregate, the Town of Gilman will receive an estimated $123,333 annually and Pierce County will receive an estimated $172,667 annually through the State of Wisconsin Shared Revenue Utility Aid Program.

TABLE 9.3-1 ESTIMATE OF REVENUE

	Total	Town of Gilman	Pierce County
MW based Payment	$148,000	$49,333	$98,667
Incentive Payment	$148,000	$74,000	$74,000
Total	$296,000	$123,333	$172,667

Additional benefits to the community and surrounding area include the possible hiring of local Project construction, commissioning, operations and maintenance staff. Jobs may be created to accommodate services, such as snow plowing, landscape maintenance, and Project access road maintenance. Additional economic benefits include significant financial stability benefits to farmland owners that are participating as land lessors to the Project. Other economic benefits not directly controlled by Western Mustang include ancillary jobs and local support positions in areas such as food service, housing/lodging, hospitality, fuel, fuel delivery, sanitation, gravel, asphalt, road repair and other resource requirements.

9.4 CONSISTENCY WITH LOCAL COMPREHENSIVE PLANS AND COMMUNITY ENGAGEMENT

The Town of Gilman and Pierce County both operate under a Comprehensive Plan. For zoning decisions involving Towns like the Town of Gilman that have adopted a Comprehensive Plan, as stated in the Pierce County Comprehensive Plan, the "County acknowledges that the responsibility for accomplishing planning objectives set forth in plans developed by towns subject to county zoning lies jointly with the Town and Pierce County. The County further acknowledges that it will seek to further each Town's planning goals and objectives when considering the establishment of conditionally permitted uses."[2]

This section addresses how the Project is consistent with the goals, objectives and policies of the Town of Gilman Comprehensive Plan and the Pierce County Comprehensive Plan. The narrative will focus on those respective comprehensive plan provisions relevant to the Project, as many plan provisions are not directly applicable to a solar energy generation facility.

9.5 PROJECT CONSISTENCY WITH TOWN OF GILMAN COMPREHENSIVE PLAN

The Project as proposed provides an opportunity for the Town of Gilman, and is consistent with the overall goals, objectives and policies set forth in the Town of Gilman Comprehensive Plan.

9.5.1 Utilities and Community Facilities:

The Town of Gilman Comprehensive Plan includes a Utilities and Communities section. The third goal within Utilities and Communities section is directly applicable to the Project and it states (with emphasis added): ***Encourage the development of alternative energy sources within the Town of Gilman***.[3] Specific objectives related to this goal include (with emphasis added):

1. Support ***alternative energy sources that will decrease energy costs***.
2. Support ***alternative energy sources that may be more environmentally sound*** than burning fossil fuels.
3. Support opportunities ***for residents to develop alternative energy sources*** that will be self-sustaining.

The policies and recommendations related to this objective include (with emphasis added):

1. Work with Pierce County to allow the development of wind turbines and alternative fuel processing facilities.
2. Support and regulate the development of wind turbines/wind energy.
3. Support and regulate the conversion of animal waste gasses and other biomass sources into useable fuels
4. ***Support and regulate the use of solar panels and solar energy.***

[2] Pierce County Comprehensive Plan, p. 11.
[3] Town of Gilman Comprehensive Plan, p. 24.

Solar energy generation can be used by electric utilities to reduce reliance on fossil-fuel burning power plants. A large solar energy system fits directly within these objectives and will help the town achieve these planning goals.

9.5.2 Land Use

Although the land use section of the Gilman Township Comprehensive Plan is not specific to solar, it does set goals to preserve and protect farmland. Moreover, it "is the expressed intent of this Comprehensive Plan to maintain the agrarian and rural character of the Town of Gilman."[4]

Western Mustang Solar will preserve and protect the land on which its solar farm will be located and will help maintain the agrarian and rural nature of the area. First, the Project's anticipated useful life of approximately 30-40 years represents a ***temporary*** land use and will not result in a permanent loss of farmland. Second, the site will be restored with a vegetative cover that over the life of the project will improve soil health. This vegetative cover will improve soil tilth through the incorporation of organic matter through it's rooting structure and will stabilize the soil from erosive forces. These activities support the harmony of surrounding agricultural activities and area landowners. Third, following the end of the Project's useful life, the Project will be decommissioned and the underlying property restorable to its prior agricultural use, as outlined in the proposed Decommissioning Plan. Fourth, since large SES may be permitted by County ordinance in all zoning districts (except the shoreland-wetland district), the Project area need not be rezoned and can remain a Primary Agriculture and General Rural district. This is important since, once the Project is decommissioned and the property is restored, the land is available for future agricultural use. Moreover, while the property remains in solar panels, it is protected and preserved as farmland and not susceptible to conversion for housing development, subdivision or other intensive and irreversible development. Fifth, there will be limited soil disturbance associated with the Project, and agricultural soils will be preserved resulting in fertile soils post-decommissioning. During project operation, the ground cover will be maintained as native or pasture grasses and legumes, which will improve water retention and allow the soil nutrient base to regenerate. Accordingly, the Project design, construction, operation, and decommissioning methods will actually support future agricultural activities similar to the resting of agricultural lands and amounts to "land banking" of the properties, which will ultimately facilitate resumption of farmland activity after the useful life of the Project.

In addition to preserving and protecting farmland, the plan also encourages compatible land use development and recommends a policy of maintaining a balance between the public interest and private property rights. The Project is highly compatible with the town's goal and public interest in preserving farmland, supporting the development of solar energy in the town and balancing the property rights of landowners who've chosen to lease property to the Project for panels.

---

[4] Town of Gilman Comprehensive Plan, p. 44.

9.5.3 Economic Development

The economic development section of the Gilman Township Comprehensive Plan articulates a goal of supporting "economic development activities which strengthen the local economy while maintaining the town's agricultural base, rural character, and healthy environment"[5] and recommends avoiding the encroachment of commercial and industrial development in actively farmed areas. The Project will support this goal by providing direct economic impacts from the Wisconsin Shared Revenue Utility Aid Program, while also reducing air pollution and providing competitively priced on-peak electricity. In addition, when solar farms are hosted on agricultural land, local farmers benefit from stable income diversification. Combining traditional agriculture production with stable solar lease payments makes farms more resilient to shifts in crop prices and yields. While the plan does not include a definition of commercial and industrial development, solar development like the Western Mustang project is ***not*** a commercial or industrial development as those terms are commonly used, such as commercial buildings, factories, and other resource intensive industrial activities. The Project will not have any of the impacts of such commercial and industrial development such as impacts pollution, water use, permanent conversion of land and presence of toxic and/or hazardous chemicals on site.

As has been discussed in sections 9.4 and 9.5, the Project is consistent with the economic development goals and recommendations in the comprehensive plan. Moreover, in addition to the economic benefits that will accrue to the Town and surrounding communities during project construction, the Town will also benefit from the increased Utility Aids from the State Shared Revenue program (which is described in section 9.3)

9.6 PROJECT CONSISTENCY WITH PIERCE COUNTY COMPREHENSIVE PLAN

The Project as proposed is also consistent with the goals, objectives and policies set forth in the Pierce County Comprehensive Plan.

9.6.1 Agricultural Resources[6]

The Pierce County Comprehensive Plan's principal agricultural goals, objectives and policies are focused on maintaining the operational efficiency, viability and productivity of the County's agricultural areas for current and future generations. The Western Mustang Project is consistent with and supports these goals, objectives and policies since it will preserve and enhance agricultural land areas in the County.

First, the Project's anticipated useful life of at least 30-40 years represents a ***temporary*** land use and will not result in a permanent loss of land for agriculture. Second, the Project area amounts to less than one-half of one percent (0.50%) of the land area used for agricultural purposes in the County, a small portion of agricultural land relative to what is

[5] Town of Gilman Comprehensive Plan, p. 40
[6] Pierce County Comprehensive Plan, p. 14.

available. Third, the site will be restored with a vegetative cover that over the life of the project will improve soil health. This vegetative cover will improve soil tilth through the incorporation of organic matter through it's rooting structure and will stabilize the soil from erosive forces. These activities support the harmony of surrounding agricultural activities and area landowners. Fourth, following the end of the Project's useful life, the Project will be decommissioned and the underlying property restorable to its prior agricultural use, as outlined in the proposed Decommissioning Plan. Fifth, since large SES may be permitted by County ordinance in all zoning districts (except the shoreland-wetland district), the Project area need not be rezoned and can remain a Primary Agriculture and General Rural district. This is important since, once the Project is decommissioned and the property is restored, the land is available for future agricultural use. Moreover, while the property remains in solar panels, it is protected and preserved as agricultural land and not susceptible to conversion for housing development, subdivision or other intensive and irreversible development. Sixth, there will be limited soil disturbance associated with the Project, and agricultural soils will be preserved resulting in fertile soils post-decommissioning. During project operation, the ground cover will be maintained as native or pasture grasses and legumes, which will improve water retention and allow the soil nutrient base to regenerate. Accordingly, the Project design, construction, operation, and decommissioning methods will actually support future agricultural activities similar to the resting of agricultural lands and amounts to "land banking" of the properties, which will ultimately facilitate resumption of agricultural activity after the useful life of the Project.

9.6.2 Natural Resources[7]

The comprehensive plan natural resources policies focus principally on using county's land resources within their environmental limits and promote stewardship of the county's land and water resources; the plan objectives aim to manage stormwater, encourage preservation to unique geological or physical significance and land uses that minimize pollution; and the plan policies encourage the preservation of open space and protection of natural resource before, during and after development.

The Project is consistent with the natural resources goals, activities and policies. Consistent with existing land uses, the Project will result in minimal new additional impervious surface areas that could affect stormwater runoff. Moreover, once the vegetation management plan activities are complete and panels installed, the native plantings and vegetation management practices will limit runoff and migration of topsoil and nutrients into surface waters. The Project is also sited to avoid impacts to sensitive natural areas and wetlands thereby preserving the natural features adjacent to the Project area.

[7] Pierce County Comprehensive Plan, p. 14

9.6.3 Economic Development

The comprehensive plan goal for economic development is as follows: "Develop a strong, diversified, base of industry, commerce, agriculture, and education that provides a broad range of job opportunities, a healthy tax base, and improved quality of services to county residents."

The Project adds to the diversity of economic activity in the County with innovative, non-polluting renewable energy. It also provides participating landowners with stable lease payments which help to diversify landowners' income, support continued agricultural operations and multi-generational family land ownership, and prevent other uses of the land, like subdivision or clustered development. Moreover, the Project is not expected to adversely affect land uses on adjacent agricultural or residential purposes. As is described in Section 9.3. of the application, the Project will generate additional revenue for the County in the form of Utility Aids from the state shared revenue program which can be used to fund other County services and programs.

9.6.4 Countywide Policies -- Use of Renewable Energy Systems[8]

The Pierce County Comprehensive Plan contains a section described are as follows:

> Some of the policies governing both the planning and management of "growth and change" within the county are not specific to individual management areas listed in the "Management Goals, Objectives, and Policies" element. To refrain from repeating the broad county-wide policies that intersect each subsection of the "Management Goals, Objectives, and Policies," those overarching policies have been grouped together here.

Included in the list under Countywide Policies is the following policy statement related to renewable energy systems: **"**Encourage energy efficiency and the use of alternative/renewable energy systems."[9]

9.7 COMMUNITY ENGAGEMENT SUMMARY

Local Residents – Western Mustang has been meeting with prospective landowners, their tenants, and nearby residents since early 2017 to determine local interest to participate in the Project

Local Units of Government – The Project has also met with local Town and County elected officials and staff to advise them of project activities, to gauge interest in a solar facility, as well as to understand permitting requirements and potential concerns:

- Town of Gilman board members and Plan Commission Chair
- Pierce County representatives (County Board members, Land Management Committee, Zoning Administrator, Highway Commissioner);

[8] Pierce County Comprehensive Plan, p. 47
[9] Pierce County Comprehensive Plan, p. 47

- Spring Valley Village Board

State Elected Representatives and Regulatory Agencies – The Project has also met with state elected representatives.

Public – In addition, the Project has engaged in outreach activities to share information and gather feedback from a broader public audience, including:

- One-on-one communication with Project neighbors and community leaders
- Presentations at public meetings of local units of government
- Established a dedicated website (www.westernmustangsolar.com) that provides information about the Project along with contact information
- Actively monitors an informational e-mail address and toll-free phone number
- Hosted an Open House on September 10, 2019, with over 70 attendees. (Over 140 invitations were sent, and the list included landowners within a 1/4 to 1/2 mile of the facility).
- The project has worked with local media to facilitate coverage of plans for the project, resulting in coverage in the local area, including front-page print articles in the Spring Valley Sun Argus.

9.8 WETLAND AND WATERWAY STUDIES

Western Mustang retained the services of Stantec to identify wetlands and waterways within the Project Area. Detailed information on wetlands and waterways is provided in the Wetland Delineation Report provided in Appendix C.

The Project Area does not contain sensitive wetlands as defined by 2015 Wisconsin Act 387, including state or federally listed waterways, trout streams, fisheries, wilderness areas, recreational areas, sensitive resources of state or federal concern, or other areas of special natural resource interest as outlined in NR 103.04, Wisc. Adm, Code.

No permanent wetland fill is proposed as part of the construction of the Project. The Project will require temporarily impacting wetlands due to placement of both panel facilities and access roads. Construction / access within wetlands will be done through the use of low ground pressure equipment, under frozen ground conditions, or through the use of construction matting in order to minimize impact. Additionally, the collection system will require crossing wetlands by either HDD or trench methods. These impacts will also only be temporary in nature, as the ground surface will be returned to pre-existing condition if trenching methods are utilized. Permits for these temporary impacts will be obtained from the U.S. Army Corps of Engineers and the Wisconsin Department of Natural Resources during the final design stages of the Project.

Waterways have been avoided to the extent practicable. The Project facilities that will require waterway crossings include access roads and the collection system. These crossings would impact waterways via the placement of culverts and backfill. Other project facilities such as the panels and associated facilities and substation will not impact waterways. Crossings for the collector system would be completed by HDD methods to avoid impacting waterways. The need for land clearing at waterway crossings is expected to be limited and no downstream impacts to waterways are expected during construction of the Project. A Chapter 30 culvert permit will be obtained from the Wisconsin Department of Natural Resources if deemed necessary during final design stages of the Project.

9.9 CULTURAL RESOURCES

Stantec contracted with Commonwealth Heritage Group to complete a review of known cultural resources (archaeological / historical) sites within and around the project limits of the Western Mustang development. In accordance with Wisconsin Statutes §44.40, if the Project will utilize state funding or require state permitting, previously recorded archaeological sites and above-ground resources that would be directly or indirectly affected by the Project would need to field checked and reassessed. Once the extent of wetland / waterway impacts are determined on the project and if any of these impacts are deemed jurisdictional by the U.S. Army Corps of Engineers, the permit process through this agency will require a field check for cultural resources in the immediate area surrounding the proposed impact. It is believed that the extent of impacts for the Project that will be considered jurisdictional and require this field check will be for culvert installations for internal access roads on defined waterways.

The Commonwealth Heritage Group study did not find any historical or archeological cultural resources that they believed would be considered eligible for listing on the National Register within or surrounding the Project area. This will be confirmed during state and federal permitting process. Western Mustang will site the Project facilities so as to avoid directly or indirectly affecting any sites or above-ground resources that are determined eligible for listing on the National Register and will maintain federal and state required buffers for these resources.

9.10 ENDANGERED SPECIES

Western Mustang conducted an informal consultation with the USFWS through the Information for Planning and Consultation online system on October 18, 2019. The gray wolf, northern long-eared bat, Karner blue butterfly and prairie bush clover were identified on the list provided.

An ER Review was conducted for the Project to identify whether any state or federally-listed rare species, natural communities, or other natural features with element occurrence records may occur within one-mile of the Project area. A Certified Endangered Resources (ER) review was submitted to the WDNR on October 28, 2019. The results of the ER Review concluded that no actions need to be taken to comply with state and/or federal endangered species laws. The WDNR approved the ER review and provided concurrence and recommendations on October 30, 2019. Because ER review indicates that there are no required actions to “maintain compliance with State and Federal Endangered Resources laws,” no habitat assessment is needed for the Project.

The Wisconsin Natural Heritage Inventory (NHI Portal) database contains all current Northern Long-eared Bat roost sites and hibernacula in Wisconsin. The NHI Portal was consulted for this project, and per U.S. Fish and Wildlife Service's 4(d) rule, it was determined that this project is more than 150 feet from a known maternity roost tree and is more than 1/4 mile from a known hibernaculum. Tree clearing as a result of Project activities is a covered activity of the Broad Incidental Take Permit and Authorization for Wisconsin Cave Bats. However, it is recommended that the Project avoid tree clearing, particularly snags or dying trees, from June 1 to August 15.

9.11 EROSION CONTROL AND STORM WATER MANAGEMENT PLAN

Once the Project is authorized, Western Mustang will submit a Water Resource Application for Project Permits (WRAPP) to the WDNR in accordance with Wis. Admin. Code § NR 216. The application will include a site-specific Erosion Control and Storm Water Management Plan. The Plan will include technical drawings and descriptions of the best management practices that will be followed in compliance with WDNR technical standards.

9.12 SUMMARY OF GLARE / GLINT STUDY

In accordance with the Pierce County Zoning Code, Western Mustang commissioned a glare hazard analysis to analyze the potential for glare from the Project. Glare is not predicted and therefore does not creates unsafe conditions for any airports, drivers of vehicles on roads adjacent to the project, or for any sensitive receptor observation points such as homes at any time of the day or any time of the year. The Glare Hazard Analysis Report is provided in Appendix E.

9.13 SUMMARY OF SOUND STUDY

Western Mustang commissioned a sound analysis for the Project to determine level of sound generated by the substation transformer and inverters. This study found that the maximum sound level that would be experienced at the nearest sound sensitive area (NSA) does not exceed the Wisconsin Public Service Commission defined daytime and nighttime standards. For full report please refer to the Pre-Construction Sound Report included in Appendix F of this application.

9.14 ESTIMATE OF MAGNETIC PROFILE CREATED BY COLLECTOR CIRCUITS

Western Mustang commissioned an Electromagnetic Field Study for the Project to determine electric and magnetic fields that may be expected as a result of the Project and found that potential magnetic and electric fields generated by project components do not represent a negative impact to the human environment. Furthermore, the Public Service Commission of Wisconsin has concluded that there is no correlation between magnetic fields and negative health effects. The Electromagnetic Field Study completed for the Project is provided in Appendix J.

APPENDIX A FIGURES

APPENDIX B ENGINEERED SCHEMATICS

APPENDIX C WETLAND / WATERWAY DELINEATION REPORT

APPENDIX D CULTURAL RESOURCE REVIEW LETTER

APPENDIX E GLARE / GLINT STUDY

APPENDIX F PRE-CONSTRUCTION SOUND REPORT

APPENDIX G PRELIMINARY GEOTECHNICAL REPORT

APPENDIX H VEGETATION MANAGEMENT PLAN

APPENDIX I DECOMISSIONING PLAN

APPENDIX J ELECTRO / MAGNETIC FREQUENCEY STUDY

APPENDIX K VISUAL SIMULATIONS

September/October 2019

American Planning Association
Planning Advisory Service
Creating Great Communities for All

PAS MEMO

Planning for Utility-Scale Solar Energy Facilities

By Darren Coffey, AICP

Solar photovoltaics (PV) are the fastest-growing energy source in the world due to the decreasing cost per kilowatt-hour—60 percent to date since 2010, according to the U.S. Department of Energy (U.S. DOE n.d.)—and the comparative speed in constructing a facility. Solar currently generates 0.4 percent of global electricity, but some University of Oxford researchers estimate its share could increase to 20 percent by 2027 (Hawken 2017). Utility-scale solar installations are the most cost-effective solar PV option (Hawken 2017).

Transitioning from coal plants to solar significantly decreases carbon dioxide emissions and eliminates sulfur, nitrous oxides, and mercury emissions. As the U.S. Department of Energy states, "As the cleanest domestic energy source available, solar supports broader national priorities, including national security, economic growth, climate change mitigation, and job creation" (U.S. DOE n.d.). As a result, there is growing demand for solar energy from companies (e.g., the "RE100," 100 global corporations committed to sourcing 100 percent renewable electricity by 2050) and governments (e.g., the Virginia Energy Plan commits the state to 16 percent renewable energy by 2022).

Federal and state tax incentives have accelerated the energy industry's efforts to bring facilities online as quickly as possible. This has created a new challenge for local governments, as many are ill-prepared to consider this new and unique land-use option. Localities are struggling with how to evaluate utility-scale solar facility applications, how to update their land-use regulations, and how to achieve positive benefits for hosting these clean energy facilities.

As a land-use application, utility-scale solar facilities are processed as any other land-use permit. Localities use the tools available: the existing comprehensive (general) plan and zoning ordinance. In many cases, however, plans and ordinances do not address this type of use. Planners will need to amend these documents to bring some structure, consistency, and transparency to the evaluation process for utility-scale solar facilities.

Figure 1. Utility-scale solar facilities are large-scale uses that can have significant land-use impacts on communities. Photo by Flickr user U.S. Department of Energy/Michael Faria.

Unlike many land uses, these solar installations will occupy vast tracts of land for one or more generations; they require tremendous local resources to monitor during construction (and presumably decommissioning); they can have significant impacts on the community depending on their location, buffers, installation techniques, and other factors (Figure 1); and they are not readily adaptable for another industrial or commercial use, hence the need for decommissioning.

While solar energy aligns with sustainability goals held by an increasing number of communities, solar industries must bring an overall value to the locality beyond the clean energy label. Localities must consider the other elements of sustainability and make deliberate decisions regarding impacts and benefits to the social fabric, natural environment, and local economy. How should a locality properly evaluate the overall impacts of a large-scale clean energy land use on the community?

This *PAS Memo* examines utility-scale solar facility uses and related land-use issues. It defines and classifies these facilities,

Figure 2. Components of a solar farm: solar panels (left), substation (center), and high-voltage transmission lines (right). Photos courtesy Berkley Group (left, right) and Pixabay (center).

analyzes their land-use impacts, and makes recommendations for how to evaluate and mitigate those impacts. While public officials tend to focus on the economics of these facilities and their overall fiscal impact to the community, the emphasis for planners is on the direct land-use considerations that should be carefully evaluated (e.g., zoning, neighbors, viewsheds, and environmental impacts). Specific recommendations and sample language for addressing utility-scale solar in comprehensive plans and zoning ordinances are provided at the end of the article.

The Utility-Scale Solar Backdrop

In contrast to solar energy systems generating power for on-site consumption, utility-scale solar, or a solar farm, is an energy generation facility that supplies power to the grid. These facilities are generally more than two acres in size and have capacities in excess of one megawatt; today's utility-scale solar facilities may encompass hundreds or even thousands of acres. A solar site may also include a substation and a switchyard, and it may require generator lead lines (*gen-tie* lines) to *interconnect* to the grid (Figure 2).

From 2008 to 2019, U.S. solar photovoltaic (PV) installations have grown from generating 1.2 gigawatts (GW) to 30 GW (SEIA 2019). The top 10 states generating energy from solar PV are shown in Figure 3. For many of these initial projects, local planning staff independently compiled information through research, used model ordinances, and relied on professional networks to cobble together local processes and permit conditions to better address the adverse impacts associated with utility-scale solar.

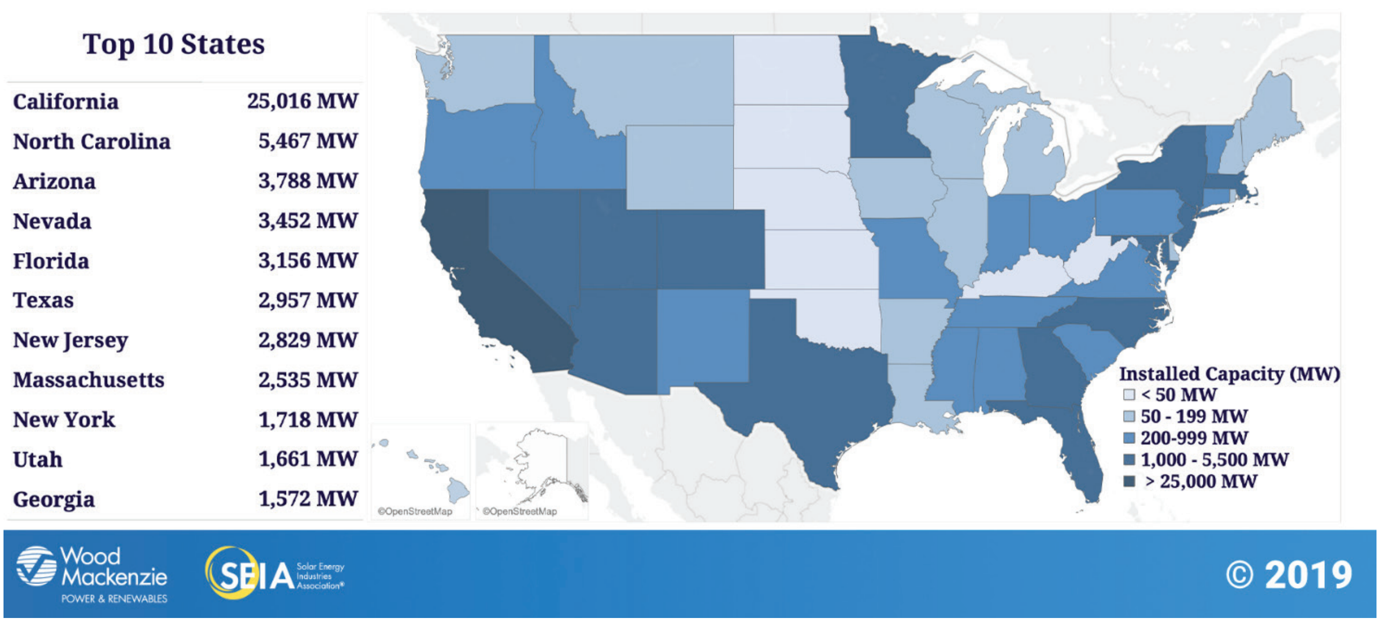


Figure 3. Utility solar capacity in the United States in 2019. Courtesy Solar Energy Industry Association.

However, each individual project brings unique challenges related to size, siting, compatibility with surrounding uses, mitigating impacts through setbacks and buffers, land disturbance processes and permits, financial securities, and other factors. This has proven to be a significant and ongoing challenge to local planning staff, planning commissions, and governing bodies.

Some localities have adopted zoning regulations to address utility-scale solar facilities based on model solar ordinance templates created by state or other agencies for solar energy facilities. However, these ordinances may not be sufficient to properly mitigate the adverse impacts of these facilities on communities. Many of these initial models released in the early 2010s aimed to promote clean energy and have failed to incorporate lessons learned from actual facility development. In addition, the solar industry has been changing at a rapid pace, particularly regarding the increasing scale of facilities. Planners should therefore revisit any existing zoning regulations for utility-scale solar facilities to ensure their relevance and effectiveness.

Rapid growth of utility-scale solar facilities has emerged for rural communities, particularly those that have significant electrical grid infrastructure. Many rural counties have thousands of acres of agricultural and forested properties in various levels of production. Land prices tend to be much more cost-effective in rural localities, and areas located close to high-voltage electric transmission lines offer significant cost savings to the industry. Figure 4 shows the extent of existing electric transmission lines in one rural Virginia county.

Federal and state tax incentives have further accelerated the pace of utility-scale solar developments, along with decreasing solar panel production costs. These factors all combine to create land-use development pressure that, absent effective and relevant land-use regulatory and planning tools, creates an environment where it is difficult to properly evaluate and make informed decisions for the community's benefit.

Solar Facility Land-Use Impacts

As with any land-use application, there are numerous potential impacts that need to be evaluated with solar facility uses. All solar facilities are not created equal, and land-use regulations should reflect those differences in scale and impact accordingly.

Utility-scale solar energy facilities involve large tracts of land involving hundreds, if not thousands, of acres. On these large tracts, the solar panels often cover more than half of the land area. The solar facility use is often pitched as "temporary" by developers, but it has a significant duration—typically projected by applicants as up to 40 years.

Establishing such a solar facility use may take an existing agricultural or forestry operation out of production, and resuming such operations in the future will be a challenge. Utility-scale solar can take up valuable future residential, commercial, or industrial growth land when located near cities, towns, or other

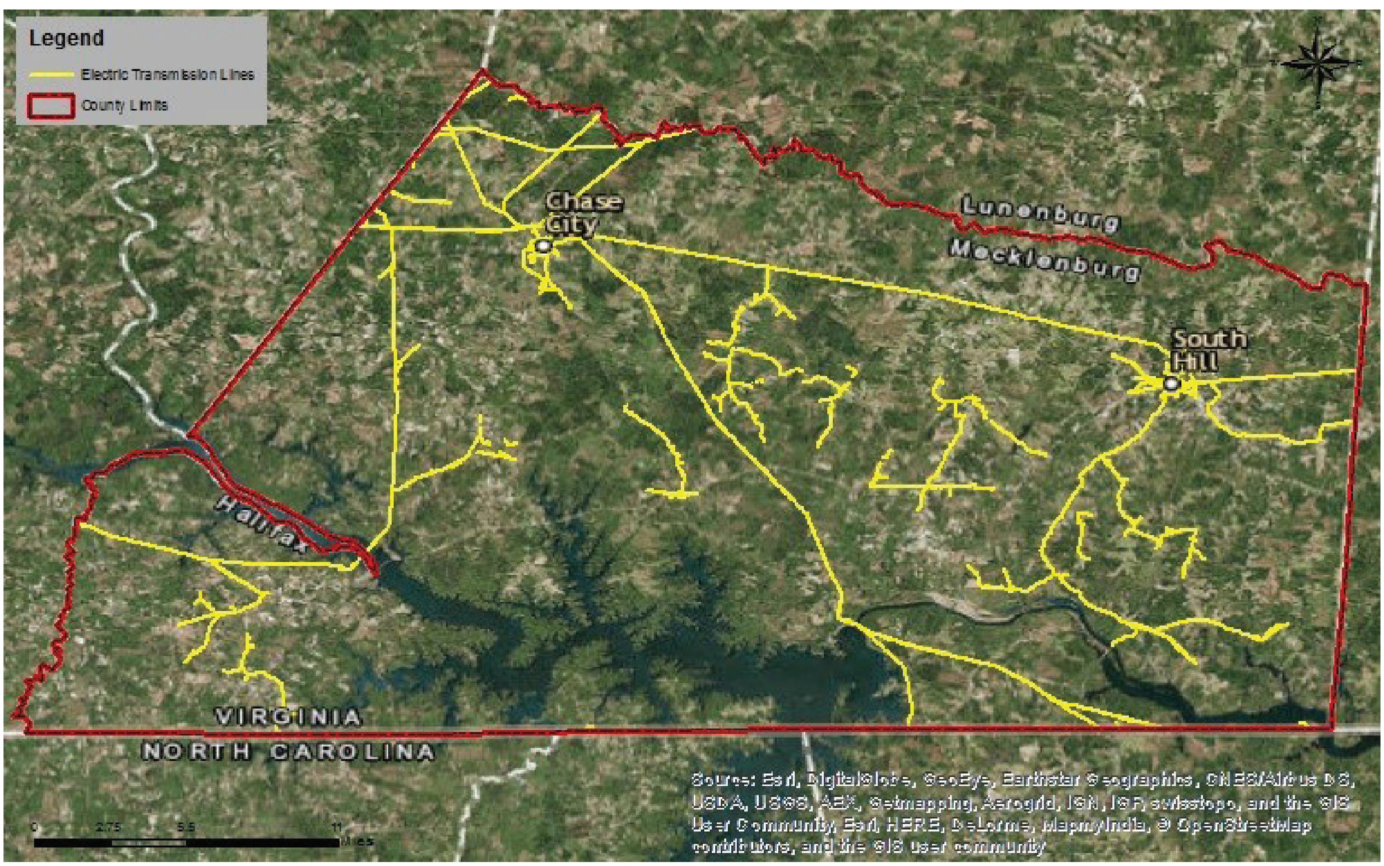


Figure 4. Electric transmission lines in Mecklenburg County, Virginia. Courtesy Berkley Group.

identified growth areas. If a solar facility is close to a major road or cultural asset, it could affect the viewshed and attractiveness of the area. Because of its size, a utility-scale solar facility can change the character of these areas and their suitability for future development. There may be other locally specific potential impacts. In short, utility-scale solar facility proposals must be carefully evaluated regarding the size and scale of the use; the conversion of agricultural, forestry, or residential land to an industrial-scale use; and the potential environmental, social, and economic impacts on nearby properties and the area in general.

To emphasize the potential impact of utility-scale solar facilities, consider the example of one 1,408-acre (2.2-square-mile) Virginia town with a 946-acre solar facility surrounding its north and east sides. The solar project area is equal to approximately 67 percent of the town's area. A proposed 332.5-acre solar facility west of town increases the solar acres to 1,278.5, nearly the size of the town. Due to its proximity to multiple high-voltage electrical transmission lines, other utility-scale solar facilities are also proposed for this area, which would effectively lock in the town's surrounding land-use pattern for the next generation or more.

The following considerations are some of the important land-use impacts that utility-scale solar may have on nearby communities.

Change in Use/Future Land Use

A primary impact of utility-scale solar facilities is the removal of forest or agricultural land from active use. An argument often made by the solar industry is that this preserves the land for future agricultural use, and applicants typically state that the land will be restored to its previous condition. This is easiest when the land was initially used for grazing, but it is still not without its challenges, particularly over large acreages. Land with significant topography, active agricultural land, or forests is more challenging to restore.

It is important that planners consider whether the industrial nature of a utility-scale solar use is compatible with the locality's vision. Equally as important are imposing conditions that will enforce the assertions made by applicants regarding the future restoration of the site and denying applications where those conditions are not feasible.

Agricultural/Forestry Use. Agricultural and forested areas are typical sites for utility-scale solar facility uses. However, the use of prime agricultural land (as identified by the USDA or by state agencies) and ecologically sensitive lands (e.g., riparian buffers, critical habitats, hardwood forests) for these facilities should be scrutinized.

For a solar facility, the site will need to be graded in places and revegetated to stabilize the soil. That vegetation typically needs to be managed (e.g., by mowing, herbicide use, or sheep grazing) over a long period of time. This prolonged vegetation management can change the natural characteristics of the soil, making restoration of the site for future agricultural use more difficult. While native plants, pollinator plants, and grazing options exist and are continually being explored, there are logistical issues with all of them, from soil quality impacts to compatibility of animals with the solar equipment.

A deforested site can be reforested in the future, but over an additional extended length of time, and this may be delayed or the land left unforested at the request of the landowner at the time of decommissioning. Clearcutting forest in anticipation of a utility-scale solar application should be avoided but is not uncommon. This practice potentially undermines the credibility of the application, eliminates what could have been natural buffers and screening, and eliminates other landowner options to monetize the forest asset (such as for carbon or nutrient credits).

For decommissioning, the industry usually stipulates removal of anything within 36 inches below the ground surface. Unless all equipment is specified for complete removal and this is properly enforced during decommissioning, future agricultural operations would be planting crops over anything left in the ground below that depth, such as metal poles, concrete footers, or wires.

Residential Use. While replacing agricultural uses with residential uses is a more typical land-use planning concern, in some areas this is anticipated and desired over time. "People have to live somewhere," and this should be near existing infrastructure typical of cities, towns, and villages rather than sprawled out over the countryside. This makes land lying within designated growth areas or otherwise located near existing population centers a logical location for future residential use. Designated growth areas can be important land-use strategies to accommodate future growth in a region. Permitting a utility-scale use on such land ties it up for 20–40 years (a generation or two), which may be appropriate in some areas, but not others.

Industrially Zoned Land. Solar facilities can be a good use of brownfields or other previously disturbed land. A challenge in many rural areas, however, is that industrially zoned land is limited, and both public officials and comprehensive plan policies place a premium on industries that create and retain well-paying jobs. While utility-scale solar facilities are not necessarily incompatible with other commercial and industrial uses, the amount of space they require make them an inefficient use of industrially zoned land, for which the "highest and best use" often entails high-quality jobs and an array of taxes paid to the locality (personal property, real estate, machinery and tool, and other taxes).

Location

The location of utility-scale solar facilities is the single most important factor in evaluating an application because of the large amount of land required and the extended period that land is dedicated to this singular use, as discussed above.

Solar facilities can be appropriately located in areas where they are difficult to detect, the prior use of the land has been marginal, and there is no designated future use specified (i.e., not in growth areas, not on prime farmland, and not near recreational or historic areas). Proposed facilities adjacent to corporate boundaries, public rights-of-way, or recreational or cultural resources are likely to be more controversial than facilities that are well placed away from existing homes, have natural buffers, and don't change the character of the area from the view of local residents and other stakeholders.

Figure 5. This scenic vista would be impacted by a solar facility proposed for the far knoll. Photo courtesy Berkley Group.

Concentration of Uses

A concentration of solar facilities is another primary concern. The large scale of this land use, particularly when solar facilities are concentrated, also significantly exacerbates adverse impacts to the community in terms of land consumption, use pattern disruptions, and environmental impacts (e.g., stormwater, erosion, habitat). Any large-scale homogenous land use should be carefully examined—whether it is rooftops, impervious surface, or solar panels. Such concentrated land uses change the character of the area and alter the natural and historic development pattern of a community.

The attraction of solar facilities to areas near population centers is a response to the same forces that attract other uses—the infrastructure is already there (electrical grid, water and sewer, and roads). One solar facility in a given geographic area may be an acceptable use of the land, but when multiple facilities are attracted to the same geography for the same reasons, this tips the land-use balance toward too much of a single use. The willingness of landowners to cooperate with energy companies is understandable, but that does not automatically translate into good planning for the community. The short- and medium-term gains for individual landowners can have a lasting negative impact on the larger community.

Visual Impacts

The visual impact of utility-scale solar facilities can be significantly minimized with effective screening and buffering, but this is more challenging in historic or scenic landscapes. Solar facilities adjacent to scenic byways or historic corridors may negatively impact the rural aesthetic along these transportation routes. Buffering or screening may also be appropriate along main arterials or any public right-of-way, regardless of special scenic or historic designation.

The location of large solar facilities also needs to account for views from public rights-of-way (Figure 5). Scenic or historic areas should be avoided, while other sites should be effectively screened from view with substantial vegetative or other types of buffers. Berms, for example, can provide a very effective screen, particularly if combined with appropriate vegetation.

Decommissioning

The proper decommissioning and removal of equipment and other improvements when the facility is no longer operational presents significant challenges to localities.

Decommissioning can cost millions in today's dollars. The industry strongly asserts that there is a significant salvage value to the solar arrays, but there may or may not be a market to salvage the equipment when removed. Further, the feasibility of realizing salvage value may depend on who removes the equipment—the operator, the tenant, or the landowner (who may not be the same parties as during construction)—as well as when it is removed.

Providing for adequate security to ensure that financial resources are available to remove the equipment is a significant challenge. Cash escrow is the most reliable security for a locality but is the most expensive for the industry and potentially a financial deal breaker. Insurance bonds or letters of credit seem to be the most acceptable forms of security but can be difficult to enforce as a practical matter. The impact of inflation over decades is difficult to calculate; therefore, the posted financial security to ensure a proper decommissioning should be reeval-

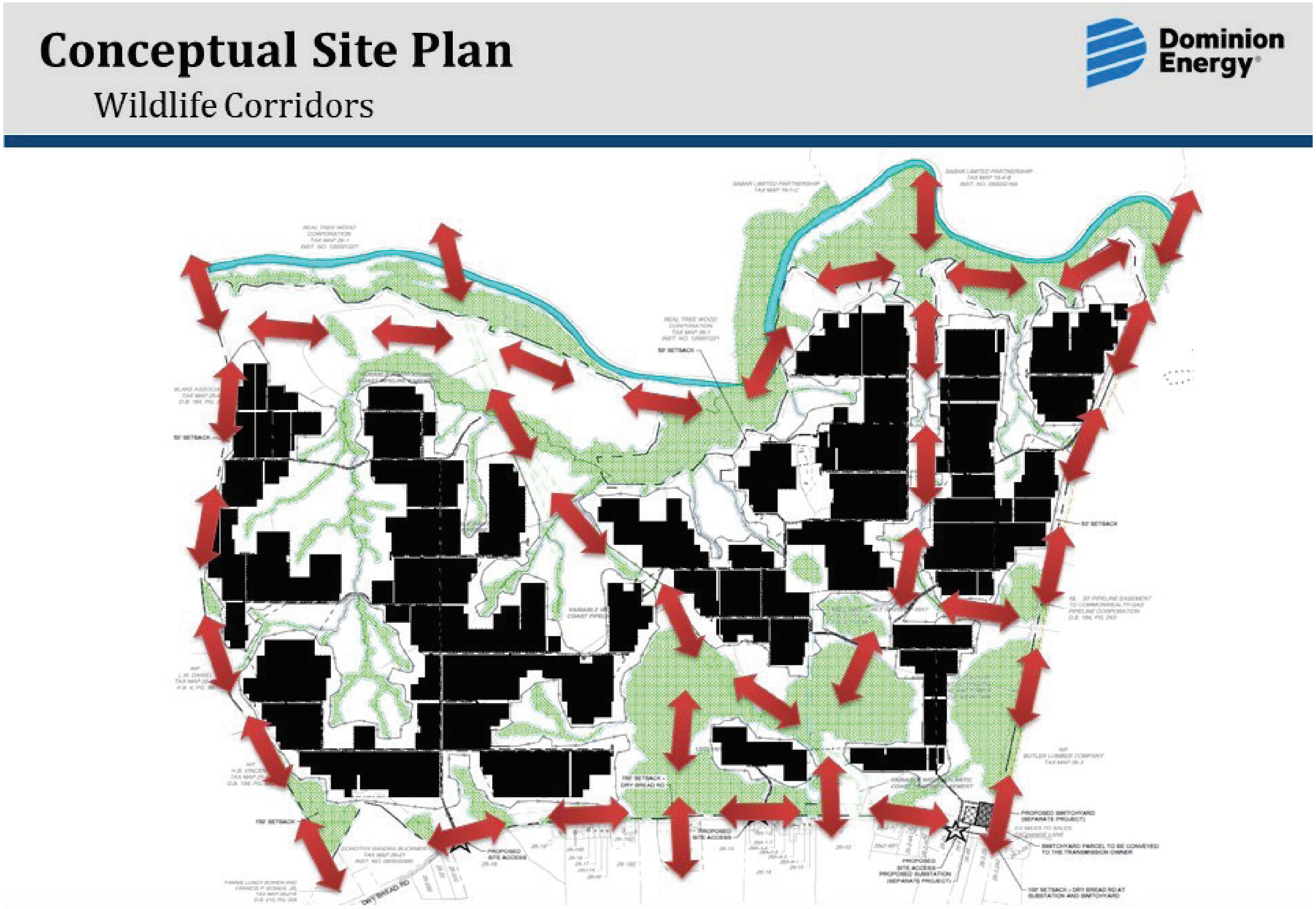


Figure 6. A conceptual site plan for a 1,491-acre utility-scale solar facility showing wildlife corridors throughout the site. Courtesy Dominion Energy.

uated periodically—usually every five years or so. The worst possible outcome for a community (and a farmer or landowner) would be an abandoned utility-scale solar facility with no resources available to pay for its removal.

Additional Solar Facility Impacts

In addition to the land-use impacts previously discussed, there are a number of significant environmental and economic impacts associated with utility-scale solar facilities that should be addressed as part of the land-use application process.

Environmental Impacts

While solar energy is a renewable, green resource, its generation is not without environmental impacts. Though utility-scale solar facilities do not generate the air or water pollution typical of other large-scale fossil-fuel power production facilities, impacts on wildlife habitat and stormwater management can be significant due to the large scale of these uses and the resulting extent of land disturbance. The location of sites, the arrangement of panels within the site, and the ongoing management of the site are important in the mitigation of such impacts.

Wildlife Corridors. In addition to mitigating the visual impact of utility-scale solar facilities, substantial buffers can act as wildlife corridors along project perimeters. The arrangement of panels within a project site is also important to maintain areas conducive to wildlife travel through the site. Existing trees, wetlands, or other vegetation that link open areas should be preserved as wildlife cover. Such sensitivity to the land's environmental features also breaks up the panel bay groups and will make the eventual restoration of the land to its previous state that much easier and more effective. A perimeter fence is a barrier to wildlife movement, while fencing around but not in between solar panel bays creates open areas through which animals can continue to travel (Figure 6).

Stormwater, Erosion, and Sediment Control. The site disturbance required for utility-scale solar facilities is significant due to the size of the facilities and the infrastructure needed to operate them. These projects require the submission of both stormwater (SWP) and erosion/sediment control (ESC) plans to comply with federal and state environmental regulations.

Depending on the site orientation and the panels to be used, significant grading may be required for panel placement, roads, and other support infrastructure. The plan review and submis-

Figure 7. Examples of compliance (left) and noncompliance (right) with erosion and sediment control requirements. Photos courtesy Berkley Group.

sion processes are no different with these facilities than for any other land-disturbing activity. However, such large-scale grading project plans are more complex than those for other uses due primarily to the scale of utility solar. Additionally, the impervious nature of the panels themselves creates stormwater runoff that must be properly controlled, managed, and maintained.

Due to this complexity, it is recommended that an independent third party review all SWP and ESC plans in addition to the normal review procedures. Many review agencies (local, regional, or state) are under-resourced or not familiar with large-scale grading projects or appropriate and effective mitigation measures. It is in a locality's best interest to have the applicant's engineering and site plans reviewed by a licensed third party prior to and in addition to the formal plan review process. Most localities have engineering firms on call that can perform such reviews on behalf of the jurisdiction prior to formal plan review submittal and approval. This extra step, typically paid for by the applicant, helps to ensure the proper design of these environmental protections (Figure 7).

The successful implementation of these plans and ongoing maintenance of the mitigation measures is also critical and should be addressed in each proposal through sufficient performance security requirements and long-term maintenance provisions.

Cultural, Environmental, and Recreational Resources. Every proposed site should undergo an evaluation to identify any architectural, archaeological, or other cultural resources on or near proposed facilities. Additionally, sites located near recreational, historic, or environmental resources should be avoided. Tourism is recognized as a key sector for economic growth in many regions, and any utility-scale solar facilities that might be visible from a scenic byway, historic site, recreational amenity, or similar resources could have negative consequences for those tourist attractions.

Economic Impacts

This *PAS Memo* focuses on the land-use impacts of utility-scale solar facilities, but planners should also be aware of economic considerations surrounding these uses for local governments and communities.

Financial Incentives. Federal and state tax incentives benefit the energy industry at the expense of localities. The initial intent of industry-targeted tax credits was to act as an economic catalyst to encourage the development of green energy. An unintended consequence has been to benefit the solar industry by saving it tax costs at the expense of localities, which don't receive the benefit of the full taxable rate they would normally receive.

Employment. Jobs during construction (and decommissioning) can be numerous, but utility-scale solar facilities have minimal operational requirements otherwise. Very large facilities may employ one or two full-time-equivalent employees. During the construction phase there are typically hundreds of employees who need local housing, food, and entertainment.

Fiscal Impact. The positive fiscal impact to landowners who lease or sell property for utility-scale solar facilities is clear. However, the fiscal impact of utility-scale solar facilities to the community as a whole is less clear and, in the case of many localities, may be negligible compared with their overall budget due to tax credits, low long-term job creation, and other factors.

Property values. The impact of utility-scale solar facilities is typically negligible on neighboring property values. This can be a significant concern of adjacent residents, but negative impacts to property values are rarely demonstrated and are usually directly addressed by applicants as part of their project submittal.

Solar Facilities in Local Policy and Regulatory Documents

The two foundational land-use tools for most communities are their comprehensive (general) plans and zoning ordinances.

These two land-use documents are equally critical in the evaluation of utility-scale solar facilities. A community's plan should discuss green energy, and its zoning ordinance should properly enable and regulate green energy uses.

The Comprehensive Plan

The comprehensive plan establishes the vision for a community and should discuss public facilities and utilities. However, solar facilities are not directly addressed in many comprehensive plans.

If solar energy facilities are desired in a community, they should be discussed in the comprehensive plan in terms of green infrastructure, environment, and economic development goals. Specific direction should be given in terms of policy objectives such as appropriate locations and conditions. If a community does not desire such large-scale land uses because of their impacts on agriculture or forestry or other concerns, then that should be directly addressed in the plan.

Some states, such as Virginia, require a plan review of public facilities—including utility-scale solar facilities—for substantial conformance with the local comprehensive plan (see Code of Virginia §15.2-2232). This typically requires a review by the planning commission of public utility facility proposals, whether publicly or privately owned, to determine if their general or approximate locations, characters, and extents are substantially in accord with the comprehensive plan.

Most comprehensive plans discuss the types of industry desired by the community, the importance of agricultural operations, and any cultural, recreational, historic, or scenic rural landscape features. An emphasis on tourism, job growth, and natural and scenic resource protection may not be consistent with the use pattern associated with utility-scale solar facilities. If a plan is silent on the solar issue, this may act as a barrier to approving this use. Plans should make clear whether utility-scale solar is desired and, if so, under what circumstances.

This plan review process should precede any other land-use application submittal, though it may be performed concurrently with other zoning approvals. Planners and other public officials should keep in mind that even if a facility is found to be substantially in accord with a comprehensive plan, that does not mean the land-use application must be approved. Use permits are discretionary. If a particular application does not sufficiently mitigate the adverse impacts of the proposed land use, then it can and should be denied regardless of its conformance with the comprehensive plan.

Similarly, in Virginia, a utility-scale solar facility receiving use permit approval without a comprehensive plan review may not be in compliance with state code. The permit approval process is a two-step process, with the comprehensive plan review preferably preceding the consideration of a use permit application.

The Zoning Ordinance

While a community's comprehensive plan is its policy guide, the zoning ordinance is the regulatory document that implements that policy. Plans are advisory in nature, although often upheld in court decisions, whereas ordinance regulations are mandatory. In addition to comprehensive plan amendments, the zoning ordinance should specifically set forth the process and requirements necessary for the evaluation of a utility-scale solar application.

In zoning regulations, uses may be permitted either by right (with or without designated performance measures such as use and design standards) or as conditional or special uses, which require discretionary review and approval. Solar facilities generating power for on-site use are typically regulated as by-right uses depending on their size and location.

Utility-scale solar facilities, however, should in most cases be conditionally permitted regardless of the zoning district and are most appropriate on brownfield sites, in remote areas, or in agriculturally zoned areas. This is particularly true for more

The Virginia Experience

The recommendations presented in this *PAS Memo* are derived from research and the author's direct experience with the described planning, ordinance amendment, and application and regulatory processes in the following three Virginia localities, all rural counties in the southern or eastern parts of the state.

Mecklenburg County

When Mecklenburg County began seeing interest in utility-scale solar facilities, the county's long-range plan did not address solar facilities, and the zoning ordinance was based on an inadequate and outdated state model that did not adequately regulate this land use.

The town of Chase City is located near the confluence of several high-voltage utility lines, and all proposed facilities were located near or within the town's corporate limits. The county approved the first utility-scale solar facility application in the jurisdiction without any conditions or much consideration. When the second application for a much larger facility (more than 900 acres) came in soon after, with significant interest from other potential applicants as well, the county commissioned the author's consulting firm, The Berkley Group, to undertake a land-use and industry study regarding utility-scale solar facilities.

As Mecklenburg officials continued with the approval process on the second utility-scale solar facility under existing regulations, they received the results of the industry study and began considering a series of amendments to the comprehensive plan and zoning ordinance. Though county officials were particularly worried about the potential concentration of facilities around Chase City, town officials expressed formal support for the proposed land use. Other Mecklenburg communities expressed more concern and wanted the facilities to be located a significant distance away from their corporate boundaries. These dis-

The Virginia Experience (continued)

cussions led to standards limiting the concentration of facilities, encouraging proximity to the electrical grid, and establishing distances from corporate boundaries where future solar facilities could not be located.

Since the adoption of the new regulations, numerous other utility-scale solar applications have been submitted and while some have been denied, most have been approved. Solar industry representatives' concerns that the new regulations were an attempt to prevent this land use have therefore not been realized; these are simply the land-use tools that public officials wanted and needed to appropriately evaluate solar facility applications. Many of the examples and best practices recommended in this article, including the model language provided at the end of the article, are a result of the utility-scale solar study commissioned by the county (Berkley Group 2017) and the subsequent policies and regulations it adopted.

Sussex County

Sussex County is located east and north of Mecklenburg, and the interest in utility-scale solar projects there has been no less immediate or profound. The announcement of the new Amazon headquarters in Arlington, Virginia, along with the company's interest in offsetting its operational energy use with green energy sources furthered interest in this rural county more than 100 miles south of Arlington.

As in Mecklenburg County, local regulations did not address utility-scale solar uses, so public officials asked for assistance from The Berkley Group to develop policies and regulations appropriate for their community. Sussex County officials outlined an aggressive timeline for considering new regulations regarding solar facilities and, within one month of initiation, swiftly adopted amended regulations for solar energy facilities.

The same metrics and policy issues examined and adopted for Mecklenburg County were used for the initial discussion in Sussex at a joint work session between the board of supervisors (the governing body) and the planning commission. Public officials tailored the proposed standards and regulations to the county context based on geography, cultural priorities, and other concerns. They then set a joint public hearing for their next scheduled meeting to solicit public comment.

Under Virginia law, land-use matters may be considered at a joint public hearing with a recommendation from the planning commission going to the governing body and that body taking action thereafter. This is not a typical or recommended practice for local governments since it tends to limit debate, transparency, and good governance, but due to the intense interest from the solar industry, coupled with the lack of land-use regulations addressing the proposed utility-scale solar uses, county officials utilized that expedited process.

No citizens and only two industry officials spoke at the public hearing, and after two hours of questions, discussion, and some negotiation of proposed standards, the new regulations were adopted the same evening.

Since the new regulations have been put into place, no new solar applications have been received, but informal discussions with public officials and staff suggest that interest from the industry remains strong.

Greensville County

Greensville County, like Mecklenburg, lies on the Virginia-North Carolina boundary. The county has processed four solar energy applications to date (three were approved and one was denied) and continues to process additional applications. Concurrently, the county is in the process of evaluating its land-use policies and regulations, which were amended in late 2016 at the behest of solar energy interests.

The reality of the land-use approval process has proved more challenging than the theory of the facilities when considered a few years ago. As with other localities experiencing interest from the solar energy industry, the issues of scale, concentration, buffers/setbacks, and other land-use considerations have been debated at each public hearing for each application. Neighbors and families have been divided, and lifelong relationships have been severed or strained. The board of supervisors has found it difficult in the face of their friends, neighbors, and existing corporate citizens to deny applications that otherwise might not have been approved.

County officials have agreed that they do want to amend their existing policies and regulations to be more specific and less open to interpretation by applicants and citizens. One of their primary challenges has been dedicating the time to discuss proposed changes to their comprehensive plan and zoning ordinance. A joint work session between the board of supervisors and planning commission is being scheduled and should lead to subsequent public hearings and actions by those respective bodies to enact new regulations for future utility-scale solar applicants.

populated areas due to the more compact nature of land uses. There are, however, areas throughout the country where utility-scale solar might be permitted by right under strict design standards that are compatible with community objectives.

To better mitigate the potential adverse impacts of utility-scale solar facilities, required application documents should include the following:

- Concept plan
- Site plan
- Construction plan
- Maintenance plan
- Erosion and sediment control and stormwater plans

Performance measures should address these issues:

- Setbacks and screening
- Plan review process
- Construction/deconstruction mitigation and associated financial securities
- Signage
- Nuisance issues (glare, noise)

The model language provided at the end of this *PAS Memo* outlines specific recommendations regarding comprehensive plan and zoning ordinance amendments, the application process, and conditions for consideration during the permitting process.

Action Steps for Planners

There are four primary actions that planners can pursue with their planning commissions and governing bodies to ensure that their communities are ready for utility-scale solar.

Review and Amend the Plan

The first, and most important, step from a planning viewpoint is to review and amend the comprehensive plan to align with how a community wants to regulate utility-scale solar uses. Some communities don't want them at all, and many cities and towns don't have the land for them. Larger municipalities and counties around the country may have to deal with this land use at some point, if they haven't already. Local governments should get their planning houses in order by amending plans before the land-use applications arrive.

Review and Amend Land-Use Ordinances

Once the plan is updated, the next step is to review and amend land-use ordinances (namely the zoning ordinance) accordingly. These ordinances are vital land-use tools that need to be up to date and on point to effectively regulate large and complex solar facilities. If local governments do not create regulations for utility-scale solar facilities, applications for these projects will occupy excessive staff time, energy, and talents, resulting in much less efficient and more open-ended results.

Evaluate Each Application Based on Its Own Merits

This should go without saying, but it is important, particularly from a legal perspective, that each project application is evaluated based on its own merits. All planners have probably seen a project denied due to the politics at play with regard to other projects: "That one shouldn't have been approved so we're going to deny this one." "The next one is better so this one needs to be denied."

The focus of each application should be on the potential adverse impacts of the project on the community and what can be done successfully to mitigate those impacts. Whether the applicant is a public utility or a private company, the issues and complexities of the project are the same. The bottom line should never be who the applicant is; rather, it should be whether the project's adverse impacts can be properly mitigated so that the impact to the community is positive.

Learn From Others

Mecklenburg County's revised solar energy policies and regulations began with emails and phone calls to planning colleagues to see how they had handled utility-scale solar projects in their jurisdictions. The primary resources used were internet research, other planners, and old-fashioned planner ingenuity and creativity.

While it is the author's hope and intent that this article offers valuable information on this topic, nothing beats the tried and true formula of "learn from and lean on your colleagues."

Conclusion

The solar energy market is having major impacts on land use across the country, and federal and state tax incentives have contributed to a flood of applications in recent years. While the benefits of clean energy are often touted, the impacts of utility-scale solar facilities on a community can be significant. Applicants often say that a particular project will "only" take up some small percentage of agricultural, forestry, or other land-use category—but the impact of these uses extends beyond simply replacing an existing (or future) land use. Fiscal benefit to a community is also often cited as an incentive, but this alone is not a compelling reason to approve (or disapprove) a land-use application.

The scale and duration of utility-scale solar facilities complicates everything from the land disturbance permitting process through surety requirements. If not done properly, these uses can change the character of an area, altering the future of communities for generations.

Local officials need to weigh these land-use decisions within the context of their comprehensive plan and carefully consider each individual application in terms of the impact that it will have in that area of the community, not only by itself but also if combined with additional sites. The concentration of solar facilities is a major consideration in addition to their individual locations. A solar facility located by itself in a rural area, close to major transmission lines, not prominently visible from public rights-of-way or adjacent properties, and not located in growth areas, on prime farmland, or near cultural, historic, or recreational sites may be an acceptable land use with a beneficial impact on the community.

Properly evaluating and, to the extent possible, mitigating the impacts of these facilities by carefully controlling their location, scale, size, and other site-specific impacts is key to ensuring that utility-scale solar facilities can help meet broader sustainability goals without compromising a community's vision and land-use future.

About the Author

Darren K. Coffey, AICP, is co-owner and chief executive officer of The Berkley Group, a local government consulting firm in Virginia. Prior to forming The Berkley Group, he worked as a land-use planner for various localities in North Carolina and Virginia. The Berkley Group began working on utility-scale solar planning issues in early 2017 as that industry began to take off in Virginia. Coffey has bachelor of science degrees in economics and geography from James Madison University and a master of arts in geography from Rutgers University, and he attained AICP certification in 2000. He may be reached at darren@bgllc.net.

The author would like to thank Denise Nelson, PE, CFM, ENV SP, Berkley Group Environmental Engineer, for her contributions to this article.

References and Resources

Berkley Group. 2017. "Solar Facility Impacts Analysis: An Examination of Land Use Impacts." Unpublished study. Mecklenburg County, Virginia.

Climate Group and CDP. 2019. "RE100."

Hawken, Paul. 2017. *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*. New York: Penguin Books.

Solar Energy Industry Association (SEIA). 2019. "U.S. Solar Market Insight." June 18.

U.S. Department of Energy (U.S. DOE). n.d. "Solar Energy in the United States." Office of Energy Efficiency and Renewable Energy.

Virginia, Commonwealth of. 2018. 2018 Virginia Energy Plan. Office of the Secretary of Commerce and Trade, Department of Mines, Minerals and Energy.

PAS Memo is a bimonthly online publication of APA's Planning Advisory Service. Joel Albizo, FASAE, CAE, Chief Executive Officer; Petra Hurtado, Research Director; Ann F. Dillemuth, AICP, Editor. Learn more at planning.org/pas.

 PAS Memo (ISSN 2169-1908) is published by the American Planning Association, which has offices at 205 N. Michigan Ave., Suite 1200, Chicago, IL 60601-5927, and 1030 15th St. NW, Suite 750 West, Washington, DC 20005-1503; planning.org.

American Planning Association
Planning Advisory Service
Creating Great Communities for All

September/October 2019

PAS MEMO ADDENDUM

Specific Planning and Zoning Recommendations for Utility-Scale Solar

This guidance and sample ordinance language for utility-scale solar facilities is drawn from actual comprehensive plan and zoning ordinance amendments as well as conditional (special) use permit conditions. These examples are from Virginia and should be tailored to localities within the context of each state's enabling legislation regarding land use.

THE COMPREHENSIVE (GENERAL) PLAN

The following topics should be addressed for comprehensive plan amendments:

- Identification of major electrical facility infrastructure (i.e., transmission lines, transfer stations, generation facilities, etc.)
- Identification of growth area boundaries around each city, town, or appropriate population center
- Additional public review and comment opportunities for land-use applications within a growth area boundary, within a specified distance from an identified growth area boundary, or within a specified distance from identified population centers (e.g., city or town limits)
- Recommended parameters for utility-scale solar facilities, such as:
  - maximum acreage or density (e.g., not more than two facilities within a two-mile radius) to mitigate the impacts related to the scale of these facilities
  - maximum percent usage (i.e., "under panel" or impervious surface) of assembled property to mitigate impacts to habitat, soil erosion, and stormwater runoff
  - location adjacent or close to existing electric transmission lines
  - location outside of growth areas or town boundary or a specified distance from an identified growth boundary
  - location on brownfields or near existing industrial uses (but not within growth boundaries)
  - avoidance of or minimization of impact to prime farmland as defined by the USDA
  - avoidance of or minimization of impact to the viewshed of any scenic, cultural, or recreational resources (i.e., large solar facilities may not be seen from surrounding points that are in line-of-sight with a resource location)
- Identification of general conditions to mitigate negative effects, including the following:
  - Concept plan compliance
  - Buffers and screening (e.g., berms, vegetation, etc.)
  - Third-party plan review (for erosion and sediment controls, stormwater management, grading)
  - Setbacks
  - Landscaping maintenance
  - Decommissioning plan and security

THE ZONING ORDINANCE

In addition to, or separate from, comprehensive plan amendments, the zoning ordinance should be amended to more specifically set forth the process and requirements necessary for a thorough land-use evaluation of an application.

Recommended Application Process

Pre-Application Meeting

The process of requiring applicants to meet with staff prior to the submission of an application often results in a better, more complete application and a smoother process once an application is submitted. This meeting allows the potential applicant and staff to sit down to discuss the location, scale, and nature of the proposed use and what will be expected during that process. The pre-application meeting is one of the most effective tools planners can use to ensure a more efficient, substantive process.

Comprehensive Plan Review

As discussed in the article, a comprehensive plan review for public utility facilities, if required, can occur prior to or as part of the land-use application process. Any application not including the review would be subject to such review in compliance if required by state code. If the plan review is not done concurrently with the land-use application, then it should be conducted prior to the receipt of the application.

An application not substantially in accord with the comprehensive plan should not be recommended for approval, regardless of the conditions placed on the use. Depending on the location, scale, and extent of the project, it is difficult to sufficiently mitigate the adverse impacts of a project that does not conform with the plan.

Land-Use Application

If the comprehensive plan review is completed and the project is found to be in compliance with the comprehensive plan, then the use permit process can proceed once a complete application is submitted. Application completion consists of the submission of all requirements set forth in the zoning ordinance and is at the discretion of the zoning administrator if there is any question as to what is required or when it is required.

Applications should contain all required elements at the time of submittal and no components should be outstanding at the time of submittal.

Sample Ordinance Language

The following sample ordinance language addresses requirements for applications, public notice, development standards, decommissioning, site plan review, and other process elements.

1. Application requirements. Each applicant requesting a use permit shall submit the following:

   a. A complete application form.
   b. Documents demonstrating the ownership of the subject parcel(s).
   c. Proof that the applicant has authorization to act upon the owner's behalf.
   d. Identification of the intended utility company who will interconnect to the facility.
   e. List of all adjacent property owners, their tax map numbers, and addresses.
   f. A description of the current use and physical characteristics of the subject parcels.
   g. A description of the existing uses of adjacent properties and the identification of any solar facilities—existing or proposed—within a five-mile radius of the proposed location.
   h. Aerial imagery which shows the proposed location of the solar energy facility, fenced areas and driveways with the closest distance to all adjacent property lines, and nearby dwellings, along with main points of ingress/egress.
   i. Concept plan.
      The facility shall be constructed and operated in substantial compliance with the approved concept plan, with allowances for changes required by any federal or state agency. The project shall be limited to the phases and conditions set forth in the concept plan that constitutes part of this application, notwithstanding any other state or federal requirements. No additional phasing or reduction in facility size shall be permitted, and no extensions beyond the initial period shall be granted without amending the use permit. The concept plan shall include the subject parcels; the proposed location of the solar panels and related facilities; the location of proposed fencing, driveways, internal roads, and structures; the closest distance to adjacent property lines and dwellings; the location of proposed setbacks; the location and nature of proposed buffers, including vegetative and constructed buffers and berms; the location of points of ingress/egress; any proposed construction phases.
   j. A detailed decommissioning plan (see item 5 below).
   k. A reliable and detailed estimate of the costs of decommissioning, including provisions for inflation (see item 5 below).
   l. A proposed method of providing appropriate escrow, surety, or security for the cost of the decommissioning plan (see item 5 below).
   m. Traffic study modelling the construction and decommissioning processes. Staff will review the study in cooperation with the state department of transportation or other official transportation authority.
   n. An estimated construction schedule.
   o. [x number of] hard copy sets (11″× 17″ or larger), one reduced copy (8½″× 11″), and one electronic copy of site plans, including elevations and landscape plans as required. Site plans shall meet the requirements of this ordinance.
   p. The locality may require additional information deemed necessary to assess compliance with this section based on the specific characteristics of the property or other project elements as determined on a case by case basis.
   q. Application fee to cover any additional review costs, advertising, or other required staff time.

2. Public notice.
   a. Use permits shall follow the public notice requirements as set forth in the zoning ordinance or by state code as applicable.
   b. Neighborhood meeting: A public meeting shall be held prior to the public hearing with the planning commission to give the community an opportunity to hear from the applicant and ask questions regarding the proposed project.
      i The applicant shall inform the zoning administrator and adjacent property owners in writing of the date, time, and location of the meeting, at least seven but

no more than 14 days in advance of the meeting date.

- ii The date, time, and location of the meeting shall be advertised in the newspaper of record by the applicant, at least seven but no more than 14 days in advance of the meeting date.
- iii The meeting shall be held within the community, at a location open to the general public with adequate parking and seating facilities which may accommodate persons with disabilities.
- iv The meeting shall give members of the public the opportunity to review application materials, ask questions of the applicant, and make comments regarding the proposal.
- v The applicant shall provide to the zoning administrator a summary of any input received from members of the public at the meeting.

3. Minimum development standards.
   a. No solar facility shall be located within a reasonable radius of an existing or permitted solar facility, airport, or municipal boundary.
   b. The minimum setback from property lines shall be a reasonable distance (e.g., at least 100 feet) and correlated with the buffer requirement.
   c. The facilities, including fencing, shall be significantly screened from the ground-level view of adjacent properties by a buffer zone of a reasonable distance extending from the property line that shall be landscaped with plant materials consisting of an evergreen and deciduous mix (as approved by staff), except to the extent that existing vegetation or natural landforms on the site provide such screening as determined by the zoning administrator. In the event that existing vegetation or landforms providing the screening are disturbed, new plantings shall be provided which accomplish the same. Opaque architectural fencing may be used to supplement other screening methods but shall not be the primary method.
   d. The design of support buildings and related structures shall use materials, colors, textures, screening, and landscaping that will blend the facilities to the natural setting and surrounding structures.
   e. Maximum height of primary structures and accessory buildings shall be a reasonable height as measured from the finished grade at the base of the structure to its highest point, including appurtenances (e.g., 15 feet). The board of supervisors may approve a greater height based upon the demonstration of a significant need where the impacts of increased height are mitigated.
   f. All solar facilities must meet or exceed the standards and regulations of the Federal Aviation Administration (FAA), State Corporation Commission (SCC) or equivalent, and any other agency of the local, state, or federal government with the authority to regulate such facilities that are in force at the time of the application.
   g. To ensure the structural integrity of the solar facility, the owner shall ensure that it is designed and maintained in compliance with standards contained in applicable local, state, and federal building codes and regulations that were in force at the time of the permit approval.
   h. The facilities shall be enclosed by security fencing on the interior of the buffer area (not to be seen by other properties) of a reasonable height. A performance bond reflecting the costs of anticipated fence maintenance shall be posted and maintained. Failure to maintain the security fencing shall result in revocation of the use permit and the facility's decommissioning.
   i. Ground cover on the site shall be native vegetation and maintained in accordance with established performance measures or permit conditions.
   j. Lighting shall use fixtures as approved by the municipality to minimize off-site glare and shall be the minimum necessary for safety and security purposes. Any exceptions shall be enumerated on the concept plan and approved by the zoning administrator.
   k. No facility shall produce glare that would constitute a nuisance to the public.
   l. Any equipment or situations on the project site that are determined to be unsafe must be corrected within 30 days of citation of the unsafe condition.
   m. Any other condition added by the planning commission or governing body as part of a permit approval.

4. Coordination of local emergency services. Applicants for new solar energy facilities shall coordinate with emergency services staff to provide materials, education and/or training to the departments serving the property with emergency services in how to safely respond to on-site emergencies.

5. Decommissioning. The following requirements shall be met:
   a. Utility-scale solar facilities which have reached the end of their useful life or have not been in active and continuous service for a reasonable period of time shall be removed at the owner's or operator's expense, except if the project is being repowered or a force majeure event has or is occurring requiring longer repairs; however, the municipality may require evidentiary support that a longer repair period is necessary.
   b. Decommissioning shall include removal of all solar electric systems, buildings, cabling, electrical components, security barriers, roads, foundations, pilings, and any other associated facilities, so that any agricultural ground upon which the facility or system was located is again tillable and suitable for agricultural uses. The site shall be graded and reseeded to restore it to as natural a condition as possible, unless the land owner requests in writing that the access roads or other land surface areas not be restored, and this request is approved by the governing body (other conditions might be more beneficial or desirable at that time).
   c. The site shall be regraded and reseeded to as natural condition as possible within a reasonable timeframe after equipment removal.

d. The owner or operator shall notify the zoning administrator by certified mail, return receipt requested, of the proposed date of discontinued operations and plans for removal.
e. Decommissioning shall be performed in compliance with the approved decommissioning plan. The governing body may approve any appropriate amendments to or modifications of the decommissioning plan.
f. Hazardous material from the property shall be disposed of in accordance with federal and state law.
g. The applicant shall provide a reliable and detailed cost estimate for the decommissioning of the facility prepared by a professional engineer or contractor who has expertise in the removal of solar facilities. The decommissioning cost estimate shall explicitly detail the cost and shall include a mechanism for calculating increased removal costs due to inflation and without any reduction for salvage value. This cost estimate shall be recalculated every five (5) years and the surety shall be updated in kind.
h. The decommissioning cost shall be guaranteed by cash escrow at a federally insured financial institution approved by the municipality before any building permits are issued. The governing body may approve alternative methods of surety or security, such as a performance bond, letter of credit, or other surety approved by the municipality, to secure the financial ability of the owner or operator to decommission the facility.
i. If the owner or operator of the solar facility fails to remove the installation in accordance with the requirements of this permit or within the proposed date of decommissioning, the municipality may collect the surety and staff or a hired third party may enter the property to physically remove the installation.

6. Site plan requirements. In addition to the site plan requirements set forth in the zoning ordinance, a construction management plan shall be submitted that includes:
    - Traffic control plan (subject to state and local approval, as appropriate)
    - Delivery and parking areas
    - Delivery routes
    - Permits (state/local)

    Additionally, a construction/deconstruction mitigation plan shall also be submitted including:
    - Hours of operation
    - Noise mitigation (e.g., construction hours)
    - Smoke and burn mitigation (if necessary)
    - Dust mitigation
    - Road monitoring and maintenance

7. The building permit must be obtained within [18 months] of obtaining the use permit and commencement of the operation shall begin within [one year] from building permit issuance.

8. All solar panels and devices are considered primary structures and subject to the requirements for such, along with the established setbacks and other requirements for solar facilities.

9. Site maintenance.
    a. Native grasses shall be used to stabilize the site for the duration of the facility's use.
    b. Weed control or mowing shall be performed routinely and a performance bond reflecting the costs of such maintenance for a period of [six (6) months] shall be posted and maintained. Failure to maintain the site may result in revocation of the use permit and the facility's decommissioning.
    c. Anti-reflection coatings. Exterior surfaces of the collectors and related equipment shall have a nonreflective finish and solar panels shall be designed and installed to limit glare to a degree that no after image would occur towards vehicular traffic and any adjacent building.
    d. Repair of panels. Panels shall be repaired or replaced when either nonfunctional or in visible disrepair.

10. Signage shall identify the facility owner, provide a 24-hour emergency contact phone number, and conform to the requirements set forth in the Zoning Ordinance.

11. At all times, the solar facility shall comply with any local noise ordinance.

12. The solar facility shall not obtain a building permit until evidence is given to the municipality that an electric utility company has a signed interconnection agreement with the permittee.

13. All documentation submitted by the applicant in support of this permit request becomes a part of the conditions. Conditions imposed by the governing body shall control over any inconsistent provision in any documentation provided by the applicant.

14. If any one or more of the conditions is declared void for any reason, such decision shall not affect the remaining portion of the permit, which shall remain in full force and effect, and for this purpose, the provisions of this are here by declared to be severable.

15. Any infraction of the above-mentioned conditions, or any zoning ordinance regulations, may lead to a stop order and revocation of the permit.

16. The administrator/manager, building official, or zoning administrator, or any other parties designated by those public officials, shall be allowed to enter the property at any reasonable time, and with proper notice, to check for compliance with the provisions of this permit.

EXAMPLE OF RECOMMENDED USE PERMIT CONDITIONS (In Virginia: conditional uses, special uses, special exceptions)

***Conditions** ([approved/revised] at the Planning Commission meeting on [date])*

If the Board determines that the application furthers the comprehensive plan's goals and objectives and that it meets the criteria set forth in the zoning ordinance, then the Planning Commission recommends the following conditions to mitigate the adverse effects of this utility-scale solar generation facility with any Board recommendation for permit approval.

1. The Applicant will develop the Solar Facility in substantial accord with the Conceptual Site Plan dated ______________________ included with the application as determined by the Zoning Administrator. Significant deviations or additions, including any enclosed building structures, to the Site Plan will require review and approval by the Planning Commission and Board of Supervisors.

2. Site Plan Requirements. In addition to all State site plan requirements and site plan requirements of the Zoning Administrator, the Applicant shall provide the following plans for review and approval for the Solar Facility prior to the issuance of a building permit:
   a. *Construction Management Plan*. The Applicant shall prepare a Construction Management Plan for each applicable site plan for the Solar Facility, and each plan shall address the following:
      i. Traffic control methods (in coordination with the Department of Transportation prior to initiation of construction), including lane closures, signage, and flagging procedures.
      ii. Site access planning directing employee and delivery traffic to minimize conflicts with local traffic.
      iii. Fencing. The Applicant shall install temporary security fencing prior to the commencement of construction activities occurring on the Solar Facility.
      iv. Lighting. During construction of the Solar Facility, any temporary construction lighting shall be positioned downward, inward, and shielded to eliminate glare from all adjacent properties. Emergency and safety lighting shall be exempt from this construction lighting condition.
   b. *Construction Mitigation Plan*. The Applicant shall prepare a Construction Mitigation Plan for each applicable site plan for the Solar Facility to the satisfaction of the Zoning Administrator. Each plan shall address, at a minimum, the effective mitigation of dust, burning operations, hours of construction activity, access and road improvements, and handling of general construction complaints.
   c. *Grading plan*. The Solar Facility shall be constructed in compliance with the County-approved grading plan as determined and approved by the Zoning Administrator or his designee prior to the commencement of any construction activities and a bond or other security will be posted for the grading operations. The grading plan shall:
      i. Clearly show existing and proposed contours;
      ii. Note the locations and amount of topsoil to be removed (if any) and the percent of the site to be graded;
      iii. Limit grading to the greatest extent practicable by avoiding steep slopes and laying out arrays parallel to landforms;
      iv. Require an earthwork balance to be achieved on-site with no import or export of soil;
      v. Require topsoil to first be stripped and stockpiled on-site to be used to increase the fertility of areas intended to be seeded in areas proposed to be permanent access roads which will receive gravel or in any areas where more than a few inches of cut are required;
      vi. Take advantage of natural flow patterns in drainage design and keep the amount of impervious surface as low as possible to reduce stormwater storage needs.
   d. *Erosion and Sediment Control Plan*. The County will have a third-party review with corrections completed prior to submittal for Department of Environmental Quality (DEQ) review and approval. The owner or operator shall construct, maintain, and operate the project in compliance with the approved plan. An E&S bond (or other security) will be posted for the construction portion of the project.
   e. *Stormwater Management Plan*. The County will have a third-party review with corrections completed prior to submittal for DEQ review and approval. The owner or operator shall construct, maintain, and operate the project in compliance with the approved plan. A stormwater control bond (or other security) will be posted for the project for both construction and post construction as applicable and determined by the Zoning Administrator.
   f. *Solar Facility Screening and Vegetation Plan*. The owner or operator shall construct, maintain, and operate the facility in compliance with the approved plan. A separate security shall be posted for the ongoing maintenance of the project's vegetative buffers in an amount deemed sufficient by the Zoning Administrator.
   g. The Applicant will compensate the County in obtaining an independent third-party review of any site plans or construction plans or part thereof.
   h. The design, installation, maintenance, and repair of the Solar Facility shall be in accordance with the most current National Electrical Code (NFPA 70) available (2017 version or later as applicable).

3. Operations.
   a. *Permanent Security Fence*. The Applicant shall install a permanent security fence, consisting of chain link, 2-inch square mesh, 6 feet in height, surmounted by three strands of barbed wire, around the Solar Facility prior to the commencement of operations of the Solar Facility.

Failure to maintain the fence in a good and functional condition will result in revocation of the permit.

b. *Lighting*. Any on-site lighting provided for the operational phase of the Solar Facility shall be dark-sky compliant, shielded away from adjacent properties, and positioned downward to minimize light spillage onto adjacent properties.

c. *Noise*. Daytime noise will be under 67 dBA during the day with no noise emissions at night.

d. *Ingress/Egress*. Permanent access roads and parking areas will be stabilized with gravel, asphalt, or concrete to minimize dust and impacts to adjacent properties.

4. Buffers.
   a. *Setbacks*.
      i. A minimum 150-foot setback, which includes a 50-foot planted buffer as described below, shall be maintained from a principal Solar Facility structure to the street line (edge of right-of-way) where the Property abuts any public rights-of-way.
      ii. A minimum 150-foot setback, which includes a 50-foot planted buffer as described below, shall be maintained from a principal Solar Facility structure to any adjoining property line which is a perimeter boundary line for the project area.
   b. *Screening*. A minimum 50-foot vegetative buffer (consisting of existing trees and vegetation) shall be maintained. If there is no existing vegetation or if the existing vegetation is inadequate to serve as a buffer as determined by the Zoning Administrator, a triple row of trees and shrubs will be planted on approximately 10-foot centers in the 25 feet immediately adjacent to the security fence. New plantings of trees and shrubs shall be approximately 6 feet in height at time of planting. In addition, pine seedlings will be installed in the remaining 25 feet of the 50-foot buffer. Ancillary project facilities may be included in the buffer as described in the application where such facilities do not interfere with the effectiveness of the buffer as determined by the Zoning Administrator.
   c. *Wildlife corridors*. The Applicant shall identify an access corridor for wildlife to navigate through the Solar Facility. The proposed wildlife corridor shall be shown on the site plan submitted to the County. Areas between fencing shall be kept open to allow for the movement of migratory animals and other wildlife.

5. Height of Structures. Solar facility structures shall not exceed 15 feet, however, towers constructed for electrical lines may exceed the maximum permitted height as provided in the zoning district regulations, provided that no structure shall exceed the height of 25 feet above ground level, unless required by applicable code to interconnect into existing electric infrastructure or necessitated by applicable code to cross certain structures (e.g. pipelines).

6. Inspections. The Applicant will allow designated County representatives or employees access to the facility at any time for inspection purposes as set forth in their application.

7. Training. The Applicant shall arrange a training session with the Fire Department to familiarize personnel with issues unique to a solar facility before operations begin.

8. Compliance. The Solar Facility shall be designed, constructed, and tested to meet relevant local, state, and federal standards as applicable.

9. Decommissioning.
   a. *Decommissioning Plan*. The Applicant shall submit a decommissioning plan to the County for approval in conjunction with the building permit. The purpose of the decommissioning plan is to specify the procedure by which the Applicant or its successor would remove the Solar Facility after the end of its useful life and to restore the property for agricultural uses.
   b. *Decommissioning Cost Estimate*. The decommissioning plan shall include a decommissioning cost estimate prepared by a State licensed professional engineer.
      i. The cost estimate shall provide the gross estimated cost to decommission the Solar Facility in accordance with the decommissioning plan and these conditions. The decommissioning cost estimate shall not include any estimates or offsets for the resale or salvage values of the Solar Facility equipment and materials.
      ii. The Applicant, or its successor, shall reimburse the County for an independent review and analysis by a licensed engineer of the initial decommissioning cost estimate.
      iii. The Applicant, or its successor, will update the decommissioning cost estimate every 5 years and reimburse the County for an independent review and analysis by a licensed engineer of each decommissioning cost estimate revision.
   c. *Security*.
      i. Prior to the County's approval of the building permit, the Applicant shall provide decommissioning security in one of the two following alternatives:
         1. Letter of Credit for Full Decommissioning Cost: A letter of credit issued by a financial institution that has (i) a credit Rating from one or both of S&P and Moody's of at least A from S&P or A2 from Moody's and (ii) a capital surplus of at least $10,000,000,000; or (iii) other credit rating and capitalization reasonably acceptable to the County, in the full amount of the decommissioning estimate; or
         2. Tiered Security:
            a. 10 percent of the decommissioning cost estimate to be deposited in a cash escrow at a financial institution reasonably acceptable to the County; and
            b. 10 percent of the decommissioning cost estimate in the form of a letter of credit issued by

a financial institution that has (i) a credit rating from one or both of S&P and Moody's of at least A from S&P or A2 from Moody's and (ii) a capital surplus of at least $10,000,000,000, or (iii) other credit rating and capitalization reasonably acceptable to the County, with the amount of the letter of credit increasing by an additional 10 percent each year in years 2–9 after commencement of operation of the Solar Facility; and

c. The Owner, not the Applicant, will provide its guaranty of the decommissioning obligations. The guaranty will be in a form reasonably acceptable to the County. The Owner, or its successor, should have a minimum credit rating of (i) Baa3 or higher by Moody's or (ii) BBB- or higher by S&P; and

d. In the tenth year after operation, the Applicant will have increased the value of the letter of credit to 100 percent of the decommissioning cost estimate. At such time, the Applicant may be entitled to a return of the 10 percent cash escrow.

ii. Upon the receipt of the first revised decommissioning cost estimate (following the 5th anniversary), any increase or decrease in the decommissioning security shall be funded by the Applicant or refunded to Applicant (if permissible by the form of security) within 90 days and will be similarly trued up for every subsequent five-year updated decommissioning cost estimate.

iii. The security must be received prior to the approval of the building permit and must stay in force for the duration of the life span of the Solar Facility and until all decommissioning is completed. If the County receives notice or reasonably believes that any form of security has been revoked or the County receives notice that any security may be revoked, the County may revoke the special use permit and shall be entitled to take all action to obtain the rights to the form of security.

d. *Applicant/Property Owner Obligation*. Within 6 months after the cessation of use of the Solar Facility for electrical power generation or transmission, the Applicant or its successor, at its sole cost and expense, shall decommission the Solar Facility in accordance with the decommissioning plan approved by the County. If the Applicant or its successor fails to decommission the Solar Facility within 6 months, the property owners shall commence decommissioning activities in accordance with the decommissioning plan. Following the completion of decommissioning of the entire Solar Facility arising out of a default by the Applicant or its successor, any remaining security funds held by the County shall be distributed to the property owners in a proportion of the security funds and the property owner's acreage ownership of the Solar Facility.

e. *Applicant/Property Owner Default; Decommissioning by the County*.

i. If the Applicant, its successor, or the property owners fail to decommission the Solar Facility within 6 months, the County shall have the right, but not the obligation, to commence decommissioning activities and shall have access to the property, access to the full amount of the decommissioning security, and the rights to the Solar Facility equipment and materials on the property.

ii. If applicable, any excess decommissioning security funds shall be returned to the current owner of the property after the County has completed the decommissioning activities.

iii. Prior to the issuance of any permits, the Applicant and the property owners shall deliver a legal instrument to the County granting the County (1) the right to access the property, and (2) an interest in the Solar Facility equipment and materials to complete the decommissioning upon the Applicant's and property owner's default. Such instrument(s) shall bind the Applicant and property owners and their successors, heirs, and assigns. Nothing herein shall limit other rights or remedies that may be available to the County to enforce the obligations of the Applicant, including under the County's zoning powers.

f. *Equipment/Building Removal.* All physical improvements, materials, and equipment related to solar energy generation, both surface and subsurface components, shall be removed in their entirety. The soil grade will also be restored following disturbance caused in the removal process. Perimeter fencing will be removed and recycled or reused. Where the current or future landowner prefers to retain the fencing, these portions of fence will be left in place.

g. *Infrastructure Removal.* All access roads will be removed, including any geotextile material beneath the roads and granular material. The exception to removal of the access roads and associated culverts or their related material would be upon written request from the current or future landowner to leave all or a portion of these facilities in place for use by that landowner. Access roads will be removed within areas that were previously used for agricultural purposes and topsoil will be redistributed to provide substantially similar growing media as was present within the areas prior to site disturbance.

h. *Partial Decommissioning*. If decommissioning is triggered for a portion, but not the entire Solar Facility, then the Applicant or its successor will commence and complete decommissioning, in accordance with the decommissioning plan, for the applicable portion of the Solar Facility; the remaining portion of the Solar Facility would continue to be subject to the decommissioning plan. Any reference to decommissioning the Solar Facility shall include the obligation to decommission all or a portion of the Solar Facility whichever is applicable with respect to a particular situation.

10. Power Purchase Agreement. At the time of the Applicant's site plan submission, the Applicant shall have executed a power purchase agreement with a third-party providing for the sale of a minimum of 80% of the Solar Facility's anticipated generation capacity for not less than 10 years from commencement of operation. Upon the County's request, the Applicant shall provide the County and legal counsel with a redacted version of the executed power purchase agreement.

STUDY OF ACOUSTIC AND EMF LEVELS FROM SOLAR PHOTOVOLTAIC PROJECTS

MASSACHUSETTS
CLEAN ENERGY
CENTER

Prepared for:
Massachusetts Clean Energy Center
9th Floor
55 Summer Street
Boston, MA 02110

Prepared by:
Tech Environmental, Inc.
303 Wyman Street, Suite 295
Waltham, MA 02451

TECH environmental
FOCUSED KNOWLEDGE. REAL SOLUTIONS.

STUDY OF ACOUSTIC AND EMF LEVELS FROM SOLAR PHOTOVOLTAIC PROJECTS

Prepared for:

Massachusetts Clean Energy Center
9th Floor
55 Summer Street
Boston, MA 02110

Prepared by:

Peter H. Guldberg, INCE, CCM
Tech Environmental, Inc.
303 Wyman Street, Suite 295
Waltham, MA 02451

December 17, 2012

ACKNOWLEDGEMENTS

The study team would like to thank the owners and managers of the four project sites for participating in this study and their cooperation in gaining access to the sites, operational data, and system specifications.

We would also like to thank Bram Claeys of the Massachusetts Department of Energy Resources as well as Elizabeth Kennedy and Peter McPhee of the Massachusetts Clean Energy Center for their thorough and insightful review of this study.

EXECUTIVE SUMMARY

Sound pressure level and electromagnetic field (EMF) measurements were made at three utility-scale sites with solar photovoltaic (PV) arrays with a capacity range of 1,000 to 3,500 kW (DC at STC) under a full-load condition (sunny skies and the sun at an approximate 40° azimuth). Measurements were taken at set distances from the inverter pads and along the fenced boundary that encloses the PV array. Measurements were also made at set distances back from the fenced boundary. Broadband and 1/3-octave band sound levels were measured, along with the time variation of equipment sound levels.

EMF measurements were also made at one residential PV installation with a capacity of 8.6 kW under a partial-load condition. PV array operation is related to the intensity of solar insolation. Less sunshine results in lower sound and EMF levels from the equipment, and no sound or EMF is produced at night when no power is produced. A description of acoustic terms and metrics is provided in Appendix A, and EMF terms and metrics are presented in Appendix B. These appendices provide useful information for interpreting the results in this report and placing them in context, relative to other sound and EMF sources.

Sound levels along the fenced boundary of the PV arrays were generally at background levels, though a faint inverter hum could be heard at some locations. Any sound from the PV array and equipment was inaudible at set back distances of 50 to 150 feet from the boundary. Average L_{eq} sound levels at a distance of 10 feet from the inverter face varied over the range of 48 dBA to 61 dBA for Site 2 and Site 3 Inverters[1], and were higher in the range of 59 to 72 dBA for Site 1 Inverters. Along the axis perpendicular to the plane of the inverter face and at distances of 10 to 30 feet, sound levels were 4 to 13 dBA higher compared to levels at the same distance along the axis parallel to the inverter face. At 150 feet from the inverter pad, sound levels approached background levels. Sound level measurements generally followed the hemispherical wave spreading law (-6 dB per doubling of distance).

The time domain analysis reveals that 0.1-second L_{eq} sound levels at a distance of 10 feet from an inverter pad generally varied over a range of 2 to 6 dBA, and no recurring pattern in the rise and fall of the inverter sound levels with time was detected. The passage of clouds across the face of the sun caused cooling fans in the inverters to briefly turn off and sound levels to drop 4 dBA.

[1] The same make of inverters were used at Sites 2 and 3.

The 1/3-octave band frequency spectrum of inverter sound at the close distance of 10 feet shows energy peaks in several mid-frequency and high-frequency bands, depending on the inverter model. Tonal sound was found to occur in harmonic pairs: 63/125 Hz; 315/630 Hz; 3,150/6,300 Hz; and 5,000/10,000 Hz. The high frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The tonal sound was not, however, audible at distances of 50 to 150 feet beyond the PV array boundary, and these tonal peaks do not appear in the background sound spectrum. All low-frequency sound from the inverters below 40 Hz is inaudible, at all distances.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has a recommended electric field level exposure limit of 4,200 Volts/meter (V/m) for the general public. At the utility scale sites, electric field levels along the fenced PV array boundary, and at the locations set back 50 to 150 feet from the boundary, were not elevated above background levels (< 5 V/m). Electric fields near the inverters were also not elevated above background levels (< 5 V/m). At the residential site, indoor electric fields in the rooms closest to the roof-mounted panels and at locations near the inverters were not elevated above background levels (< 5 V/m).

The International Commission on Non-Ionizing Radiation Protection has a recommended magnetic field level exposure limit of 833 milli-Gauss (mG) for the general public. At the utility scale sites, magnetic field levels along the fenced PV array boundary were in the very low range of 0.2 to 0.4 mG. Magnetic field levels at the locations 50 to 150 feet from the fenced array boundary were not elevated above background levels (<0.2 mG). There are significant magnetic fields at locations a few feet from these utility-scale inverters, in the range of 150 to 500 mG. At a distance of 150 feet from the inverters, these fields drop back to very low levels of 0.5 mG or less, and in many cases to background levels (<0.2 mG). The variation of magnetic field with distance generally shows the field strength is proportional to the inverse cube of the distance from equipment.

At the residential site, indoor magnetic field levels in the rooms closest to the roof-mounted panels were in the low range of 0.2 to 1.4 mG. There are low-level magnetic fields at locations a few feet from the inverters, in the range of 6 to 10 mG. At a distance of no more than 9 feet from the inverters, these fields dropped back to the background level at this residential site of 0.2 mG. Due to the relatively high background level in the residential site basement where the inverters were housed, the relationship of magnetic field strength to distance from the inverters could not be discerned.

TABLE OF CONTENTS

Section	Contents	Page
1.0	INTRODUCTION	1
2.0	MEASUREMENT METHODS AND LOCATIONS	4
3.0	MEASUREMENT RESULTS	6
	3.1 Site 1 – Achusnet ADM	6
	3.2 Site 2 – Southborough Solar	15
	3.3 Site 3 – Norfolk Solar	23
	3.4 Site 4 – Residential Solar at Mass. Audubon Society in Sharon	30
4.0	CONCLUSIONS	32

APPENDIX A ACOUSTIC TERMS AND METRICS....................A-1
APPENDIX B EMF TERMS AND METRICS....................B-1

1.0 INTRODUCTION

The goal of this study is to conduct measurements at several ground-mounted PV arrays in Massachusetts to determine the sound pressure levels and electromagnetic field (EMF) levels generated by PV arrays and the equipment pads holding inverters and small transformers. This information will be used to inform local decision-makers and the public about the acoustic and EMF levels in the vicinity of PV projects.

Measurements were made at three utility-scale sites having PV arrays with a capacity range of 1,000 to 3,500 kW (DC at STC), with weather conditions consisting of sunny skies and the sun at approximately 40° azimuth. Measurements were also made at one residential[2] PV installation with a capacity of 8.6 kW under a partial-load condition. Sound level and EMF data were collected at set distances from the inverter pads and along the fenced boundary of the PV array. Measurements were also made at set distances back from the fenced boundary. Broadband and 1/3-octave band sound levels were measured, along with the time variation of equipment sound levels. Figure 1 shows a schematic map of a typical utility scale PV array containing four inverter pads and a fenced boundary. The orange stars show typical measurement locations around the fenced boundary of the array and at fixed set back distances of 50 feet, 100 feet, and 150 feet from the boundary. The green stars represent typical measurement locations at three set back distances from inverters on two of the equipment pads. At each equipment pad that was sampled, sound level measurements were made in two directions: along an axis parallel to the inverter face and along an axis perpendicular to the inverter face. Figure 2 illustrates a sound meter setup along the axis perpendicular to (90° from) an inverter face.

Section 2.0 of this report describes the measurement methods and locations, while Section 3.0 presents the measurement results in detail for the four sites. Study conclusions are given in Section 4.0. A description of acoustic terms and metrics is provided in Appendix A, and EMF terms and metrics are presented in Appendix B. These appendices provide useful information for interpreting the results in this report and placing them in context, relative to other sound and EMF sources.

---

[2] Only EMF measurements were made at the residential site.

Figure 1. Schematic Map of Sound and EMF Measurement Locations at a Solar Photovoltaic (PV) Array

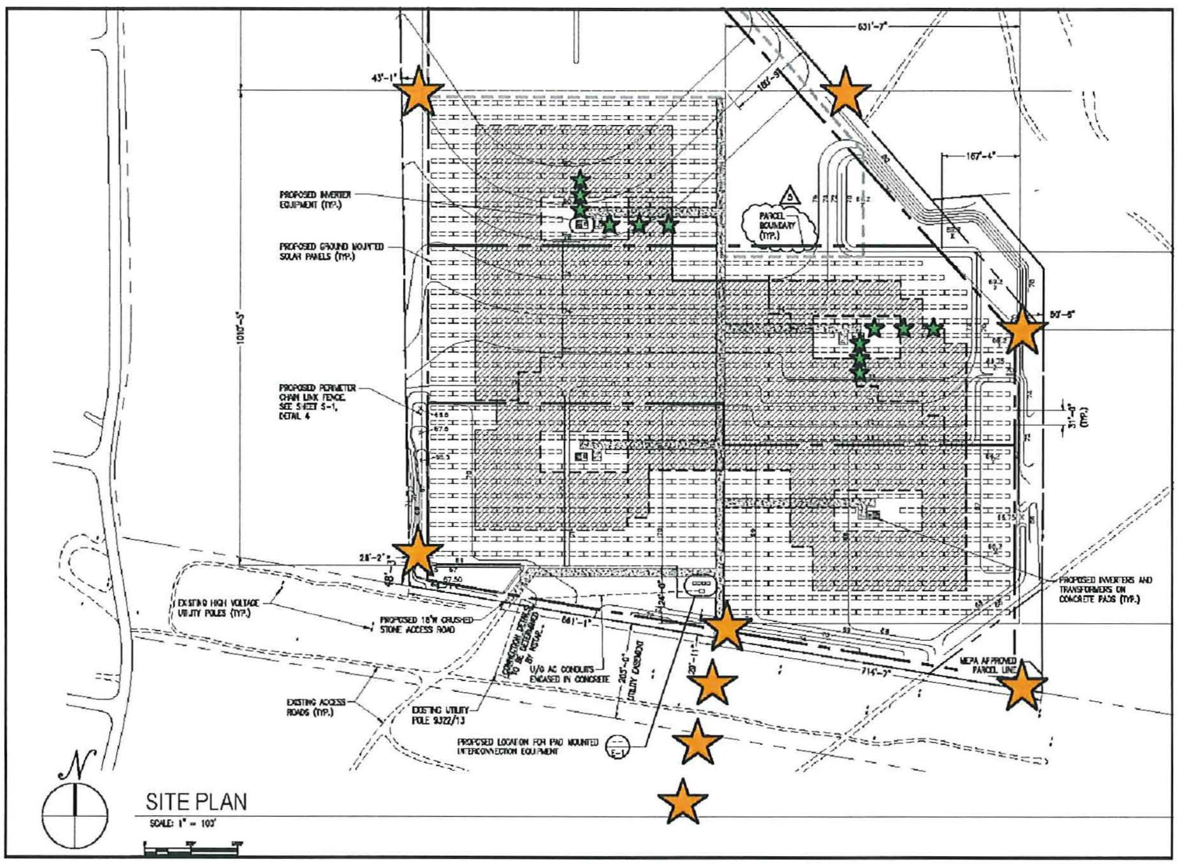
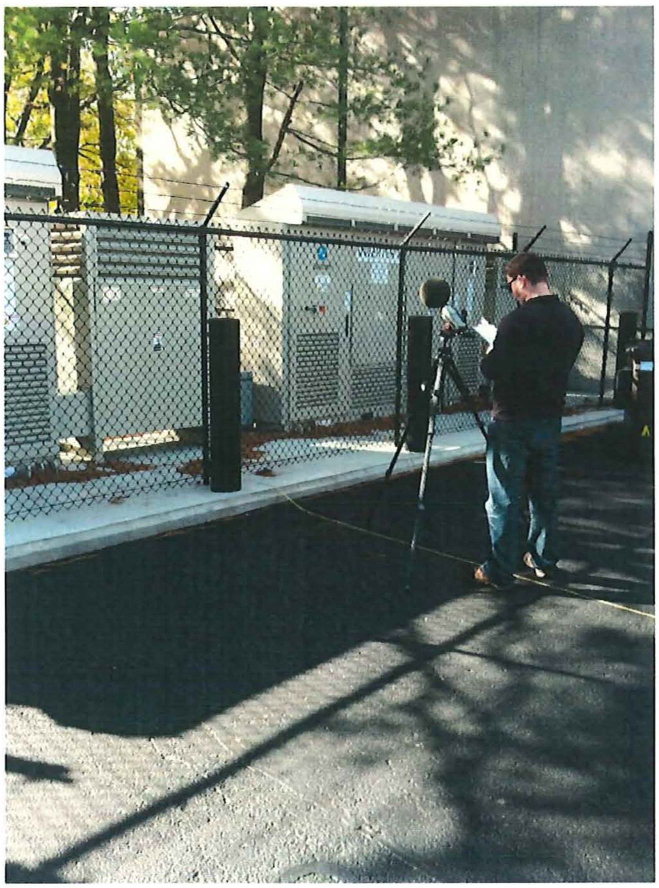


Figure 2. Sound Level Meter on the Axis Perpendicular to the Face of an Inverter at a Solar Photovoltaic (PV) Array



2.0 MEASUREMENT METHODS AND LOCATIONS

Sound pressure and EMF levels were measured along the fenced boundary of each PV array, at three set back distances from the boundary, and at fixed distances from equipment pads housing inverters and transformers (see Figures 1 and 2). Sound levels were measured with a tripod-mounted ANSI Type 1 sound meter, a Bruel & Kjaer Model 2250 meter, equipped with a large 7-inch ACO-Pacific WS7-80T 175 mm (7-inch) wind screen that is oversize and specially designed to screen out wind flow noise. An experimental study of wind-induced noise and windscreen attenuation effects by Hessler[3] found that the WS7-80T windscreen keeps wind-induced noise at the infrasound frequency band of 16 Hz to no more than 42 dB for moderate across-the–microphone wind speeds. That minimal level of wind-induced noise is 8 to 20 dB below the 16-Hz levels measured in this study.

The B&K Model 2250 measures 1/3-octave bands down to 6.3 Hz, well into the infrasonic range, and up to 20,000 Hz, the upper threshold of human hearing. The sound meter first recorded short-term (1-minute L_{eq} and L_{90}) broadband sound levels (in A-weighted decibels, dBA) at the established survey points. Then the sound meter was placed at the nearest measurement distance to each equipment pad to record a 10-minute time series of broadband and 1/3-octave band L_{eq} sound levels (in decibels, dB) at 0.1-second intervals. The L_{90} sound level removes intermittent noise and thus is lower than the L_{eq} sound level in the tables of results provided in Section 3.

EMF levels of both the magnetic field (in milliGauss, mG) and the electric field (in Volts/meter, V/m) were measured using a pair of Trifield Model 100XE EMF Meters. These instruments perform three-axis sampling simultaneously, enabling rapid survey of an area. The Trifield meters have a range for magnetic fields of 0.2 to 10,000 mG, and for electric fields from 5 to 1,000 V/m. EMF measurements were taken at the same survey points as the sound level measurements.

Measurements were made along the fenced boundary around each PV array at four to six evenly-spaced locations (depending on the size of the array), and at three additional locations set back 50 feet, 100 feet, and 150 feet from the boundary. At each equipment pad that was sampled, sound level

[3] Hessler, G., Hessler, D., Brandstatt, P., and Bay, K., "Experimental study to determine wind-induced noise and windscreen attenuation effects on microphone response for environmental wind turbine and other applications", Noise Control Eng. J., 56(4), 2008.

measurements were made in two directions: parallel to the inverter face, and perpendicular to the equipment face. The closest sound monitoring location was selected at a distance "1X" where the inverter or transformer sound was clearly audible above background levels. The closest EMF monitoring location was selected at a distance "1X" where magnetic field levels were approximately 500 mG, a level that is below the ICNIRP-recommended[4] human exposure limit of 833 mG (see Appendix B). Additional sampling points were then placed at distances[5] of 2X, 3X, and at 150 feet from the equipment pad, in the two orthogonal directions. There were a total of eight monitoring locations for each equipment pad, and seven to nine locations for the PV array boundary.

Measurements were made on October 11, 17, 22 and 26, 2012 around 12:30 p.m. EDT, the time of peak solar azimuth, and only on days for which clear skies were forecast to maximize solar insolation to the PV array. The peak solar azimuth in southern Massachusetts was approximately 40° azimuth on these dates. Consistent with standard industry practice, background levels of sound and EMF were measured at representative sites outside the fenced boundary of the PV array and far enough away to not be influenced by it or any other significant nearby source. The background levels presented for each site were made at distances of 50 feet, 100 feet, and 150 feet from the fenced boundary around the PV array (see Figure 1).

[4] International Commission on Non-Ionizing Radiation Protection.

[5] Location 2X is twice the distance from the equipment as location 1X; Location 3X is three times that distance.

3.0 MEASUREMENT RESULTS

Sound and EMF measurements were made at the following four PV arrays, presented in the following sections:

Site 1 – Achusnet ADM, Wareham, MA
Site 2 – Southborough Solar, Southborough, MA
Site 3 – Norfolk Solar, Norfolk, MA
Site 4 – Residential PV array owned by Massachusetts Audubon Society, Sharon, MA

3.1 Site 1 – Achusnet ADM

Facility Location:	27 Charlotte Furnace Road, Wareham, MA
Facility Owner:	Borrego Solar Systems, Inc.
System Capacity:	3,500 kW
Power Output During Monitoring:	3,500 kW
No. & Size Inverters:	(7) 500-kW inverters
Date Measured:	Thursday October 11, 2012
Cloud Cover:	0%
Winds:	West 10-12 mph
Ground:	Open area between cranberry bogs, no buildings or vegetation.
Background Sound:	Mean value L_{eq} of 46.4 dBA (range of 45.6 to 47.0 dBA). Mean value of L_{90} 43.9 dBA (range of 41.6 to 45.4 dBA). Sources included highway traffic on I-495 (to the south), earthmoving equipment to the east, birds and other natural sounds.
Background EMF:	None (< 0.2 mG and < 5 V/m) except along southern boundary from hi-voltage power lines overhead, and near the eastern boundary from low-voltage power lines overhead.

The solar photovoltaic array is in a flat area between cranberry bogs east of Charlotte Furnace Road in Wareham and the boundary of the array is fenced. The surrounding area has no buildings or vegetation. There are four equipment pads within the PV array, each housing one or two inverters. Measurements were made at two equipment pads: 1) the Northwest Pad, which contains two inverters and a small transformer, and 2) the Northeast Pad, which has one inverter and a small transformer. The sound and EMF measurements made at Site 1 are summarized in Tables 1 through 3. Figures 3 and 4 present a time series graph of 0.1-second L_{eq} sound levels at the nearest measurement location

(1X) for the Northwest and Northeast Equipment Pads, while Figure 5 provides the corresponding 1/3-octave band spectra for the sound level measurements at those same locations along with the spectrum for background sound levels.

Sound Levels

Background sound levels varied over time and space across the site. Highway traffic noise was the primary background sound source and higher levels were measured for locations on the south side of the site closer to the highway. Variable background sound was also produced by trucking activity to the east of the PV array, where sand excavated during the PV array's construction and stored in large piles was being loaded with heavy equipment into dump trucks and hauled away. Background sound levels varied over a range of 6 dBA. Background mean value L_{eq} and L_{90} levels were 46.4 dBA and 43.9 dBA, respectively. The PV array was inaudible outside of the fenced boundary, and was also inaudible everywhere along the boundary except at the North East boundary location where a faint inverter hum could be heard. Broadband sound levels at the locations set back 50 to 150 feet from the boundary are not elevated above background levels.

L_{eq} sound levels at a distance of 10 feet from the inverter face on the North West Pad (which holds two 500-kW inverters) were 68.6 to 72.7 dBA and at the same distance from the North East Pad (which holds only one 500-kW inverter) were lower at 59.8 to 66.0 dBA. Along the axis perpendicular to the inverter face measured sound levels were 4 to 6 dBA higher than at the same distance along the axis parallel to the inverter face. The sound levels generally declined with distance following the hemispherical wave spreading law (approximately -6 dB per doubling of distance) and at a distance of 150 feet all inverter sounds approached background sound levels. Due to the layout of the solar panels, the measurements made perpendicular to the inverter face and at a distance of 150 feet were blocked from a clear line of sight to the inverter pad by many rows of solar panels, which acted as sound barriers.

The time domain analysis presented in Figures 3 and 4 reveal that 0.1-second L_{eq} sound levels at the close distance of 10 feet generally varied 3 to 4 dBA at the North West Pad and 2 to 3 dBA at the North East Pad. The graphs show no recurring pattern in the rise and fall of the inverter sound levels over the measurement period of ten minutes. The inverters registered full 500-kW capacity during both 10-minute monitoring periods.

The frequency spectrum of equipment sound at the close distance of 10 feet (Figure 5) shows energy peaks in four 1/3-octave bands, which are most pronounced for the North West Pad: 315 Hz, 630 Hz, 3,150 Hz, and 6,300 Hz. The two higher frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The second frequency peak in each pair is a first-harmonic tone (6,300 Hz being twice the frequency of 3,150 Hz). The tonal sound exhibited by Figure 5 is not, however, audible at distances of 50 to 150 feet beyond the PV array boundary, and these tonal peaks do not appear in the background sound spectrum shown in Figure 5. The dashed line in Figure 5 is the ISO 226 hearing threshold and it reveals that low-frequency sound from the inverters below 40 Hz is inaudible, even at a close distance. The background sound spectrum is smooth except for a broad peak around 800 Hz caused by distant highway traffic noise and a peak at 8,000 Hz that represents song birds.

Electric Fields

Electric field levels along the PV array boundary, and at the locations set back 50 to 150 feet from the boundary, are not elevated above background levels (< 5 V/m). The one measurement at 5.0 V/m in Table 1 was caused by the field around a nearby low-voltage power line overhead. Electric fields near the inverters are also not elevated above background levels (< 5 V/m). The one measurement at 10.0 V/m in Table 3 was caused by the meter being close to the front face of a solar panel at the 150-foot set back distance.

Magnetic Fields

Magnetic field levels along the PV array boundary and 50 feet from the boundary were in the very low range of 0.2 to 0.3 mG, except at the southern end of the boundary that is close to overhead high-voltage power lines, owned by the local utility and not connected to the project, where levels of 0.7 to 3 mG were measured, caused by those hi-voltage power lines. Magnetic field levels at the location 100 feet from the boundary were elevated by a low-voltage power line overhead. At 150 feet from the boundary, the magnetic field is not elevated above background levels (<0.2 mG).

Table 3 reveals that there are significant magnetic fields at locations a few feet from inverters, around 500 mG. These levels drop back to 0.2 to 0.5 mG at distances of 150 feet from the inverters. The variation of magnetic field with distance shown in Table 3 generally shows the field strength is proportional to the inverse cube of the distance from equipment. Following that law, the magnetic field at 5 feet of 500 mG should decline to 0.02 mG (< 0.2 mG) at 150 feet. The measured levels of 0.1 to 0.5 mG at 150 feet listed in Table 3 are likely caused by small-scale magnetic fields setup around the PV cells and connecting cables near the sampling locations.

TABLE 1

SOUND AND EMF LEVELS MEASURED AT SITE 1
PV ARRAY BOUNDARY

Boundary Location	L_{90} Level (dBA)	L_{eq} Level (dBA)	Magnetic Field (mG)	Electric Field (V/m)
North West Boundary	39.1	42.5	< 0.2	< 5
South West Boundary	43.6	44.7	1.8	< 5
South Center Boundary	44.8	48.1	3.0	< 5
South East Boundary	44.0	45.6	0.7	< 5
North East Boundary	42.2	43.9	< 0.2	< 5
North Center Boundary	43.4	44.3	0.3	< 5
Background Mean Values	43.9	46.4	< 0.2	< 5
Set back 50 feet from Boundary	41.6	47.0	0.2	< 5
Set back 100 feet from Boundary	45.4	46.7	0.4	5.0
Set back 150 feet from Boundary	44.7	45.6	< 0.2	< 5

TABLE 2

SOUND LEVELS MEASURED AT SITE 1
EQUIPMENT PADS

Equipment Pad / Direction / Distance	L_{90} Level (dBA)	L_{eq} Level (dBA)
North West Pad / Parallel to Inverter Face / 10 feet	67.6	68.6
North West Pad / Parallel to Inverter Face / 20 feet	61.8	63.1
North West Pad / Parallel to Inverter Face / 30 feet	58.8	60.6
North West Pad / Parallel to Inverter Face / 150 feet	45.2	46.0
North West Pad / Perpendicular to Inverter Face / 10 feet	71.8	72.7
North West Pad / Perpendicular to Inverter Face / 20 feet	63.5	64.8
North West Pad / Perpendicular to Inverter Face / 30 feet	59.5	62.3
North West Pad / Perpendicular to Inverter Face / 150 feet	41.8	43.0
North East Pad / Parallel to Inverter Face / 10 feet	59.1	59.8
North East Pad / Parallel to Inverter Face / 20 feet	55.4	56.2
North East Pad / Parallel to Inverter Face / 30 feet	54.8	55.7
North East Pad / Parallel to Inverter Face / 150 feet	43.4	44.0
North East Pad / Perpendicular to Inverter Face / 10 feet	65.5	66.0
North East Pad / Perpendicular to Inverter Face / 20 feet	59.8	60.2
North East Pad / Perpendicular to Inverter Face / 30 feet	56.3	56.9
North East Pad / Perpendicular to Inverter Face / 150 feet	41.0	43.6

TABLE 3

EMF LEVELS MEASURED AT SITE 1 EQUIPMENT PADS

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
North West Pad / Parallel to Inverter Face / 5 feet 3 inches	500	< 5
North West Pad / Parallel to Inverter Face / 10 feet 6 inches	10.5	< 5
North West Pad / Parallel to Inverter Face / 15 feet 9 inches	2.75	< 5
North West Pad / Parallel to Inverter Face / 150 feet	0.2	< 5
North West Pad / Perpendicular to Inverter Face / 4 feet	500	< 5
North West Pad / Perpendicular to Inverter Face / 8 feet	200	< 5
North West Pad / Perpendicular to Inverter Face / 12 feet	6.5	< 5
North West Pad / Perpendicular to Inverter Face / 150 feet	0.5	< 5
North East Pad / Parallel to Inverter Face / 3 feet 10 inches	500	< 5
North East Pad / Parallel to Inverter Face / 7 feet 8 inches	30	< 5
North East Pad / Parallel to Inverter Face / 11 feet 10 inches	4.5	< 5
North East Pad / Parallel to Inverter Face / 150 feet	0.2	10.0
North East Pad / Perpendicular to Inverter Face / 7 feet 6 inches	500	< 5
North East Pad / Perpendicular to Inverter Face / 15 feet	10	< 5
North East Pad / Perpendicular to Inverter Face / 22 feet 6 inches	2.1	< 5
North East Pad / Perpendicular to Inverter Face / 150 feet	0.1	< 5

Figure 3. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pads for Site #1

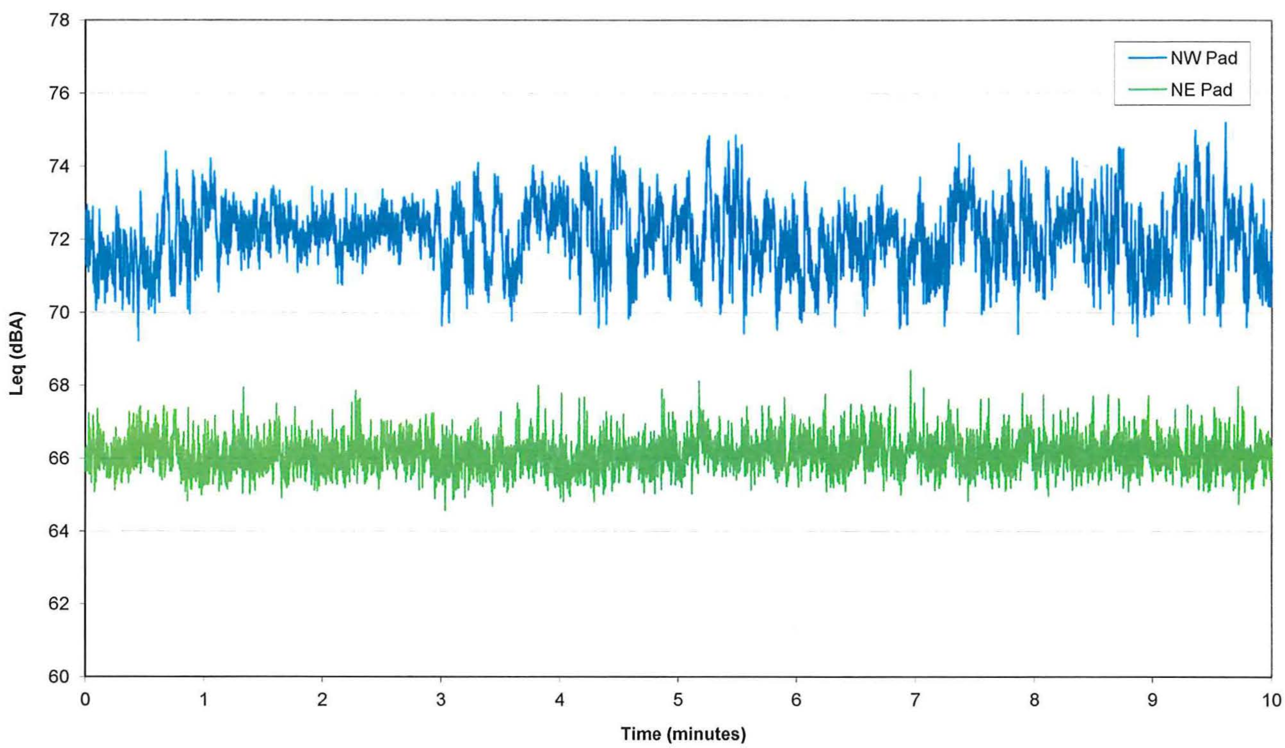


Figure 4. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pads for Site #1 - First 10 Seconds of Measurements

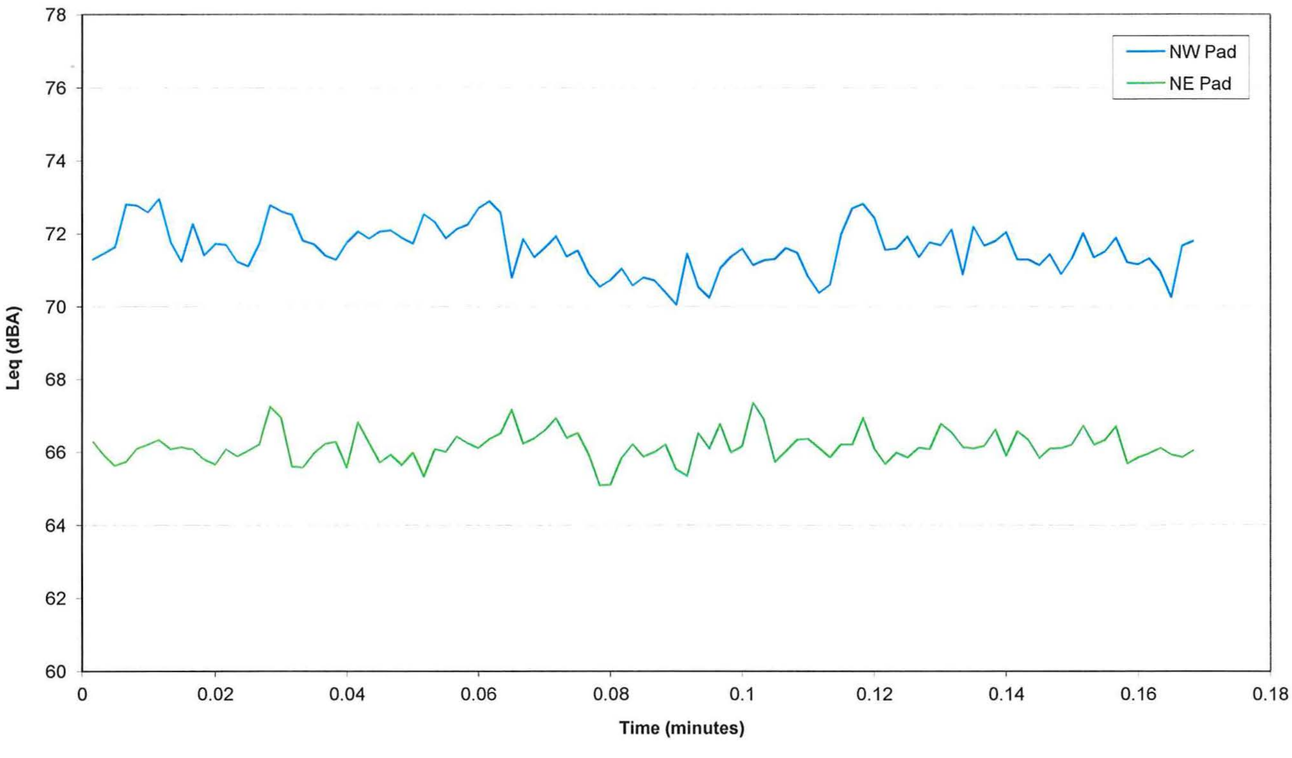
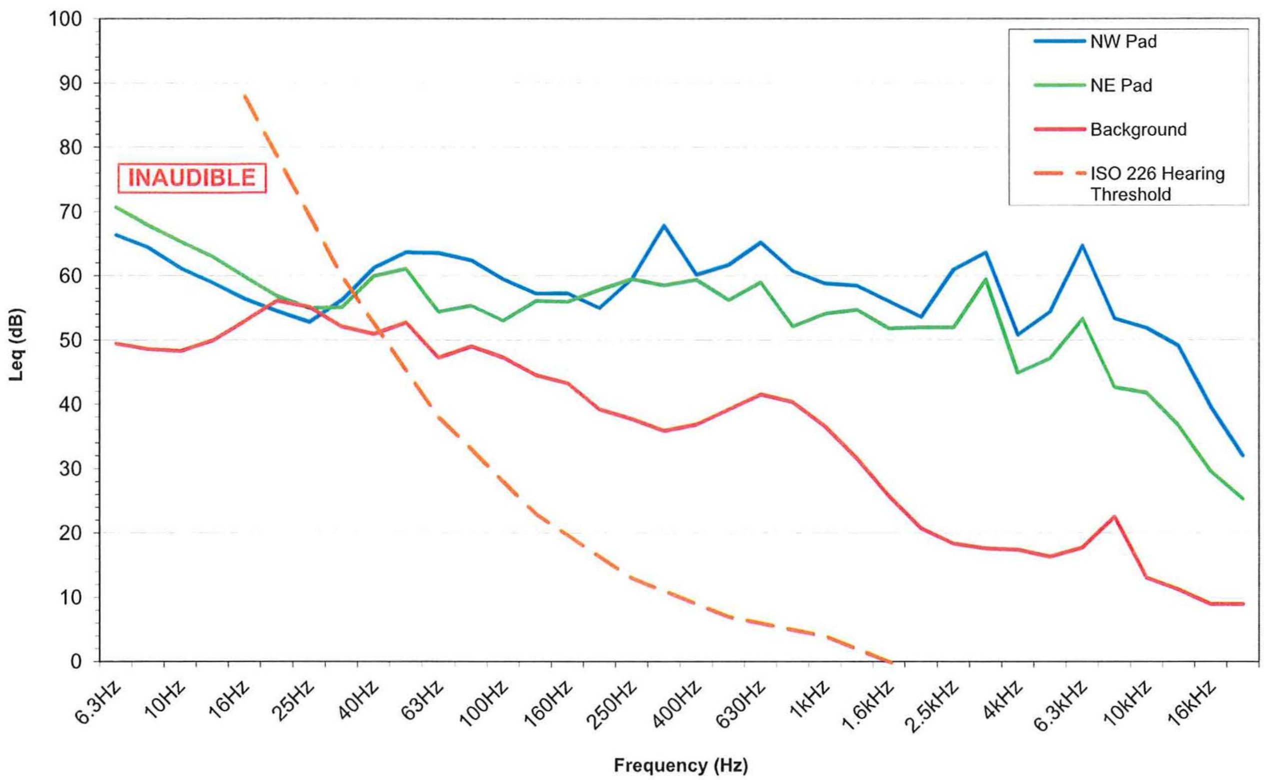


Figure 5. Frequency Spectrum of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pads for Site #1



3.2 Site 2 – Southborough Solar

Facility Location:	146 Cordaville Road, Southborough, MA
Facility Owner:	Southborough Solar, LLC
System Capacity:	1,000 kW
Power Output During Monitoring:	1,000 kW
No. & Size Inverters:	(2) 500-kW inverters
Date Measured:	Wednesday October 17, 2012
Cloud Cover:	5% (high, thin cirrus)
Winds:	Northwest 3-5 mph
Ground:	Wooded areas and wetlands surround the PV array, and a building is located to the south where the inverters are housed.
Background Sound:	Mean value L_{eq} of 53.1 dBA (range of 51.0 to 55.9 dBA). Mean value L_{90} of 49.6 dBA (range of 48.6 to 50.3 dBA). Sources included roadway traffic on Cordaville Road (to the west) and Route 9 (to the north) and natural sounds.
Background EMF:	None (< 0.2 mG and < 5 V/m).

The solar photovoltaic array is in a cleared area of land east of Cordaville Road in Southborough and the boundary of the array is fenced. The array is surrounded by wetlands and woods. The two inverters are not within the PV array; instead they are located on a single pad at the southeast corner of the building that lies south of the PV array. Measurements were made at the one equipment pad housing the two inverters. Due to the close proximity of wetlands to the fenced boundary for the PV array, it was not possible to obtain measurements 50 to 150 feet from the boundary. Instead, measurements were taken 50 to 150 feet set back from the property boundary of the site near where the inverter pad is located. The sound and EMF measurements made at Site 2 are summarized in Tables 4 through 6. Figures 6 and 7 present a time series graph of 0.1-second L_{eq} sound levels at the nearest measurement location (1X) for the equipment pad, while Figure 8 provides the corresponding 1/3-octave band spectra for the sound level measurements at those same locations along with the spectrum for background sound levels.

Sound Levels

Background sound levels varied over time and space across the site, depending on the distance from Cordaville Road, which carries heavy traffic volumes. Roadway traffic noise was the primary background sound source and higher levels were measured for locations on the west side of the site closer to Cordaville Road. Background sound levels varied over a range of 5 to 7 dBA. The background mean value L_{eq} and L_{90} levels were 53.1 dBA and 49.6 dBA, respectively. The inverters were inaudible at a distance of 50 feet outside of the site boundary. Broadband sound levels at the locations set back 50 to 150 feet from the boundary are not elevated above background levels.

L_{eq} sound levels at a distance of 10 feet from the inverter face on the equipment pad (which holds two 500-kW inverters) were 48.1 to 60.8 dBA. Along the axis perpendicular to the inverter face, measured sound levels were 10 to 13 dBA higher than at the same distance along the axis parallel to the inverter face. The sound levels did not follow the expected hemispherical wave spreading law (approximately -6 dB per doubling of distance) and declined at a lower rate with increasing distance due to the relatively high background sound levels from nearby roadway traffic. At a distance of 150 feet, all inverter sounds were below background sound levels.

The time domain analysis presented in Figures 6 and 7 reveal that 0.1-second L_{eq} sound levels at the close distance of 10 feet generally varied 5 to 6 dBA. The graphs show no recurring pattern in the rise and fall of the inverter sound levels over the measurement period of ten minutes. The rise and fall in inverter sound levels over several minutes is thought to be due to the passage of sheets of high thin cirrus clouds across the face of the sun during the measurements. The inverters registered full 500-kW capacity during both 10-minute monitoring periods.

The frequency spectrum of equipment sound at the close distance of 10 feet (Figure 8) shows energy peaks in two 1/3-octave bands: 5,000 and 10,000 Hz. These high frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The second frequency peak is a first-harmonic tone (10 kHz being twice the frequency of 5 kHz). The tonal sound exhibited by Figure 8 is not, however, audible at distances of 50 to 150 feet beyond the site boundary, and these tonal peaks do not appear in the background sound spectrum shown in Figure 8. The dashed line in Figure 8 is the ISO 226 hearing threshold and it reveals that low-frequency sound from the inverters below 40 Hz is inaudible, even at a close distance. The background sound spectrum declines smoothly with increasing frequency in the audible range except for a rise around 800 to 2,000 Hz caused by nearby roadway traffic noise.

Electric Fields

Electric field levels along the PV array boundary, and at the locations set back 50 to 150 feet from the site boundary, are not elevated above background levels (< 5 V/m).

Magnetic Fields

Magnetic field levels along the PV array boundary were in the very low range of 0.2 to 0.4 mG. Magnetic field levels at the locations 50 to 150 feet from the site boundary were not elevated above background levels (<0.2 mG).

Table 6 reveals that there are significant magnetic fields at locations a few feet from inverters, in the range of 200 to 500 mG. These levels drop back to background levels (<0.2 mG) at distances of 95 to 150 feet from the inverters. The variation of magnetic field with distance shown in Table 6 generally shows the field strength is proportional to the inverse cube of the distance from equipment.

TABLE 4

SOUND AND EMF LEVELS MEASURED AT SITE 2
PV ARRAY BOUNDARY

Boundary Location	L_{90} Level (dBA)	L_{eq} Level (dBA)	Magnetic Field (mG)	Electric Field (V/m)
North West Boundary	53.3	54.4	0.2	< 5
South West Boundary	52.4	54.4	0.2	< 5
South East Boundary	48.3	50.8	0.4	< 5
North East Boundary	46.8	49.8	< 0.2	< 5
Background Mean Values	49.6	53.1	< 0.2	< 5
Set back 50 feet from Boundary	50.3	52.3	< 0.2	< 5
Set back 100 feet from Boundary	49.9	55.9	< 0.2	< 5
Set back 150 feet from Boundary	48.6	51.0	< 0.2	< 5

TABLE 5

SOUND LEVELS MEASURED AT SITE 2
EQUIPMENT PAD

Equipment Pad / Direction / Distance	L_{90} Level (dBA)	L_{eq} Level (dBA)
Parallel to Inverter Face / 10 feet	46.7	48.1
Parallel to Inverter Face / 20 feet	44.8	46.2
Parallel to Inverter Face / 30 feet	44.3	45.6
Parallel to Inverter Face / 95 feet*	44.0	45.6
Perpendicular to Inverter Face / 10 feet	59.9	60.8
Perpendicular to Inverter Face / 20 feet	57.3	58.7
Perpendicular to Inverter Face / 30 feet	53.4	54.5
Perpendicular to Inverter Face / 150 feet	46.2	47.5

*Measurements could not be taken at 150 feet parallel to inverter face because of the close proximity of wetlands. Instead, a measurement was made at the farthest practical distance in that direction at 95 feet.

TABLE 6

EMF LEVELS MEASURED AT SITE 2 EQUIPMENT PAD

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
Parallel to Inverter Face / 4 feet	200	< 5
Parallel to Inverter Face / 8 feet	10	< 5
Parallel to Inverter Face / 12 feet	0.8	< 5
Parallel to Inverter Face / 95 feet*	<0.2	< 5
Perpendicular to Inverter Face / 4 feet	500	< 5
Perpendicular to Inverter Face / 8 feet	25	< 5
Perpendicular to Inverter Face / 12 feet	4.5	< 5
Perpendicular to Inverter Face / 150 feet	<0.2	< 5

*Measurements could not be taken at 150 feet parallel to inverter face because of the close proximity of wetlands. Instead, a measurement was made at the farthest practical distance in that direction at 95 feet.

Figure 6. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #2

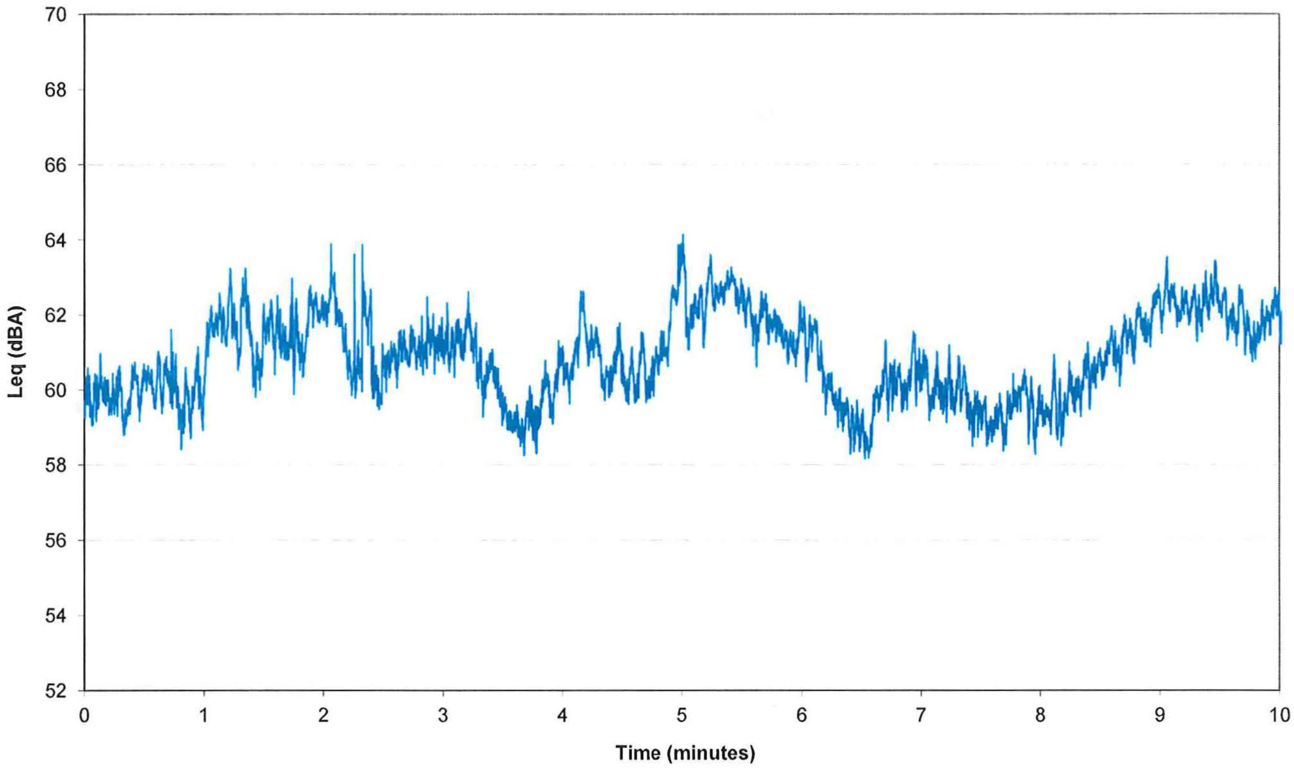


Figure 7. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #2 - First 10 Seconds of Measurements

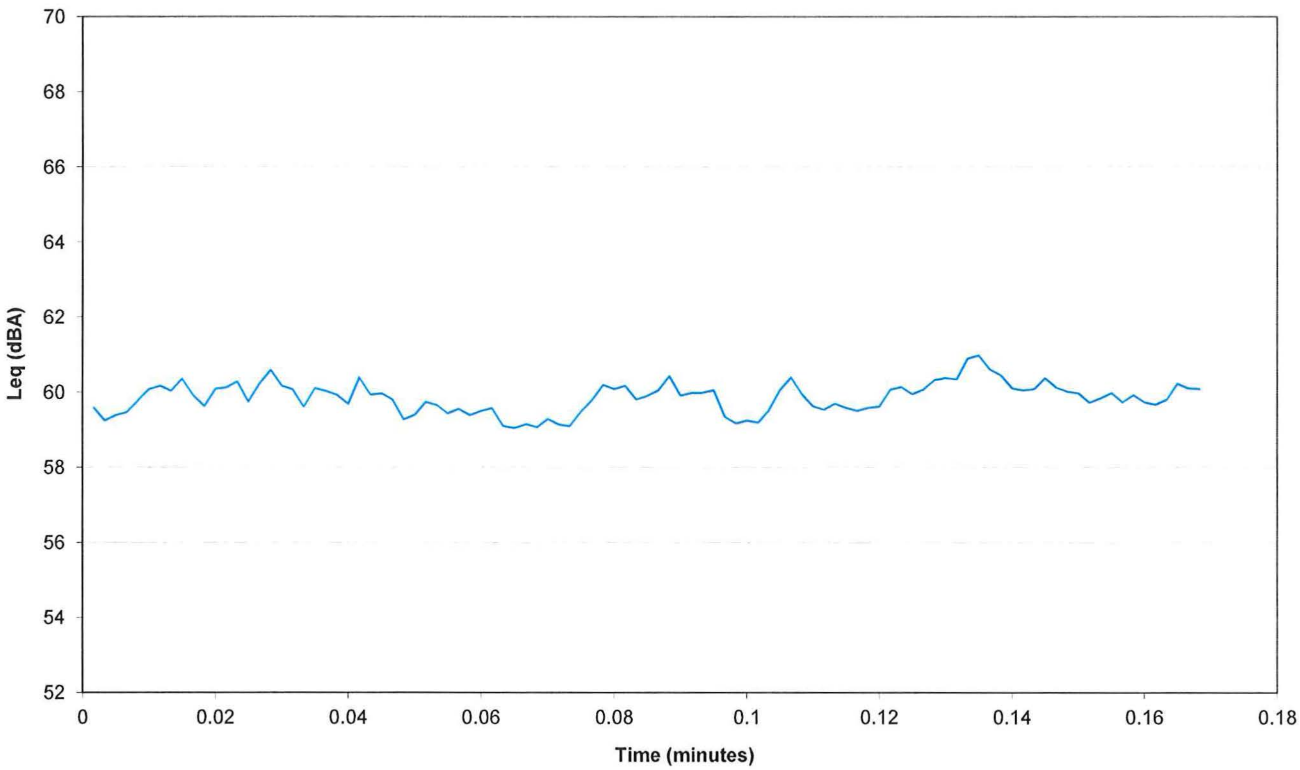
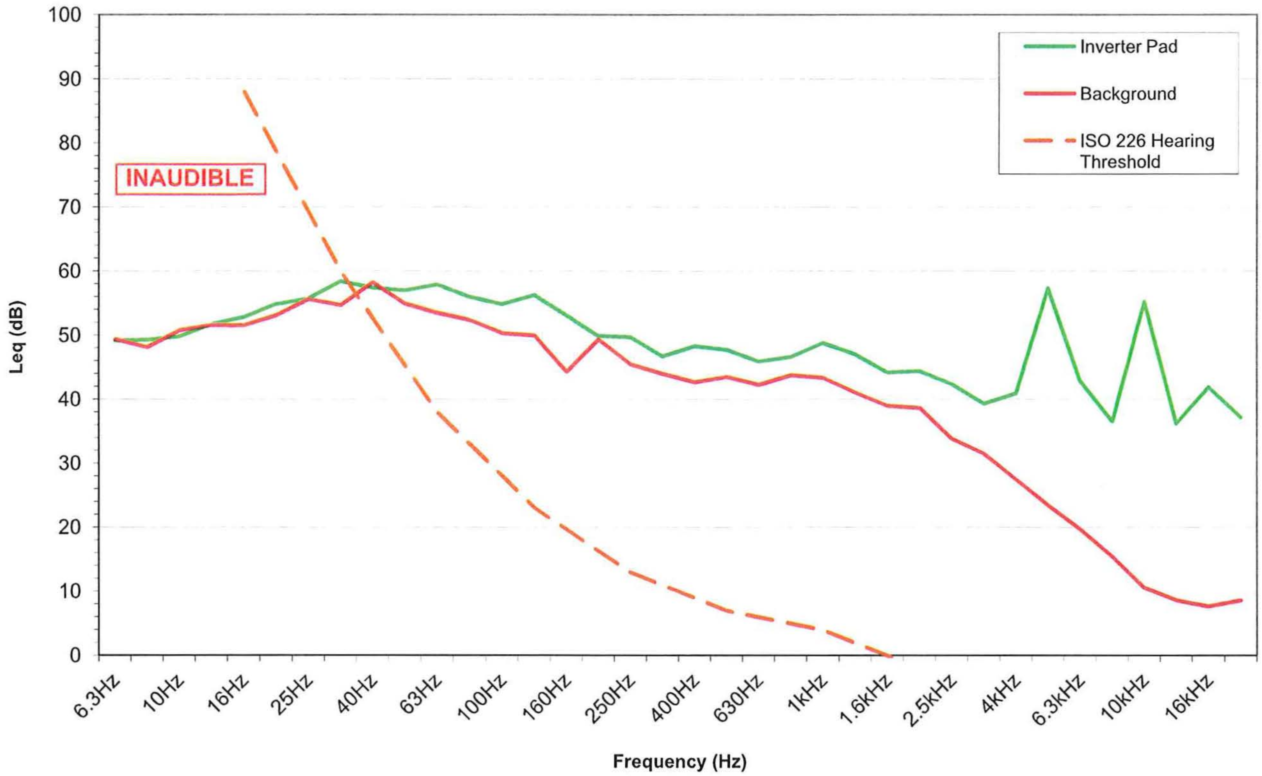


Figure 8. Frequency Spectrum of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad at Site #2



3.3 Site 3 – Norfolk Solar

Facility Location:	33 Medway Branch Road, Norfolk, MA
Facility Owner:	Constellation Solar Massachusetts, LLC
System Capacity:	1,375 kW
Power Output During Monitoring:	1,200 to 1,375 kW
No. & Size Inverters:	(2) 500-kW inverters and (1) 375-kW inverter
Date Measured:	Monday October 22, 2012
Sky Cover:	10% (passing small cumulus clouds)
Winds:	West 10-12 mph
Ground:	One PV array sits high on top of the closed landfill with grass cover and no surrounding vegetation. The other, larger PV array is in a wooded area on relatively flat ground. Measurements were made at the larger PV array.
Background Sound:	Mean value L_{eq} of 45.3 dBA (range of 43.1 to 47.5 dBA). Mean value L_{90} of 42.5 dBA (range of 42.1 to 43.2 dBA). Sources included distant traffic noise and natural sounds.
Background EMF:	None (< 0.2 mG and < 5 V/m).

There are two solar photovoltaic arrays on the land of the Town of the Norfolk Department of Public Works. One array sits on top of a capped landfill and has a single equipment pad with one inverter. The second, and larger, array is in a cleared flat area east of the capped landfill and has a single equipment pad housing two inverters. The boundaries of the PV arrays are fenced. The surrounding area has only grass cover or low vegetation. Measurements were made at the larger PV array and at the equipment pad housing two inverters with a capacity of 875 kW. The sound and EMF measurements made at Site 3 are summarized in Tables 7 through 9. Figures 9 and 10 present a time series graph of 0.1-second L_{eq} sound levels at the nearest measurement location (1X) for the equipment pad, while Figure 11 provides the corresponding 1/3-octave band spectra for the sound level measurements at those same locations along with the spectrum for background sound levels.

<u>Sound Levels</u>

Background sound levels were fairly constant across the site and distant roadway traffic was the primary background sound source. The background mean value L_{eq} and L_{90} levels were 45.3 dBA and 42.5 dBA, respectively. The PV array was inaudible outside of the fenced boundary except at the South East boundary location where a faint inverter hum could be heard. Broadband sound levels at the locations set back 50 to 150 feet from the boundary are not elevated above background levels.

L_{eq} sound levels at a distance of 10 feet from the inverter face on the equipment pad (which holds two inverters) were 54.8 to 60.9 dBA. Along the axis perpendicular to the inverter face measured sound levels were 6 to 7 dBA higher than at the same distance along the axis parallel to the inverter face. The sound levels generally followed the expected hemispherical wave spreading law (approximately -6 dB per doubling of distance). At a distance of 150 feet, all inverter sounds were below background sound levels.

The time domain analysis presented in Figures 9 and 10 reveal that 0.1-second L_{eq} sound levels at the close distance of 10 feet generally varied 3 to 4 dBA. The graphs show no recurring pattern in the rise and fall of the inverter sound levels over the measurement period of ten minutes. Between 7 and 9 minutes into the 10-minute measurement, clouds passed over the face of the sun, power production dropped, and the inverter cooling fans turned off for a brief period, as shown by the abrupt 4 dBA drop in sound level in Figure 9.

The frequency spectrum of equipment sound at the close distance of 10 feet (Figure 11) shows energy peaks in four 1/3-octave bands: 63, 125, 5,000 and 10,000 Hz. The high frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The second frequency peak in each pair is a first-harmonic tone (10 kHz being twice the frequency of 5 kHz). The tonal sound exhibited by Figure 11 is not, however, audible at distances of 50 to 150 feet beyond the site boundary, and these tonal peaks do not appear in the background sound spectrum shown in Figure 11. The dashed line in Figure 11 is the ISO 226 hearing threshold and it reveals that low-frequency sound from the inverters below 40 Hz is inaudible, even at a close distance. The background sound spectrum declines smoothly with increasing frequency in the audible range except for a slight rise around 800 to 2,000 Hz caused by distant roadway traffic noise.

Electric Fields

Electric field levels along the PV array boundary, and at the locations set back 50 to 150 feet from the site boundary, are not elevated above background levels (< 5 V/m).

Magnetic Fields

Magnetic field levels along the PV array boundary were in the very low range, at or below 0.2 mG. Magnetic field levels at the locations 50 to 150 feet from the site boundary were not elevated above background levels (<0.2 mG).

Table 9 reveals that there are significant magnetic fields at locations a few feet from inverters, in the range of 150 to 500 mG. These levels drop back to levels of 0.4 mG in the perpendicular direction and to background levels (<0.2 mG) in the parallel direction at 150 feet from the inverters. The variation of magnetic field with distance shown in Table 9 generally shows the field strength is proportional to the inverse cube of the distance from equipment.

TABLE 7

SOUND AND EMF LEVELS MEASURED AT SITE 3
PV ARRAY BOUNDARY

Boundary Location	L_{90} Level (dBA)	L_{eq} Level (dBA)	Magnetic Field (mG)	Electric Field (V/m)
North West Boundary	46.2	48.3	< 0.2	< 5
South West Boundary	48.9	50.6	< 0.2	< 5
South East Boundary	43.3	44.3	0.2	< 5
North East Boundary	43.9	46.1	< 0.2	< 5
Background Mean Values	42.5	45.3	< 0.2	< 5
Set back 50 feet from Boundary	43.2	47.5	< 0.2	< 5
Set back 100 feet from Boundary	42.2	45.4	< 0.2	< 5
Set back 150 feet from Boundary	42.1	43.1	< 0.2	< 5

TABLE 8

SOUND LEVELS MEASURED AT SITE 3 EQUIPMENT PAD

Equipment Pad / Direction / Distance	L_{90} Level (dBA)	L_{eq} Level (dBA)
Perpendicular to Inverter Face / 10 feet	59.7	60.9
Perpendicular to Inverter Face / 20 feet	57.3	58.6
Perpendicular to Inverter Face / 30 feet	49.4	50.1
Perpendicular to Inverter Face / 150 feet	43.9	47.0
Parallel to Inverter Face / 10 feet	53.9	54.8
Parallel to Inverter Face / 20 feet	50.6	51.3
Parallel to Inverter Face / 30 feet	45.5	48.0
Parallel to Inverter Face / 150 feet	41.8	43.7

TABLE 9

EMF LEVELS MEASURED AT SITE 3 EQUIPMENT PAD

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
Parallel to Inverter Face / 3 feet	150	< 5
Parallel to Inverter Face / 6 feet	10	< 5
Parallel to Inverter Face / 9 feet	5	< 5
Parallel to Inverter Face / 150 feet	< 0.2	< 5
Perpendicular to Inverter Face / 3 feet	500	< 5
Perpendicular to Inverter Face / 6 feet	200	< 5
Perpendicular to Inverter Face / 9 feet	80	< 5
Perpendicular to Inverter Face / 150 feet	0.4	< 5

Figure 9. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #3

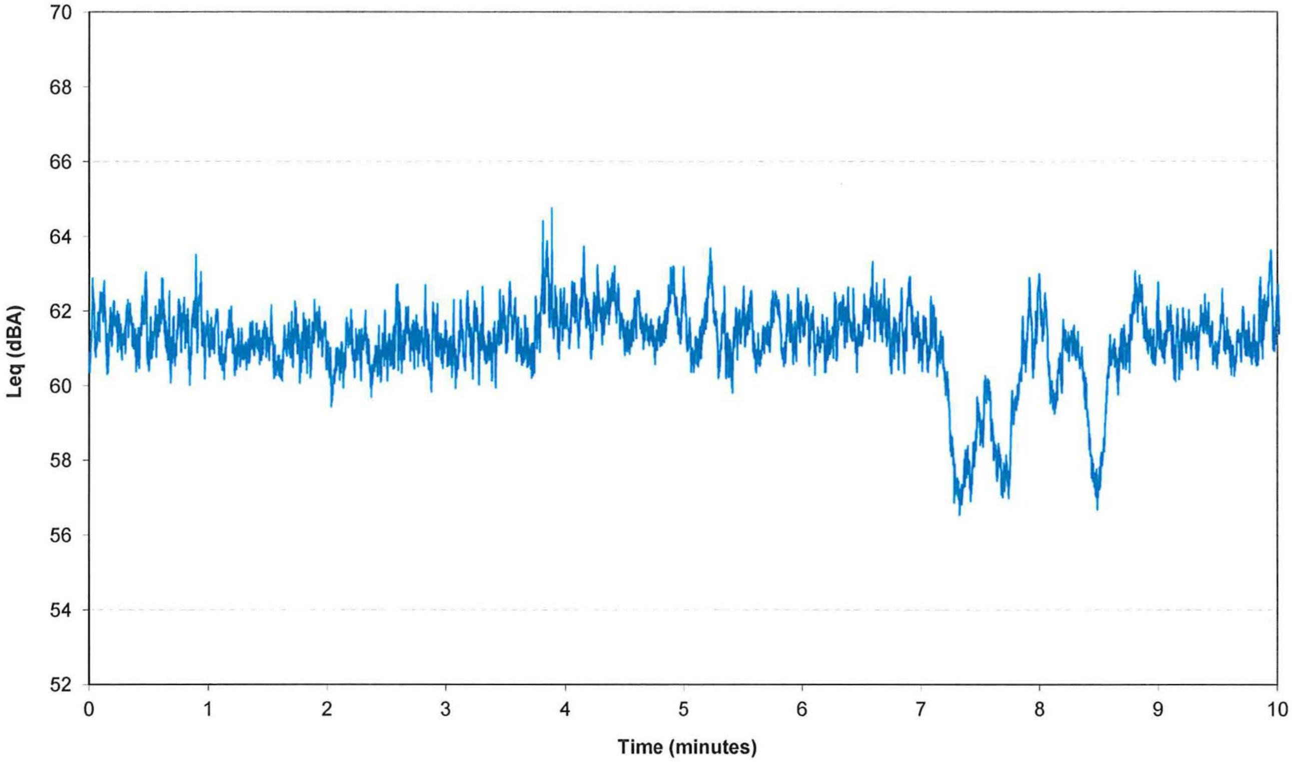


Figure 10. Time Variation of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad for Site #3 - First 10 Seconds of Measurements

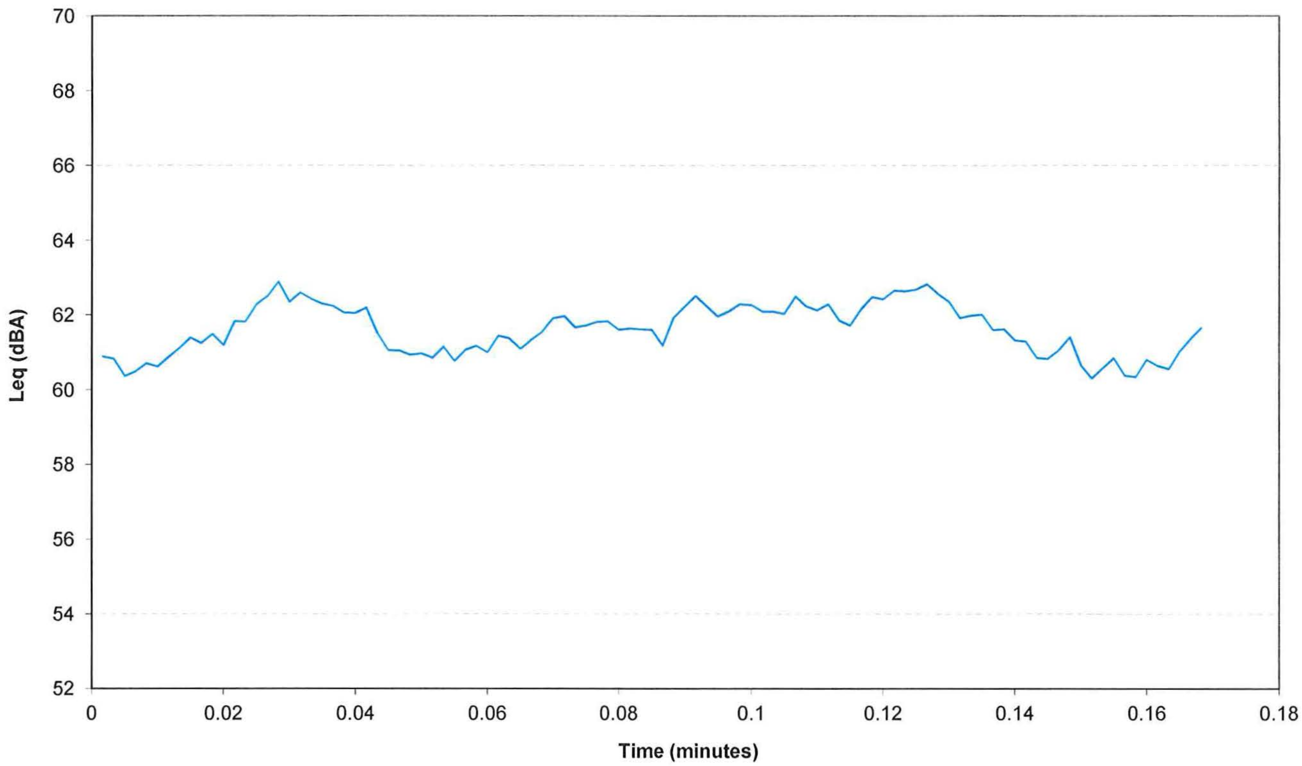
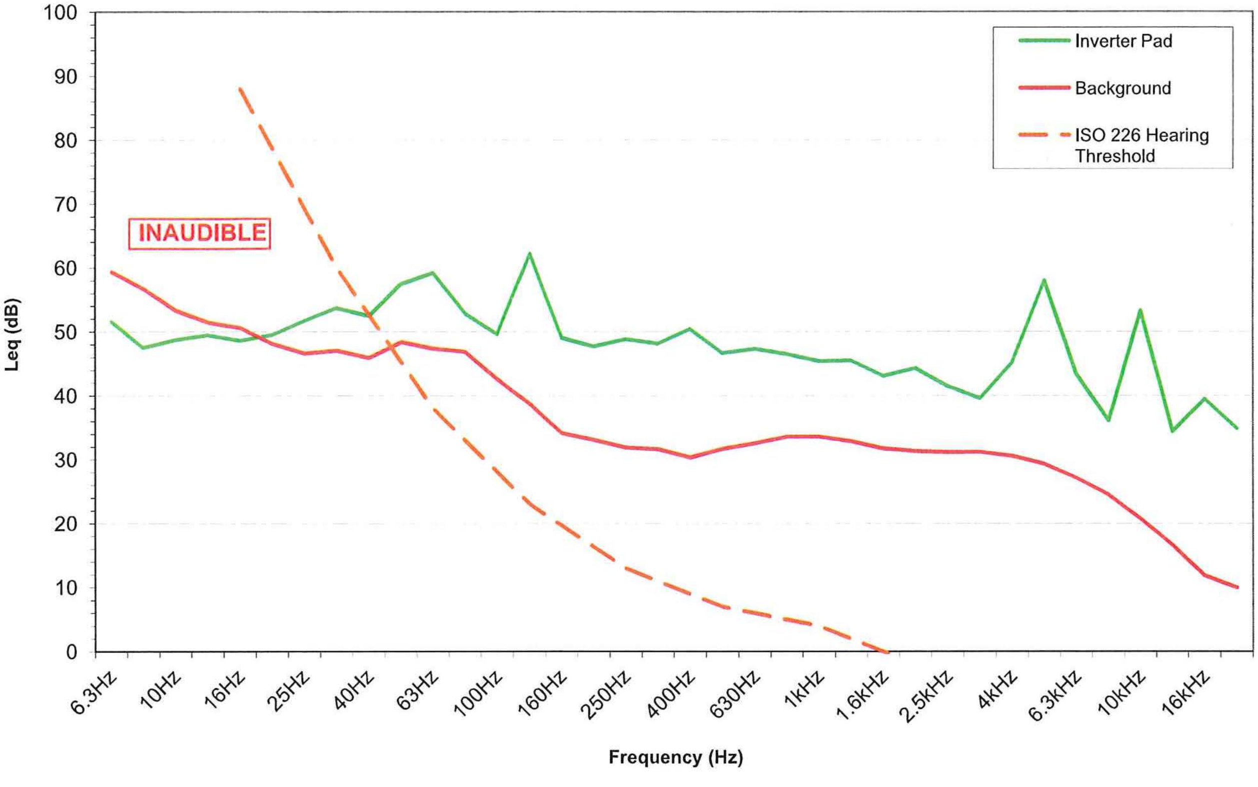


Figure 11. Frequency Spectrum of Sound Levels (Leq) at a Distance of 10 Feet from the Inverter Pad at Site #3



3.4 Site 4 – Residential Solar at Mass. Audubon Society in Sharon

Facility Location:	Moose Hill Sanctuary, 293 Moose Hill Road, Sharon, MA
Facility Owner:	Massachusetts Audubon Society
System Capacity:	8.6 kW
Power Output During Monitoring:	4.2 kW
No. & Size Inverters:	(1) 5-kW inverter and (1) 3.6-kW inverter
Date Measured:	Friday October 26, 2012
Sky Cover:	50% (scattered clouds)
Winds:	Northwest 0-3 mph
Ground:	(42) Evergreen solar panels are mounted on the pitched roof of the two-story building and face south. The ground around the site is cleared and opens to the south with surrounding woods at a distance.
Background EMF:	None in occupied rooms (< 0.2 mG and < 5 V/m). In the basement storage space where the inverters were housed, a background magnetic field of 2 mG was present and the background electric field was < 5 V/m.

EMF measurements were made inside the headquarters building of the Massachusetts Audubon Moose Hill Sanctuary. No sound measurements were made for this residential sized solar installation. The EMF measurements were made in rooms on the second floor of the building, the closest locations occupants have to the roof-mounted panels. Measurements were also made at the inverters inside the basement of the building, in a space not readily accessible to the public. The EMF measurements made at Site 4 are summarized in Tables 10 and 11.

Electric Fields

Electric field levels in the rooms on the top floor, nearest the roof-mounted solar panels are not elevated above background levels (< 5 V/m). In the basement, electric fields near the inverters (3 feet) are not elevated above background levels (< 5 V/m).

Magnetic Fields

Magnetic field levels in the rooms on the top floor, nearest the roof-mounted solar panels were in the very low range of 0.2 to 1.4 mG. Table 11 reveals that there are low-level magnetic fields at locations a few feet from inverters, around 6 to 10 mG. These levels dropped back to a floor of 2 mG at a distance of 6 to 9 feet from the inverters. Nearby electrical lines and other equipment in the basement created a background of 2 mG in the space where the inverters were housed.

TABLE 10

EMF LEVELS MEASURED INSIDE THE RESIDENTIAL BUILDING, TOP FLOOR AT SITE 4

Boundary Location	Magnetic Field (mG)	Electric Field (V/m)
North West Room	0.9	< 5
South West Room	1.4	< 5
South East Room	0.2	< 5
North East Room	0.5	< 5

TABLE 11

EMF LEVELS MEASURED INSIDE THE RESIDENTIAL BUILDING, BASEMENT AT SITE 4

Equipment Pad / Direction / Distance	Magnetic Field (mG)	Electric Field (V/m)
Parallel to Inverter Face / 3 feet	10	< 5
Parallel to Inverter Face / 6 feet	6	< 5
Parallel to Inverter Face / 9 feet	2	< 5
Parallel to Inverter Face / 15 feet	2	< 5
Perpendicular to Inverter Face / 3 feet	6	< 5
Perpendicular to Inverter Face / 6 feet	2	< 5
Perpendicular to Inverter Face / 9 feet	2	< 5
Perpendicular to Inverter Face / 15 feet	2	< 5

4.0 CONCLUSIONS

Sound pressure level and electromagnetic field (EMF) measurements were made at three utility-scale PV arrays with a capacity range of 1,000 to 3,500 kW under a full-load condition with sunny skies and the sun at approximately 40° azimuth. Measurements were taken at set distances from the inverter pads and along the fenced boundary of the PV array. Measurements were also made at set distances back from the boundary. Broadband and 1/3-octave band sound levels were measured, along with the time variation of sound levels from the equipment.

EMF Measurements were also made at one residential[6] PV installation with a capacity of 8.6 kW under a partial-load condition. PV array operation is related to the intensity of solar insolation. Less sunshine results in lower sound and EMF levels from the equipment, and no sound or EMF is produced at night when no power is produced. A description of acoustic terms and metrics is provided in Appendix A, and EMF terms and metrics are presented in Appendix B. These appendices provide useful information for interpreting the results in this report and placing them in context, relative to other sound and EMF sources.

Sound Levels

At the utility scale sites, sound levels along the fenced boundary of the PV arrays were generally at background levels, though a faint inverter hum could be heard at some locations along the boundary. Any sound from the PV array and equipment was inaudible and sound levels are at background levels at set back distances of 50 to 150 feet from the boundary.

Average L_{eq} sound levels at a distance of 10 feet from the inverter face varied over the range of 48 dBA to 61 dBA for Site 2 and Site 3 Inverters[7], and were higher in the range of 59 to 72 dBA for Site 1 Inverters. Along the axis perpendicular to the plane of the inverter face and at distances of 10 to 30 feet, sound levels were 4 to 13 dBA higher compared to levels at the same distance along the axis parallel to the plane of the inverter face. At a distance of 150 feet from the inverter pad, sound levels

[6] Only EMF measurements were made at the residential site.

[7] The same make of inverters were used at Sites 2 and 3.

approached background levels. Sound level measurements generally followed the hemispherical wave spreading law (-6 dB per doubling of distance).

The time domain analysis reveals that 0.1-second L_{eq} sound levels at a distance of 10 feet from an inverter pad generally varied over a range of 2 to 6 dBA, and no recurring pattern in the rise and fall of the inverter sound levels with time was detected. The passage of clouds across the face of the sun caused cooling fans in the inverters to briefly turn off and sound levels to drop 4 dBA.

The 1/3-octave band frequency spectrum of equipment sound at the close distance of 10 feet shows energy peaks in several mid-frequency and high-frequency bands, depending on the inverter model. Tonal sound was found to occur in harmonic pairs: 63/125 Hz; 315/630 Hz; 3,150/6,300 Hz; and 5,000/10,000 Hz. The high frequency peaks produce the characteristic "ringing noise" or high-frequency buzz heard when one stands close to an operating inverter. The tonal sound was not, however, audible at distances of 50 to 150 feet beyond the PV array boundary, and these tonal peaks do not appear in the background sound spectrum. All low-frequency sound from the inverters below 40 Hz is inaudible, at all distances.

Electric Fields

The International Commission on Non-Ionizing Radiation Protection has a recommended exposure limit of 4,200 V/m for the general public. At the utility scale sites, electric field levels along the fenced PV array boundary, and at the locations set back 50 to 150 feet from the boundary, were not elevated above background levels (< 5 V/m). Electric fields near the inverters were also not elevated above background levels (< 5 V/m).

At the residential site, indoor electric fields in the rooms closest to the roof-mounted panels and at locations near the inverters were not elevated above background levels (< 5 V/m).

Magnetic Fields

The International Commission on Non-Ionizing Radiation Protection has a recommended exposure limit of 833 mG for the general public. At the utility scale sites, magnetic field levels along the fenced PV array boundary were in the very low range of 0.2 to 0.4 mG. Magnetic field levels at the locations

50 to 150 feet from the array boundary were not elevated above background levels (<0.2 mG). There are significant magnetic fields at locations a few feet from inverters, in the range of 150 to 500 mG. At a distance of 150 feet from these utility-scale inverters, these fields drop back to very low levels of 0.5 mG or less, and in many cases to background levels (<0.2 mG). The variation of magnetic field with distance generally shows the field strength is proportional to the inverse cube of the distance from equipment.

At the residential site, indoor magnetic field levels in the rooms closest to the roof-mounted panels were in the low range of 0.2 to 1.4 mG. There are low-level magnetic fields at locations a few feet from the inverters, in the range of 6 to 10 mG. At a distance of no more than 9 feet from the inverters, these fields dropped back to the background level at the residential site of 2 mG. Due to the relatively high background level in the residential site basement where the inverters were housed, the relationship of magnetic field strength to distance from the inverters could not be discerned.

APPENDIX A
ACOUSTIC TERMS AND METRICS

All sounds originate with a source – a human voice, vehicles on a roadway, or an airplane overhead. The sound energy moves from the source to a person's ears as sound waves, which are minute variations in air pressure. The loudness of a sound depends on the **sound pressure level**[8], which has units of decibel (dB). The **decibel scale** is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. On this scale, the quietest sound we can hear is 0 dB, while the loudest is 120 dB. Every 10-dB increase is perceived as a doubling of loudness. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 dB to 90 dB.

A property of the decibel scale is that the numerical values of two separate sounds do not directly add. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB) on the decibel scale, not a doubling to 140 dB. In terms of sound perception, 3 dB is the minimum change most people can detect. In terms of the human perception of sound, a halving or doubling of loudness requires changes in the sound pressure level of about 10 dB; 3 dB is the minimum perceptible change for **broadband** sounds, i.e. sounds that include all frequencies. Typical sound levels associated with various activities and environments are presented in Table A-1. The existing sound levels at a PV project site are determined primarily by the proximity to roads and highways, the source of traffic noise. Sound exposure in a community is commonly expressed in terms of the **A-weighted sound level (dBA)**; A-weighting approximates the frequency response of the human ear and correlates well with people's perception of loudness.

The level of most sounds change from moment to moment. Some are sharp impulses lasting one second or less, while others rise and fall over much longer periods of time. There are various measures of sound pressure designed for different purposes. The equivalent sound level $\mathbf{L_{eq}}$ is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the energy-average sound

[8] The sound pressure level is defined as $20 * \log_{10}(P/P_o)$ where P is the sound pressure and P_o is the reference pressure of 20 micro-Pascals (20 μPa), which by definition corresponds to 0 dB.

level and it includes in its measure all of the sound we hear. EPA has determined that the **L_{eq}** average sound level correlates best with how people perceive and react to sound.[9]

To establish the background sound level in an area, the **L_{90}** metric, which is the sound level exceeded 90% of the time, is typically used. The **L_{90}** can be thought of as the level representing the quietest 10% of any time interval. The **L_{90}** is a broadband sound pressure measure. By definition, the **L_{90}** metric will filter out brief, loud sounds, such as intermittent traffic on a nearby roadway.

Sound pressure level measurements typically include an analysis of the sound spectrum into its various frequency components to determine tonal characteristics. The unit of frequency is **Hertz (Hz)**, measuring the cycles per second of the sound pressure waves. In the physiology of human hearing, every octave jump of a tone corresponds to a doubling of the sound frequency in Hz. For example, Middle-C on a piano has a frequency of approximately 260 Hz. High-C, one octave above, has a frequency of approximately 520 Hz. The hearing range for most people is 20 Hz to 20,000 Hz. In acoustic studies, the sound spectrum is divided into **octave bands** with center frequencies that are an octave apart, or 1/3-octave bands with center frequencies that are 1/3 of an octave apart. There are 11 whole octave bands centered in the audible range from 20 to 20,000 Hz. For the extended frequency range of 6.3 Hz to 20,000 Hz used in this study, there are 36 1/3-octave bands.

Low-frequency sound generally refers to sounds below 250 Hz in frequency, which is close to the tone of Middle-C on a piano. **Infrasound** is low-frequency sound at frequencies below 20 Hz, a sound wave oscillating only 20 cycles per second. For comparison, the lowest key on a piano produces a tone of 28 Hz, and human speech is in the range of 500 to 2,000 Hz. The hearing threshold for infrasound at 16 Hz is 90 decibels (dB).[10] We are enveloped in naturally occurring infrasound, which is inaudible. Infrasound is always present in the outdoor environment due to sounds generated by air turbulence, shoreline waves, motor vehicle traffic and distant aircraft.

---

9 U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Publication EPA-550/9-74-004.

10 International Standards Organization, ISO 226:2003.

TABLE A-1

VARIOUS INDOOR AND OUTDOOR SOUND LEVELS

Outdoor Sound Levels	Sound Pressure (μPa)		Sound Level (dBA)	Indoor Sound Levels
	6,324,555	-	110	Rock Band at 5 m
Jet Over-Flight at 300 m		-	105	
	2,000,000	-	100	Inside New York Subway Train
Gas Lawn Mower at 1 m		-	95	
	632,456	-	90	Food Blender at 1 m
Diesel Truck at 15 m		-	85	
Noisy Urban Area--Daytime	200,000	-	80	Garbage Disposal at 1 m
		-	75	Shouting at 1 m
Gas Lawn Mower at 30 m	63,246	-	70	Vacuum Cleaner at 3 m
Suburban Commercial Area		-	65	Normal Speech at 1 m
Quiet Urban Area -- Daytime	20,000	-	60	
		-	55	Quiet Conversation at 1m
Quiet Urban Area--Nighttime	6,325	-	50	Dishwasher Next Room
		-	45	
Suburban Area--Nighttime	2,000	-	40	Empty Theater or Library
		-	35	
Rural Area--Nighttime	632	-	30	Quiet Bedroom at Night
		-	25	Empty Concert Hall
Rustling Leaves	200	-	20	Average Whisper
		-	15	Broadcast and Recording Studios
	63	-	10	
		-	5	Human Breathing
Reference Pressure Level	20	-	0	Threshold of Hearing

Notes:
μPa - Micropascals describe sound pressure levels (force/area).
dBA - A-weighted decibels describe sound pressure on a logarithmic scale with respect to 20 μPa.

APPENDIX B

EMF TERMS AND METRICS

An electromagnetic field (**EMF**) is the combination of an **electric field** and a **magnetic field.** The electric field is produced by stationary charges, and the magnetic field by moving charges (currents). From a classical physics perspective, the electromagnetic field can be regarded as a smooth, continuous field, propagated in a wavelike manner. From the perspective of quantum field theory, the field is seen as quantized, being composed of individual particles (photons).

EMFs are present everywhere in our environment but are invisible to the human eye. For example, electric fields are produced by the local build-up of electric charges in the atmosphere associated with thunderstorms, and the earth's magnetic field causes a compass needle to orient in a North-South direction and is used for navigation. Besides natural sources, the electromagnetic spectrum also includes fields generated by man-made sources. For example, the electricity that comes out of every power socket has associated low frequency EMFs. A photovoltaic (PV) project generates low-frequency EMFs from inverters (that convert DC-current to AC-current), transformers (that step-up the PV project voltage), and current-carrying cables. The EMFs from PV project components are classified as "non-ionizing radiation," because the electromagnetic waves have low-energy quanta incapable of breaking chemical bonds in objects through which they pass.

The strength of the **electric field** is measured in volts per meter (**V/m**). Any electrical wire that is charged will produce an associated electric field. This field exists even when there is no current flowing. The higher the voltage, the stronger the electric field at a given distance from the wire. Magnetic fields arise from the motion of electric charges. The strength of the **magnetic field** is measured by the magnetic flux density in milli-Gauss (**mG**). In contrast to electric fields, a magnetic field is only produced once a device is switched on and current flows. The higher the current, the greater the strength of the magnetic field produced at a given distance. EMFs are strongest close to a source, and their strength rapidly diminishes with distance from it. Field strength is generally proportional to the inverse cube of the distance.

Typical household fixtures and appliances produce both types of fields. For example, at a distance of one foot from a fluorescent light, electric and magnetic fields of 50 V/m and 2 mG, respectively, are measured. At a distance of 1 inch from the power cord for an operating personal computer, fields of 40 V/m and 1 mG, respectively, are detected.

There are no federal, State or local regulatory exposure limits for electric or magnetic fields that apply to solar photovoltaic arrays. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has recommended exposure limits of 4,200 V/m and 833 mG for the general public. ICNIRP is an organization of 15,000 scientists in 40 nations who specialize in radiation protection, and their recommendations are routinely used in EMF exposure studies.

An Exploration of Property-Value Impacts Near Utility-Scale Solar Installations

Leila Al-Hamoodah, Kavita Koppa, Eugenie Schieve, D. Cale Reeves, Ben Hoen, Joachim Seel and Varun Rai

Abstract

Nationwide, electric utilities increasingly rely on solar installations as part of their energy portfolio. This trend begs the question of how they affect nearby home values. Understanding whether these installations are amenities or disamenities and the scale thereof will help policymakers, solar developers, and local utilities to site and build solar installations with minimal disruption to nearby communities. This paper investigates where large solar installations are located, the housing and income characteristics of the surrounding areas, and if the installations affect nearby residential property values. We approach these questions using geospatial analysis and a survey of residential property assessors. Geospatial analysis examines both housing density and median income surrounding these facilities, while the survey gauges local assessors' opinions of the impacts of these installations on property values. Property values can be a useful proxy for various non-market goods like scenic value, tax benefits, and of particular interest here, both positive and negative perceptions of utility-scale solar facilities. Our results show that while a majority of survey respondents estimated a value impact of zero, some estimated a negative impact associated with close distances between the home and the facility, and larger facility size. Regardless of these perceptions, geospatial analysis shows that relatively few homes are likely to be impacted. Though only one component of a larger analysis, these property value impacts are likely to be of growing interest as more solar facilities are built. This exploration of impacts will help inform solar developers, public officials, home assessors, and homeowners about the effects and implications of solar energy infrastructure.

Introduction

The installation of utility-scale solar facilities continues at a rapid pace across the United States, with over ten gigawatts of new photovoltaic (PV) capacity installed in 2016 alone (Bollinger et al., 2017: p. 1; Perea et al., 2016). These utility-scale PV installations, often informally called solar farms (Fehrenbacher, 2016; New York State PV Trainers Network, 2017), are defined here to include installations one megawatt (MW_{AC}) and larger. Like other power plants, these utility-scale solar installations have the potential to impact nearby home values. The potential adverse impact on home prices due to the installation of solar utilities is relevant to solar developers, public officials, home appraisers, and homeowners, yet no peer-reviewed literature has directly addressed the subject to date.

The primary research question is: Do utility-scale solar PV installations impact the value of nearby homes? This study contributes to the existing literature on amenities and disamenities by extending the research to utility-scale solar PV installations. Amenities are considered to be features that increase the value of a home, while disamenities have the opposite effect. The information in this study tackles relevant issues for solar stakeholders and identifies questions for future research.

Background and Literature Review

Residential housing literature covers a broad range of amenities and disamenities, including open-space and water views (Anderson & West, 2006; Bond et al., 2002), as well as landfills, coal-fired power plants, shale gas production facilities, oil and sour gas facilities, and transmission lines (Anderson et al., 2007; Des Rosiers, 2002; Case et al., 2006; Muehlenbachs et al., 2014; Davis, 2008; Locke, 2012), respectively. Research on High Voltage Transmission Lines (HVTLs), for example, has found adverse effects on proximate home values to be present in some analyses, while not in others, and, in general to be sensitive to micro-siting differences (Anderson et al., 2007; Des Rosiers, 2002). Alternatively, research on power plants and natural gas facilities has found that increasing proximity to the disamenity correlates to a greater change in property values (Davis, 2008; Boxall, 2005).

In the case of utility-scale wind turbines, much of the available research in the U.S. has not found consistent or compelling evidence of sales price impacts on homes (Hoen et al., 2015; Hoen & Atkinson-Palombo, 2016; Lang & Opaluch, 2013). In fact some studies have documented wind turbines' connection to increased property tax revenues to local school districts (and local taxing entities), which might be connected to increased property values by extension (Loomis & Aldeman, 2011). Additional benefits of utility-scale wind can include job growth, supply industry growth, landowner profits, and road improvement, most of which are an effect of increased tax revenue from the large installations (Loomis et al., 2016). Recent survey results suggest that U.S. residents living near wind facilities prefer living next to a wind turbine over more conventional energy infrastructure, such as coal, nuclear and natural gas (Hoen et al., 2018). Respondents in the same survey who lived within a half a mile of a wind project expressed similar preferences between living next to a wind (37 percent) or a solar facility (24 percent), with roughly a third having no opinion, but these differences were not statistically significant. This, therefore, suggests that disamenity research on wind's effects on property values, a proxy for local preferences, might provide a reasonable basis for comparison to utility-scale solar facilities.

To the best of the authors' knowledge, no existing peer-reviewed research provides quantitative evidence of property value impacts associated with utility-scale solar facilities, but existing studies address related areas. Previous research on residential PV installations, for example, has indicated that buyers place a premium on homes with PV systems (Hoen et al., 2017). In addition, available literature has explored public opinions surrounding utility-scale solar installations and perceived property value impacts. A survey by Carlisle et al. found that around 80 percent of U.S. survey respondents support the development of large-scale solar facilities both in the U.S. generally, and within their own county (2015). However, this survey also indicated that 70 percent of respondents believe these installations will decrease property values. A public opinion survey on solar facilities by the Idaho National Laboratory found that 43 percent of respondents in the southwest United States believed that a view of a large-scale solar facility would decrease the value of their home, while 23 percent believed it would increase the value (Idaho National Laboratory, 2013). In the same survey, one fifth of respondents indicated that a buffer of less than a mile would be acceptable between utility-scale solar facilities and residential areas (21 percent), while the remainder believed the buffer should be between one and five miles (26 percent), six and ten miles (16 percent), more than ten miles (21 percent), or were unsure or had no preference (16 percent). Notably, respondents in the southwest sample were more open to proximity to solar installations within one mile of a residential area (26 percent) than was the national sample. Finally, select appraiser research conducted in North Carolina has found that utility-scale solar facilities have no impact on property values (Kirkland, 2006).

In addition to the above research, various media outlets provide evidence of a perceived impact on home prices by homeowners. News articles from California, North Carolina, and Tennessee, for example, identify communities that expressed displeasure over solar installations proposed or constructed near their homes (Lunetta, 2017; McShane, 2014; West, 2015). Online forums also indicate concern by homeowners about the potential impact of a solar farm on home values (Zillow, 2017; Realtor.com, 2011; HackettstownLiFE, 2011). Some common concerns over proximity to solar farms include changes in property values due to the solar installation's appearance, safety or health concerns, or changes in the environment, such as water run-off or displaced wildlife (McShane, 2014; HackettstownLiFE, 2011; West, 2015; Appraisers Forum, 2015). Other homeowners expressed no concern about living near a solar facility, or even preferred solar farms to alternative uses like animal agriculture, wind farms, industrial uses, or housing development (Zillow, 2017; HackettstownLiFE, 2011). Online forums also indicate that appraisers have varying opinions about whether solar installations may constitute a disamenity (Appraisers Forum, 2015).

Building upon the available amenity, disamenity, and public opinion literature, this study explores the impact of utility-scale solar installations on home values using two complementary analytical approaches: a geospatial solar-siting analysis and a survey of property assessors. First, the solar-siting analysis examines both housing density and median income surrounding these solar facilities. This will provide context on the scope of potential impacts due to proximity to solar, by identifying the number of homes that may be affected and the characteristics of those residents. Next, a survey of residential property assessors was conducted to evaluate the scale and direction of those impacts, if any. This research seeks to understand both the characteristics of utility-scale solar installations as they relate to neighboring homes, and any potential impact on home prices due to proximity to a solar installation. The remainder of the paper outlines the data, methodology, and results of each analytical approach. It then identifies limitations and suggestions for further research, and concludes with recommendations for policymakers and other stakeholders.

Solar-Siting Analysis

The solar-siting analysis assesses the scope and equity distribution of utility-scale solar's potential impact on nearby property values. It does so by considering the number of homes that may be affected by proximity to solar. To do this, we mapped the locations for utility-scale solar facilities in ArcGIS 10.5, and combined it with housing census and median income data. The median income data was compared to the national average to determine if the siting of utility-scale solar raises any equity concerns.

Data

The primary data for this analysis is 956 unique solar sites completed in 2016 or earlier with confirmed latitude and longitude coordinates. This list was developed using data from the U.S. Energy Information Administration's (EIA) Form 860 and proprietary data from Lawrence Berkeley National Lab (LBNL), containing a total of 1,805 solar installations. Many utility-scale solar sites were included in both datasets, but sometimes differed in coordinates or total capacity due to aggregation. To ensure the accuracy of the latitude and longitude coordinates for these sites, the research team reviewed satellite images of each site. Installations were excluded if the provided coordinates were not directly on top of solar panels in satellite imagery. Where the EIA and LBNL sources reported different coordinates, the coordinates that more accurately aligned with the center of the array were used. Finally, entries in the EIA's database with a shared plant code ID were combined into a single facility with their summed nameplate capacity.

Ultimately we used 956 out of 1,805 installations that had been cleaned and compiled from the EIA and LBNL sources in this mapping analysis. In general, this sample of facilities used in the analysis has a similar distribution of nameplate capacity to the 1,805 installation sites. The average nameplate capacity of the full sample (1,805 installations) and the selection used in our analysis (956 installations) were not statistically significantly different (p-value = 0.5). For a complete comparison of the analyzed and total solar installation descriptive statistics, see **Appendix C.1.** The location of the facilities is also similarly distributed, with California hosting the most facilities, followed by North Carolina, in both sets. Thus, these 956 sites are representative of the total 1,805 installations from the EIA and LBNL sources. **Figures C.2 and C.3** in the appendix present histograms of total nameplate capacity for the two groups. The minimum, median, average, and maximum capacity of these 956 installations is $0.4MW_{AC}$, $4MW_{AC}$, $12MW_{AC}$, and $314MW_{AC}$, respectively.[1] These installations were then broken into categories based on capacity: 1-4.99MW, 5-9.99MW, 10-19.99MW, 20-49.99MW, 50-99.99MW, and 100+ MW.

[1] While we define utility-scale solar as facilities 1MW and higher, three sites under 1MW were included in the underlying EIA database. These were included in our dataset as well.

These GIS data are merged with data on housing density and median household income estimates throughout the United States. We used data on housing population density and median household income from the American Community Survey's 5-Year estimates of unweighted sample housing units and median household income by census block group. We joined estimated housing units and median household income per block group to TIGER/Line Shapefiles provided by the U.S. Census Bureau and displayed them as a density across the United States.

Methodology

To begin this analysis, the latitude and longitude coordinates for the verified operating solar facilities were plotted in ArcGIS. Starting from the coordinates of the solar facility, radii of 100 feet up to three miles were used to create select areas, or buffers, around the solar facilities. To account for the area of the solar facility itself, where no home could possibly exist, a circular area originating from the center of the facility was created, which we call here a "pseudo-polygon" (See **Figure A.1**). These pseudo-polygons were calculated by estimating the average area of utility-scale solar installations (the team assumed an average of 6 acres/MW), and then calculating the radius needed to equal the estimated area required. Pseudo-polygons were created for the following categories: 1MW = 1-4.99MW (6 acre circle); 5MW = 5-9.99MW (30 acres), 10MW = 10-19.99MW (60 acres); 20MW = 20-49.99MW (120 acres); 50MW = 50-99.99MW (300 acres); and 100MW = 100MW+ (600 acres) facilities. For the complete pseudo-polygon calculations, see **Appendix C.4**. Outside the pseudo-polygon, buffer zones of 100 feet, 500 feet, 1,000 feet, one half mile, one mile, and three miles were then used to estimate distances from the facilities. For a full extent of the buffer zones, see **Appendix C.5**. Estimates of the number of homes that exist within each zone were calculated, using the proportion of the block groups which overlapped with the distance radii. The number of homes within each distance radii were summed, by combining the buffer zones with aggregate housing data block group polygons. In some cases, those polygons did not fall completely within the buffer zones. In that case, housing units were estimated by comparing the area of the block group to the area intersecting the buffer zone, and proportioning the total housing units for the block group accordingly.

Albuquerque Solar Energy Center
Distance Radii and Pseudo-Polygon

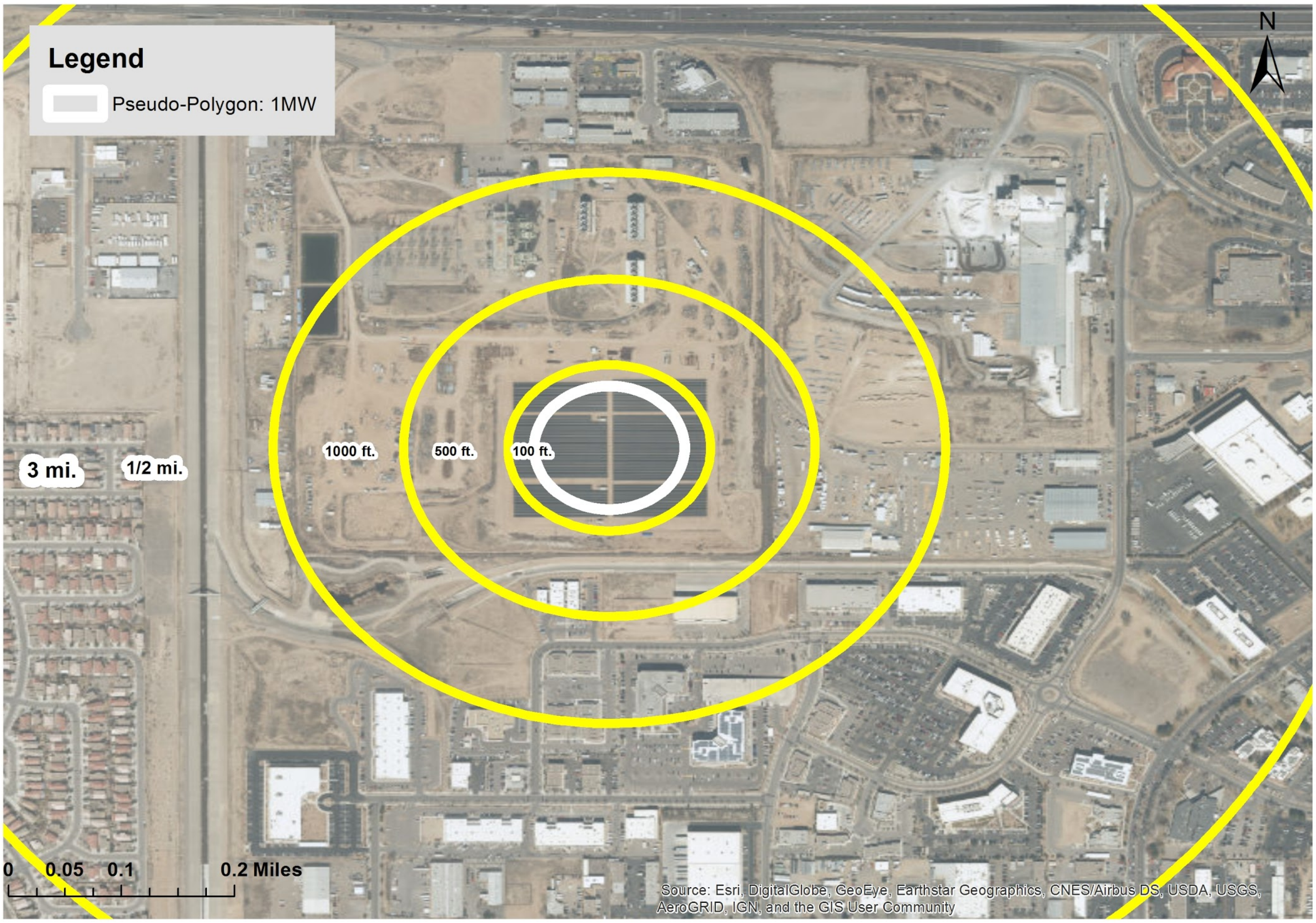


Figure A.1: *A satellite image of a pseudo-polygon (white) and the buffers (yellow) beginning at 100ft out to ½ mile are shown above. The pseudo-polygon buffers the area of the facility to account for the area where no homes can exist. As presented above, the pseudo-polygon does not encompass the entire facility, making the polygons a conservative estimate of the true facility size.*

The next analysis with ArcGIS sought to compare the median household income of residents living near utility-scale solar installations to that of the national average. Given the rapid growth of utility-scale solar within the past decade, the income of residents living nearby utility-scale solar utilities serves as an important indicator of equity in the siting of those facilities. This may be due, in part, to lower land prices. If solar were to be determined a disamenity, disproportionate build-out of utility-scale solar in lower-income communities could raise concerns about equity. In contrast, if proximity to solar is found to be an amenity, presence near lower income communities could increase home values. To determine whether or not utility-scale solar is located in communities which earn less than the national median income, we compared 2015 median income figures by block group within three miles of utility-scale solar installations to the national median income in the same year.

As above, 2015 U.S. median household income by block group data from the IPUMS NHGIS Database was joined with 2015 Block Group TIGER/Line shapefiles in ArcGIS. Of the median income data, approximately 6,484 of the 217,203 block groups (about 3 percent) did not report median incomes. As with housing density, most distance radii capture multiple block groups with differing reported median incomes. To estimate the median income at every distance, each distance radius was broken down by its percent of block groups. The median income of each weighted block group was then totaled to find a unique median income for every distance radius. In ArcGIS, this was accomplished using the same installation data and pseudo-polygons as above, and by intersecting these datasets with block group median income. A weighted sum of median income surrounding each facility at every buffer distance was calculated by determining the area of the block group intersected in proportion to the rest of the buffer area. The proportion of the block group area was then multiplied by its median income. Finally, the median income for the total area of the buffer was summed using the facility ID.

Results

Our analysis indicates that the greatest <u>total</u> number of estimated homes in proximity to solar installations is within three miles (cumulatively) of 1MW facilities (534,725 homes), while the smallest number of estimated homes is within 100 feet of 100MW facilities (ten homes). Heat maps of housing population with utility-scale solar installation locations both nationwide and California alone are presented in **Appendices C.6** and **C.7**. An estimate of the total number of homes within three miles of the 956 solar facilities used in our analysis is presented in **Table A.1** (for an extrapolation of the total number of homes within three miles of all 1,805 facilities, see **Appendix C.7**). These findings are consistent with the authors' expectations that more homes will be located near smaller facilities, where areas of higher population densities can only permit small facilities, and accordingly that the largest facilities will be located in rural regions. Not surprisingly, the total number of homes increases as distance from the facility, and therefore land area, increases. Further, an estimate of the <u>average</u> number of homes residing within the various distance radii of the capacity range of solar facilities is shown in **Table A.2**. These findings show similar trends: more homes will be found further from facilities and near smaller facilities. An average of 22 homes are located within three miles of a 1MW facility, while less than one home will be located within 100 feet of a 100MW facility, on average. Finally, a stacked bar of new utility-scale solar installations by year online and capacity size is presented in **Chart A.1**. This suggests that while the total number of all facilities is rapidly increasing, the largest facilities, 50MW and 100MW+ appear to be increasing the most rapidly.

Table A.1: *The table below provides a count of the total number of homes in the U.S. located within certain distances of utility-scale solar. As indicated below, housing estimates increase as the utility-scale solar installations decreases in MW capacity and distance from the facility increases.*

Table A.1
Total Number of Homes Near Select Utility-Scale Solar Installations in the United States
by Proximity and Installation Size

Distance from Installation	Facility Size					
	1 - 4.99MW	**5 - 9.99MW**	**10 - 19.99MW**	**20 - 49.99MW**	**50 - 99.99MW**	**100MW**
	n = 521	n = 230	n = 83	n = 72	n = 23	n = 27
100 feet	184	129	42	41	14	10
500 feet	821	313	90	69	20	13
1000 feet	2,341	664	195	115	30	17
1/2 mile	14,146	2,747	942	438	77	34
1 mile	58,497	9,675	3,349	1,407	204	72
3 miles	534,725	87,597	27,983	10,970	1,890	419

Note: These housing counts are inlcusive of estimated homes near 956 utility-scale solar installations with verified coordinates. It does not represent a count housing near all known utility-scale solar installations in the United States.

Sources: U.S. Census Bureau 2012-2016 American Community Survey 5-Year Estimates, Unweighted Sample Housing Units. Solar installation coordinates based on EIA's Form 860 2016 Early Release and Lawrence Berkeley National Lab's proprietary Solar Installation data.

Table A.2: *The table below provides a count of the average number of homes within a certain distances of individual utility-scale solar installations. The actual number of homes will vary by facility, but this table may serve as a useful tool for estimating the number of homes impacted by utility-scale solar*

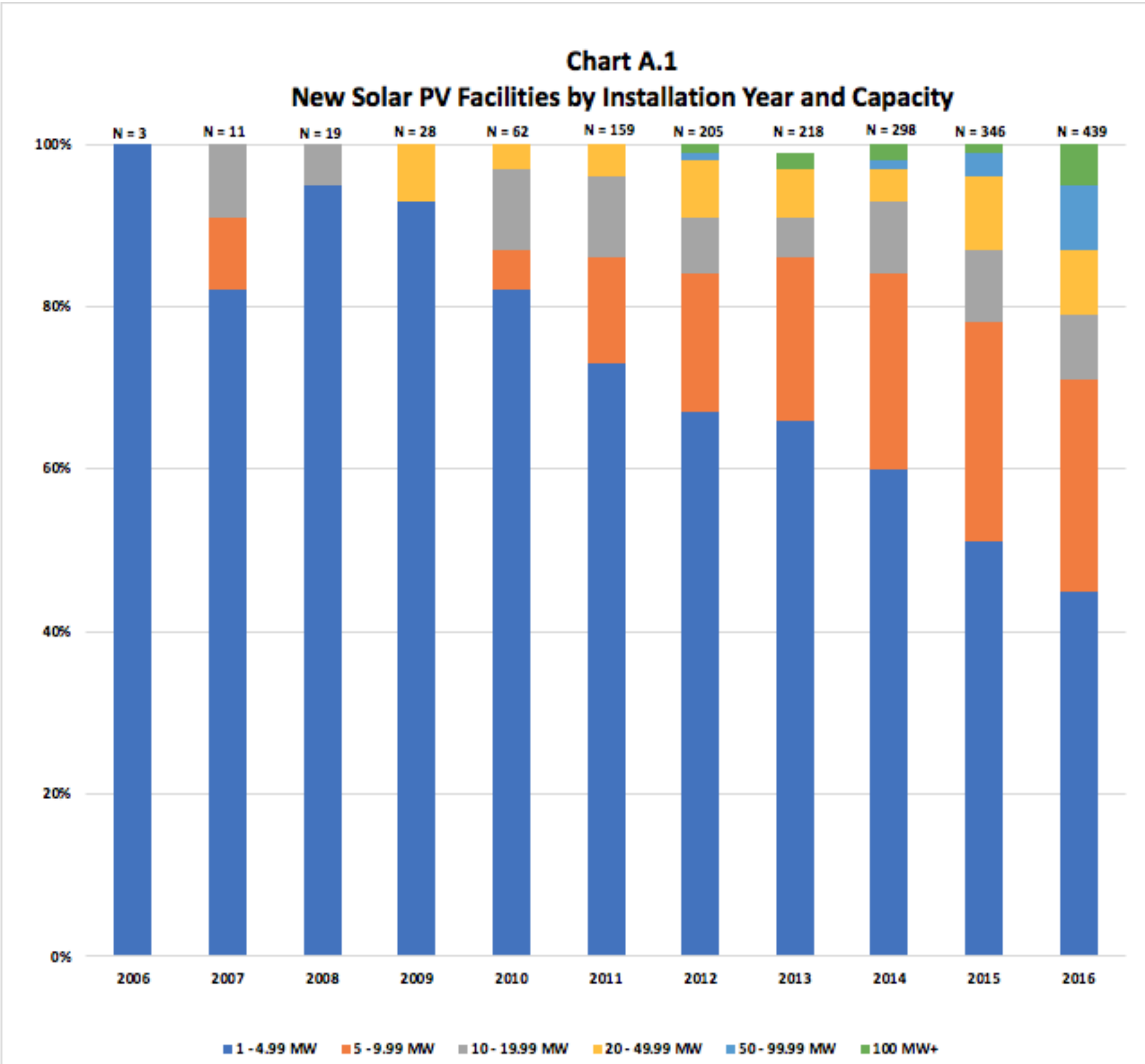
Table A.2
Average Number of Homes Near Select Utility-Scale Solar Installations in the United States
by Proximity and Installation Size

Distance from Installation	Facility Size					
	1 - 4.99MW	**5 - 9.99MW**	**10 - 19.99MW**	**20 - 49.99MW**	**50 - 99.99MW**	**100MW+**
	n = 521	n = 230	n = 83	n = 72	n = 23	n = 27
100 feet	0.30	0.48	0.41	0.46	0.53	0.26
500 feet	0.98	0.97	0.76	0.73	0.68	0.27
1000 feet	2.23	1.72	1.45	0.94	0.91	0.34
1/2 mile	6.86	4.89	4.88	2.05	1.96	0.57
1 mile	13.25	9.64	10.24	3.53	4.00	1.11
3 miles	21.57	21.67	23.84	12.89	12.27	2.22

Note: These average housing counts are based on estimated homes near 956 utility-scale solar installations with verified coordinates only. They do not include all known utility-scale solar installations in the United States.

Sources: U.S. Census Bureau 2012-2016 American Community Survey 5-Year Estimates, Unweighted Sample Housing Units. Solar installation coordinates based on EIA's Form 860 2016 Early Release and Lawrence Berkeley National Lab's proprietary Solar Installation data.

Chart A.1: The chart below provides a count of utility-scale solar shown by capacity and year online, shown as a percentage. While 1MW are steadily increasing, larger utility-scale solar installations appear to be gaining prominence.

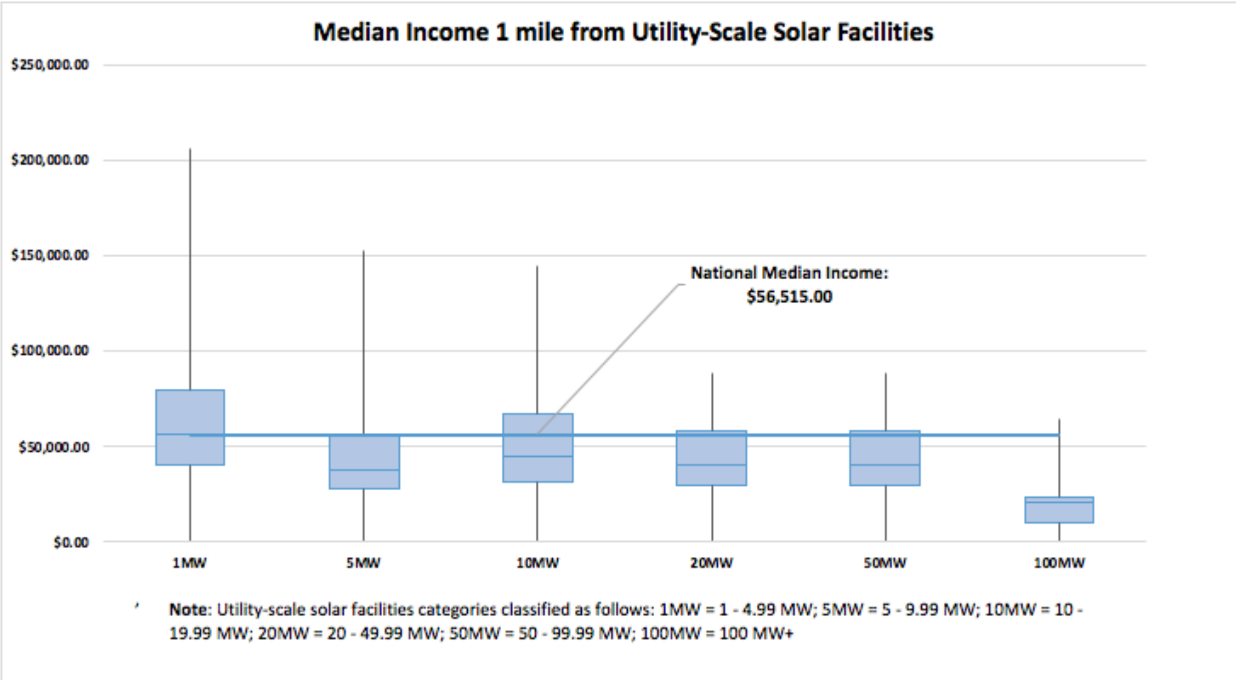


These housing density estimates inform the survey analysis discussed below by estimating the magnitude of property value impacts, if present. These total housing estimates are conservative as they only consider the 956 confirmed utility-scale solar sites, rather than all known solar sites in the United States. While an extrapolation is made in the appendix (**C.8**), the estimates are less certain. Further analysis should be expanded to all utility-scale solar sites in the U.S. with corrected coordinates, and continued analysis that stretches beyond 2015-2016 will be critical given the rapid growth of utility-scale solar. In regards to the average housing density estimates, they follow the trend that fewer homes will be expected at increasing facility sizes and decreasing distance from a facility. This housing data can be used to estimate the number of transactions that occur within these buffer zones. Transaction estimates can be adjusted based on region and current market trends.

This analysis also considered median household incomes surrounding solar installations. The estimates of 2015 median income by block group is displayed below as a box plot with a horizontal line indicating the national median household income for that year ($56,515) (See **Chart A.2**). The highest median income was located within three miles of 1MW facilities ($59,579), while the lowest median income was located within one mile of 50MW facilities ($34,223). Most notable were the consistencies of the median income near 1MW facilities with that of the national average; and that the interquartile ranges for 100MW facilities are lower than the interquartile ranges of 50MW facilities, at all distances. These findings highlight that larger facilities tend to be sited in areas with lower incomes. However, because only 27 100MW facilities were included in this analysis – in contrast to the 521 1MW facilities – the fewer observations will make the median income reported near the 27 100MW facilities more impactful to the analysis. Overall, less variability in median income of nearby residents was observed with increasing distance from a facility. Residents living within 100 feet to three miles of a 1MW utility-scale solar facility maintained relatively similar incomes ranging from approximately $57,000 to $59,000.

While not definitive, these findings raise preliminary concerns regarding equity in the locating of utility-scale solar. Our analyses suggest that the largest utility-scale solar facilities are most likely to be located in areas where residents earn lower incomes than the national average. This is consistent with the expectation that the largest facilities would require hundreds of acres of land, which will more likely be located in rural areas. Issues with unreported median incomes by some block groups influenced the calculations performed. An estimated median income of $58.89 within one mile of a 50MW facility was calculated here, but is unlikely. These low estimates are the result of unreported median income data in some block groups. While the null values were not included in the analysis, the values nevertheless affected the weighted sum calculations. Despite unreported median incomes, examination of the interquartile ranges provide valuable insight on the economic status of residents living near utility-scale solar. With the rapid expansion of utility-scale solar, our research suggests that property value impacts, whether positive, neutral or negative, could disproportionately affect homeowner’s with lower incomes.

Chart A.2: *These box plots display reported median income of all residents living within one mile of utility-scale solar installations. The horizontal line displays the national median income. In general the interquartile ranges of reported median income appear to decline as installation size increases. Extreme minimums are the result of unreported income by block groups, as noted above. For a complete overview of median income, see* ***Appendix C.***



Survey of Home Assessors

Data

In addition to evaluating the scope of potential property value impacts, this research sought to quantify the scale and direction of those impacts. We distributed an online survey to public sector property assessors in 430 unique counties identified by the EIA Form 860 data as having at least one utility-scale solar PV installation. The aim of this survey was to collect opinions as to the effects of utility-scale solar PV installations on property values. Survey questions sought to evaluate, a) whether assessors believe there is an impact on home prices from utility-scale solar installations, b) the scale and direction of those impacts, and c) the sources of those impacts. Assessors, appraisers and real estate agents were all considered as possible targets for this survey research. We ultimately selected assessors, or appraisers hired by the public sector (herein referred to jointly as “assessors”), because of their work as public servants responsible for providing assessments of property values, in accordance with professional standards.

The survey asked respondents to provide several control variables, including their state and county, years of professional experience, and whether their manual provides instructions regarding utility-scale solar PV installations. They were also asked to provide their opinion of solar energy in the United States, using a 7-point Likert scale. For a full copy of the survey, see **Appendix D.1**.

To address our research questions regarding possible property value impacts, respondents were asked to estimate the impact on residential property values of three sizes of solar PV installations – 1.5MW, 20MW and 102MW – at distances ranging from 100 feet to three miles from the nearest home. These questions took the form of sliders with a range of negative 50 percent to positive 50 percent. A satellite image indicating the approximate size of each installation was also provided as a visual aid. In preparing these questions, we hoped to capture actual adjustments made by assessors in their professional practice, but allowed for perceptions of potential impacts for those assessors that have not made such adjustments. Additionally, the respondents were asked to indicate on a 5-point Likert scale whether various features of solar installations, such as their size, height, and presence of a fence or other visual barriers, would have a positive or negative impact on property values.

This survey was determined by the University of Texas at Austin IRB to be exempt from review.[2] The survey was distributed via email to approximately 400 email addresses obtained via publicly available websites. In addition, 53 counties with high numbers of installations, high total PV solar capacity, and/or older installations were identified as high priority survey targets, and were selected for phone follow-up to request their county's participation. Phone follow-ups occurred over two weeks and not all counties were reached. This follow-up procedure motivated an additional eight responses.

[2] IRB Study Number 2017-12-0067 was determined to be exempt for the qualifying period 03/20/2018 to 03/19/2021.

Survey Results

Of the approximately 400 assessors contacted via email, 37 consented to participate in the survey (a 10 percent response rate, approximately). Survey respondents were geographically dispersed across the United States, and represented 23 states of the 42 known to have utility-scale solar facilities, according to the EIA Form 860. North Carolina provided the most respondents (8), followed by Florida (3), Massachusetts (2), Connecticut (2) and Utah (2). All other states represented had one respondent. Notably, no responses were recorded from California, despite efforts to contact 13 California counties by phone. Below, **Figure B.1** provides a map of responses by state. For a more detailed breakdown of response rates by state and question, see **Appendix D.2**.

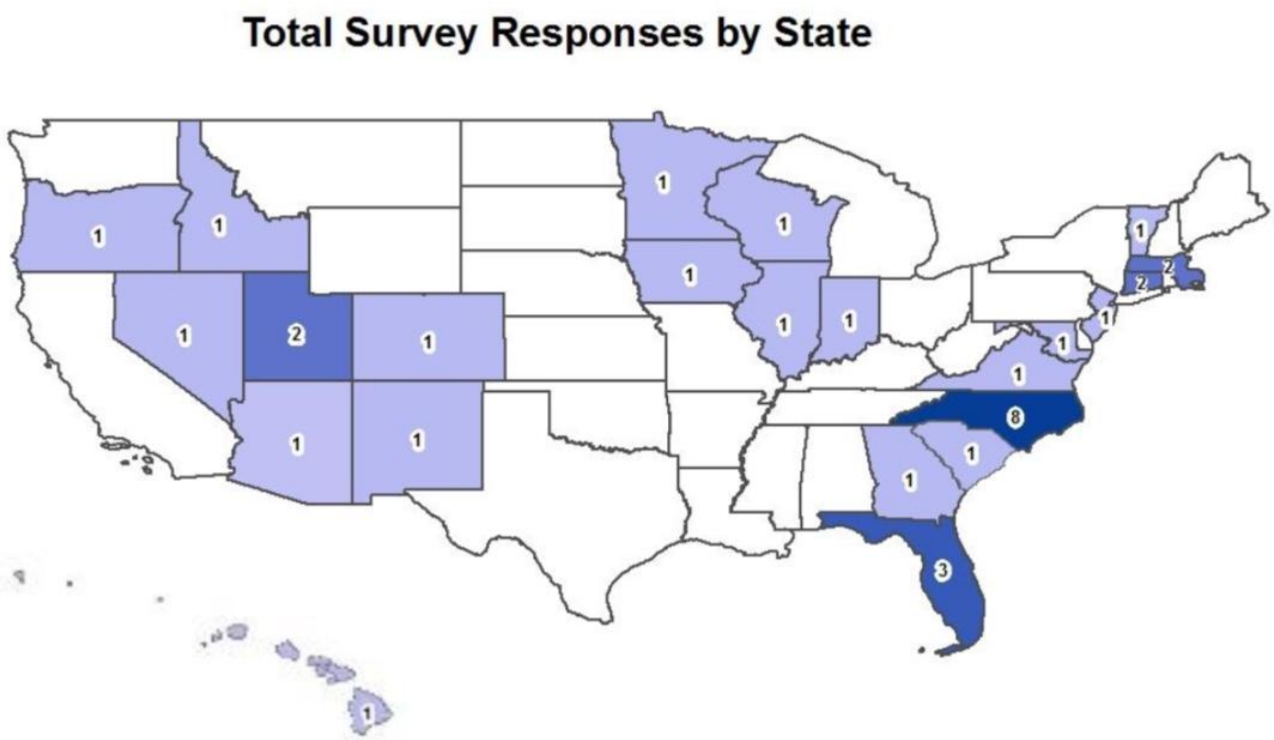
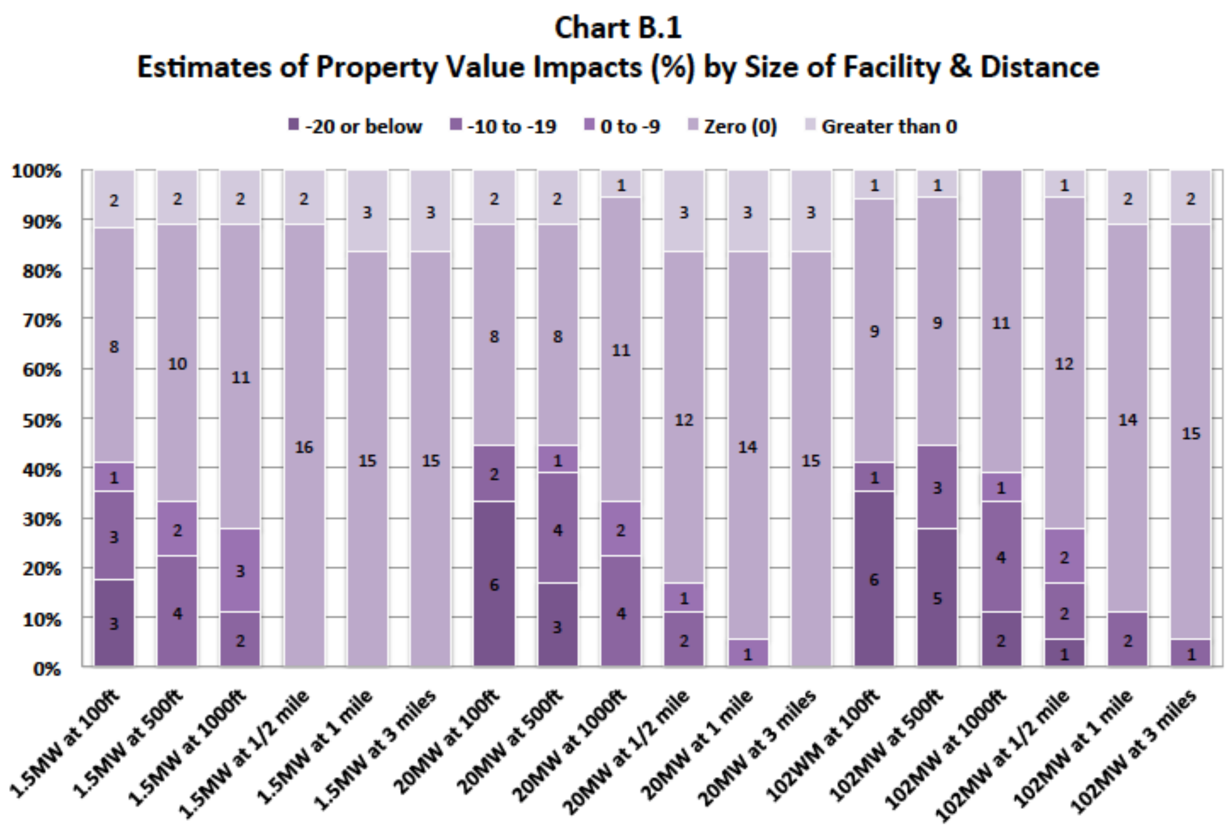


Figure B.1: *A map with the county of respondents by state is shown above.*

The number of responses varied per question, from a low of 18 to a high of 36, with more respondents providing information for control variables than for research questions surrounding estimates of property value impacts. Of the respondents that elected to participate, all were current assessors with between two years and over 40 years of assessment experience, and a mean of 21 years. The majority of respondents have completed a residential home assessment within the last two years (77 percent). Almost all respondents have completed a residential home assessment since a solar facility came online in their county (91 percent). About half of respondents that provided an answer indicated they had assessed a home near a utility-scale solar installation (45 percent), while the remainder had not (55 percent). Only one respondent (5 percent) had actually adjusted the value of a home based on the presence of a solar installation, while 21 (95 percent) had not, with the remainder declining to answer. Finally, on a 5-point Likert scale, all respondents indicated having either a neutral, positive, or extremely positive opinion of solar.

To estimate the scale and direction of property value impacts from solar installations, if any, respondents were asked to estimate this impact in percentage terms at varying distances from three sizes of solar facilities: 1.5MW, 20MW and 102MW. A summary of these responses can be seen in **Chart B.1** below. Additional descriptive statistics of the results can be seen in **Appendices D.3 - D.5**.

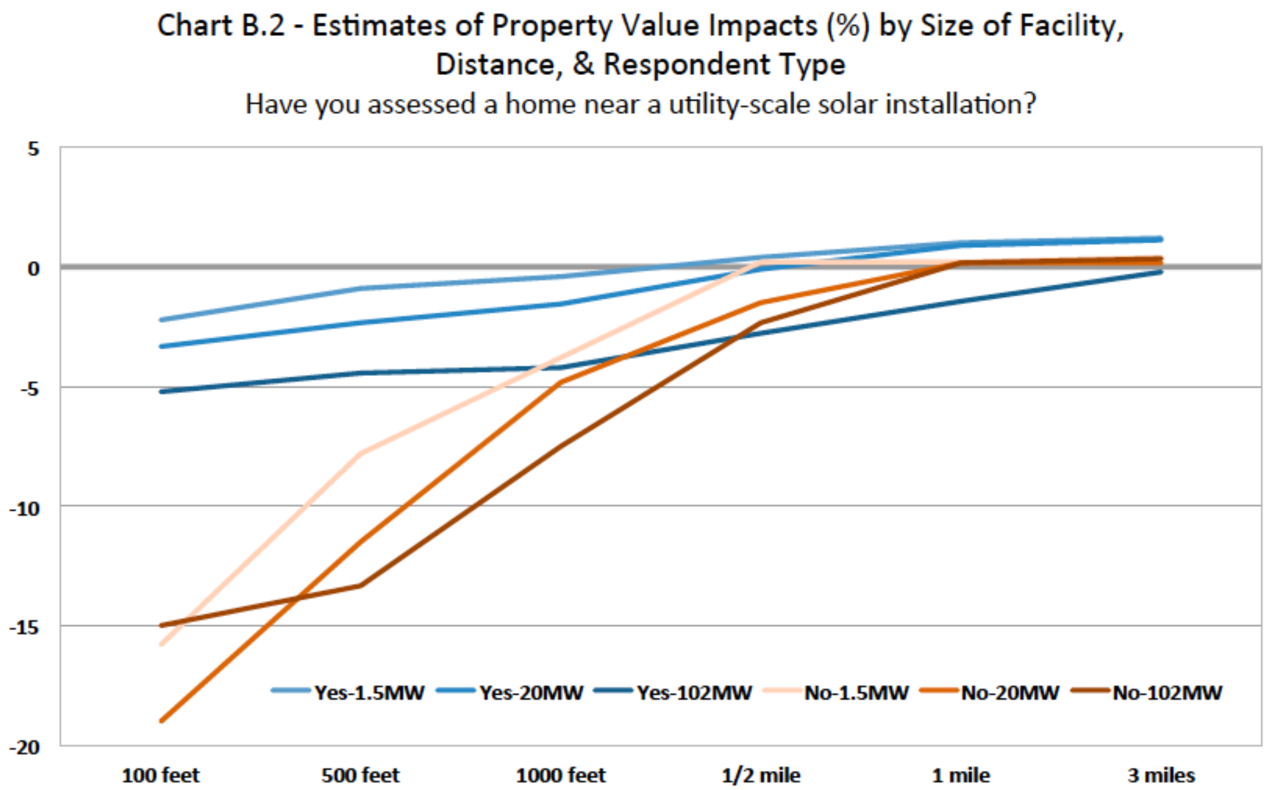
Chart B.1: *The below chart shows the estimates of home value impacts for all respondents, broken down by share of responses in various groups, at each distance for the three facility sizes.*



Estimated property value impacts at all distances and all facility sizes had a median and mode of zero percent. The majority of responses suggested either no impact (66 percent of all estimates) on home prices, or a positive impact (11 percent of all estimates), as a result of proximity to solar installations. However, some respondents did estimate a negative impact on home prices associated with solar installations. When averaging estimates across all respondents, the estimated impact was negative up to 1,000 feet, one half mile and one mile for 1.5MW, 20MW and 102MW facilities, respectively. The averages suggest that respondents estimate that greater proximity to utility-scale solar installations is linked to a more negative property value impact, and that those impacts would be larger as the size of the solar installation increases. In discussing the averages, however, it is worthy of note that highly negative estimates from a few respondents appeared to be pulling the average away from the median. For a discussion of property value impacts in dollars, see **Appendix D.7**.

Survey respondents were also asked to indicate whether they have assessed a home near a utility-scale solar installation. When comparing results of the estimated property value impacts of those that have assessed homes near solar installations to those that haven't, the data suggest that those with experience assessing near these installations are more conservative in their estimates of impact. The average estimated impact at each facility size, distance, and by assessor group is shown in **Chart B.2**. On average, respondents that have assessed near solar installations (n = 10) estimated that home value would decline by 3 percent, on average, when within 100 feet of a 20MW installation. Respondents that have not assessed near solar installations (n = 6), by contrast, estimated a 19 percent drop, on average, for the same facility size and distance. These differences were statistically significant at 100 feet and 500 feet, for 1.5MW and 20MW facilities, respectively, at the 5 percent significance level. While the responses of these two groups are different at closer proximities, they appear to converge at around one half mile.

Chart B.2: *The below chart shows the average estimate of home value impacts for two groups of respondents - those that have assessed a home near a utility-scale solar installation ("Yes") and those that have not ("No"). It shows the average of responses for each group for each distance and facility size.*



Facility size, distance, and an assessor's experience assessing near a solar installation all appear to influence estimates of impact provided by the respondent. A linear regression with clustered standard errors by respondent was used to evaluate the scale and significance of those effects. Results from this regression are shown below in **Table B.1**. The results indicate that distance does impact estimates, with greater distance between the home and the installation being associated with less negative estimates (0.04 percent per 100 feet). The results also suggest that experience assessing near a solar installation is associated with a much less negative estimate of impact (4.2 percent). Finally, the results suggest that an increase in the installation's size is associated with a more negative estimate (-0.02 percent per MW), although this result is not significant at the 10 percent level. Overall, this model has an R^2 value of 0.16, indicating relatively low explanatory power.

Table B.1: *The below table provides results from a regression model with estimates of property value impact, in percentage terms, due to proximity to solar installations as the dependent variable, and facility size (in MW), distance (in 100 feet), and a dummy variable for whether the respondent has assessed a home near a utility-scale solar installation in the past as independent variables.*

Table B.1
Regression of Estimated PV Impact (%) against Size, Distance, and Prior Assessment Near Solar

Variable	Coefficient (St. Error)	p-value
Facility Size (MW)	-0.022	0.121
	(0.013)	
Distance (in 100 ft)	0.042 **	0.014
	(0.015)	
Prior Assessment Near Solar	4.200 *	0.092
	(2.335)	
Constant	-6.420 **	0.016
	(2.356)	
R^2	0.164	
No. of Observations	268	

Note: ** significant at the 5% level
* significant at the 10% level

Further, to control for the explanatory power of individual respondent's own opinions underlying their estimates of impact, we add fixed effects for each respondent to the model, removing the flag for prior assessment experience. The resulting model has an R^2 of 0.44. The coefficients on size (-0.02 percent per MW) and distance (0.04 percent per 100 feet) show little change, while size has become significant at the 10 percent level. Results for this regression are shown in **Table B.2** below.

Table B.2: *The below table provides results from a regression model with estimates of property value impact, in percentage terms, due to proximity to solar installations as the dependent variable, and facility size (in MW), distance (in 100 feet), and fixed effects for each respondent as independent variables.*

Table B.2
Regression of Estimated PV Impact (%) against Size, Distance, and Respondent ID

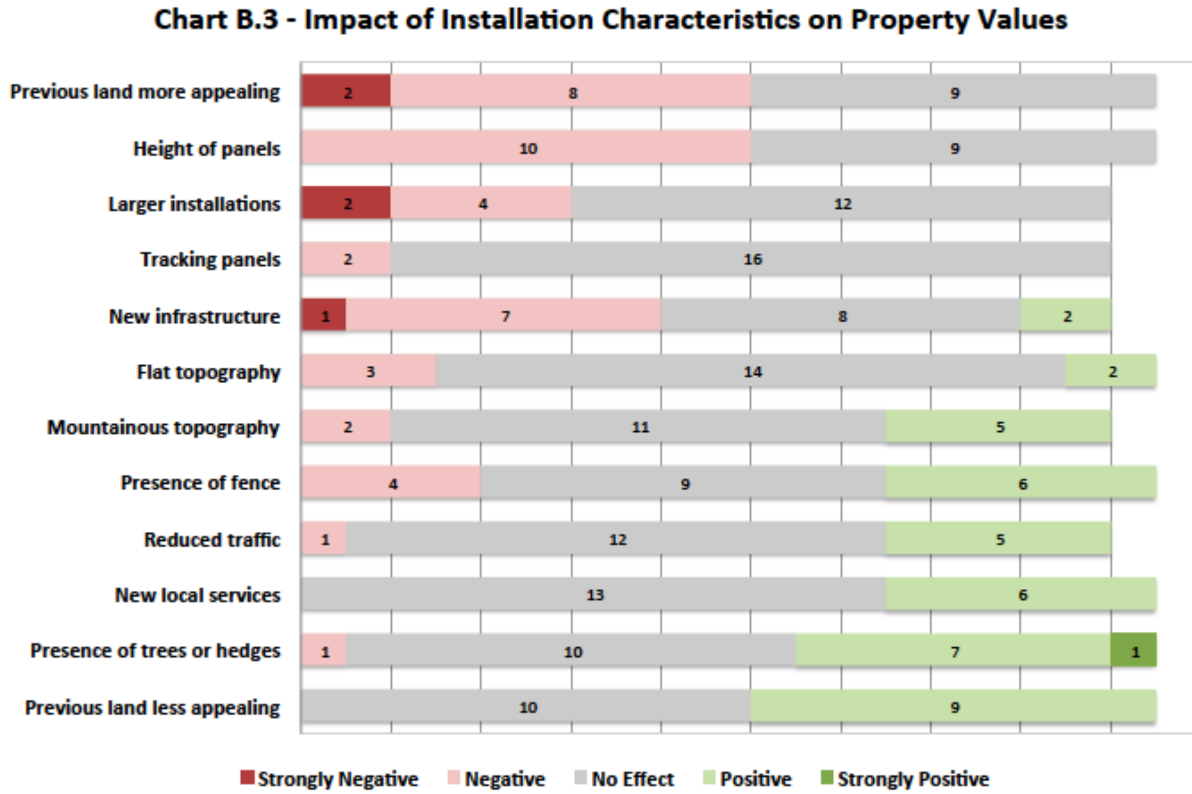
Variable	Coefficient (St. Error)	p-value	Prior Assessment
Facility Size (MW)	-0.022 * (0.011)	0.070	
Distance (in 100 ft)	0.043 *** (0.014)	0.005	
Respondent 2	7.500 *** (0.000)	0.000	Y
Respondent 3	7.500 *** (0.000)	0.000	Y
Respondent 4	7.500 *** (0.000)	0.000	--
Respondent 5	7.500 *** (0.000)	0.000	Y
Respondent 6	6.269 *** (0.523)	0.000	Y
Respondent 7	7.500 *** (0.000)	0.000	N
Respondent 8	-3.730 *** (0.227)	0.000	N
Respondent 9	0.000 (0.000)	0.387	N
Respondent 10	7.500 *** (0.000)	0.000	Y
Respondent 11	2.667 *** (0.000)	0.000	Y
Respondent 12	8.722 *** (0.000)	0.000	Y
Respondent 13	9.167 *** (0.000)	0.000	Y

Respondent 14	7.500 *** (0.000)	0.000	Y
Respondent 15	-3.330 *** (0.000)	0.000	–
Respondent 16	4.722 *** (0.000)	0.000	–
Respondent 17	-2.778 *** (0.000)	0.000	Y
Respondent 18	8.444 *** (0.000)	0.000	N
Respondent 19	-2.684 *** (0.065)	0.000	N
Constant	-8.422 *** (0.513)	0.000	
R^2	0.439		
No. of Observations	322		

Note: *** significant at the 1% level
** significant at the 5% level
* significant at the 10% level

In addition to estimates of impact, this survey aimed to identify which features of utility-scale installations, if any, might influence whether the facility is an amenity or disamenity. Respondents were asked to indicate on a 5-point Likert scale whether 12 distinct features of a solar installation would have a positive or negative impact on nearby residential property values. For full results, see **Chart B.3.** In general, the installation of a solar facility on land that was previously more appealing is opined to have a negative impact. By contrast, the installation of solar on land that had an unappealing use previously is believed to have a positive property value impact. Other features associated with negative property value impacts included higher panels, larger installations, and new infrastructure, such as power lines. The presence of trees or hedges around the array, the introduction of new local services, and reduced traffic flow were considered to have positive property value impacts. Noteworthy, however, is that the majority of respondents indicated that any given feature had no impact on property values, suggesting the features of the installation itself will not impact whether it is an amenity or disamenity.

Chart B.3: *The below bar chart shows the count of responses of each type about the impact of each characteristic of solar installations on property values. Responses ranged from "Strongly Negative" to "Strongly Positive".*



Other noteworthy observations can be drawn from the survey data. Respondents were asked to indicate if they have adjusted a home's value due to proximity to a solar installation. Only one respondent out of 18 that had assessed homes near solar facilities, indicated they had made such an adjustment. This respondent estimated a negative impact of 10 percent, 15 percent, and 25 percent for homes within 100 feet of a 1.5MW, 20MW and 102MW installation, respectively. Meanwhile, only two respondents indicated that their professional manual or other training materials provide instructions regarding residential assessments near utility-scale solar installations. These respondents were located in North Carolina and Wisconsin, states with a very large number of utility-scale solar installations and very few, respectively. Of those two, only the respondent from North Carolina provided estimates of value impacts, estimating zero percent impact across all three facility sizes at all distances.

While the survey results suggest there could be negative residential property value impacts at some proximity to solar installations, the results of the geospatial analysis suggest these impacts are unlikely to be felt by many homeowners. Estimated negative impacts from proximity to solar installations were greatest at 100 feet from the installation. However, the results of the solar-siting analysis suggest that there is less than one home, on average, within 100 feet of a utility-scale solar installation. Within half a mile of solar installations – a distance at which the average estimated impact was negative for all facility sizes – there are only seven homes near a 1MW installation, on average, and even fewer as the size of the installation increases. At the highest estimated housing density, there are 22 homes, on average, within three miles of a 1MW solar installation. However, at this distance survey respondents estimated a positive property value impact of 0.8 percent, on average.

Discussion

The results of our solar-siting analysis and survey provide some information on which to begin to estimate potential property value impacts due to proximity to solar installations. Survey responses were mixed; estimates were zero or positive for most responses, but were negative at some distances on average. Our regression models suggested that estimates were more negative at closer proximity to the installation, with greater installation size, and when provided by assessors that had not previously assessed a home near a utility-scale solar facility. In reviewing the survey results, the role of an assessor's experience working near solar facilities is worthy of note. Assessors with experience assessing near solar installations perceived considerably smaller impacts than those without such experience. In addition, the majority of assessors with experience assessing homes near solar installations did not adjust property values based on that proximity. We cannot determine from the survey whether this is because the assessors see no evidence of value impacts, or because they lack professional instructions on how make such adjustments. Even where respondents estimated negative impacts, these were typically at close proximity to the facilities. At these proximities, our solar-siting analysis suggested the number of homes likely to be impacted would be low.

The research team faced several challenges when cleaning and collecting the data for our analysis. For the solar-siting analysis, determining the accuracy of installation coordinates via satellite imagery was subject to human error. In addition, the missing block group data for median income estimates led to lower estimates than are feasible in some regions. For the survey, the geographic distribution of respondents was not representative of the distribution of solar facilities across the United States. In particular, there were no responses from California which is home to the largest number of utility-scale solar facilities. In addition, due to our small sample size, we were unable to conduct many statistical tests to test relationships in our data. These low sample sizes also led responses from a few respondents to shift the mean far from the median values. Finally, some respondents expressed hesitation in completing the survey given the lack of statistical evidence to support any estimates of property value impacts. This was difficult to address given our goal of establishing such evidence. In addition, some assessors were not aware of installations in their county, despite EIA installation data demonstrating otherwise.

Despite these challenges, the survey illuminated the opinions of assessors nationwide regarding large solar projects. Multiple assessors noted in the survey that installations in their counties are located in rural areas. These isolated settings led one respondent assessor to indicate they, "have seen no impact on real estate (home) values." Multiple respondents also noted that there is insufficient data to answer the survey questions, either due to a lack of statistical evidence or because there was only one installation in their area for reference. Our data show a discrepancy between the actual number of installations in a given county and the number perceived to be there by the assessor, which suggests that assessors may be unaware of installations within their own counties. It also indicates a lack of responsiveness to the presence of installations in such a case. One respondent cited “reasonable setback/buffers and screening” as neutralizing any potential property value impacts. Finally, another respondent introduced the importance of homeowner perception, in that “the initial fears of homeowners are the worst, being clear and upfront about how scale, potential reflection and appearance are important.” Overall, we see that the assessors surveyed often see no impact due to rurality or do not feel they can make a judgment due to lack of data or evidence.

In the future, several modifications could be made to improve upon this research. In the geospatial analysis, coordinate accuracy was reviewed via satellite imagery. However, rather than excluding inaccurate coordinates, future research could improve upon this by correcting those coordinates. While our geospatial analysis relied on pseudo-polygons to estimate the surface area of facilities, generating polygon shapefiles for every site would provide more accurate estimates of housing density and median income surrounding those facilities. In addition, while the pseudo-polygons provide a significant improvement upon housing and income estimates, they were limited by the use of buckets for the size of the facilities. These polygons were based on estimates of the sizes of 1MW, 5MW, 10MW, 20MW, 50MW, and 100MW facilities only, and therefore do not estimate the exact area of each individual facility based on its capacity. As a result, these pseudo-polygons are conservative estimates of the facility’s total area. There are also multiple options for continued survey research on this topic. A contingent valuation (Type III) survey could ask respondents to comment on the property values of two homes that are identical except for proximity to a utility-scale solar installation. Alternatively, a survey tool like the one used in this research could gauge perceptions of realtors or homeowners and ask about willingness to pay as a proxy for property values.

In addition to the analyses conducted here, future analyses could be improved by focusing on solar sites that are both of an appropriate size to potentially impact home values, and near a sufficient number of properties. In addition, current housing estimates could estimate the number of home transactions occurring near utility-scale solar installations. The number of homes transactions needed to generate sufficient statistical power and effect size for a hedonic regression model, for example, can inform future disamenity research. To better incorporate the effect of visual disturbance, future studies could also incorporate ArcGIS Viewshed analysis, elevation contours, or dummy variables for visibility. This study did not differentiate between ground-mounted and rooftop installations, although the vast majority of the analyzed plants are assumed to be ground-mounted. Future research could make this distinction and remove rooftop installations from the dataset. In addition, multiple assessors indicated that the installations in their counties were rural and not proximate to residential properties. Subsequent studies could pivot by investigating effects on land values, rather than home values, to account for rurality. Finally, to shift from perceived to actual property value impacts, future research can conduct analyses on home sales data to collect empirical evidence of actual property value impacts.

Conclusion

This study has investigated utility-scale solar facilities as a potential amenity or disamenity. To do so, it aimed to understand both the scope of homes potentially impacted by proximity to solar installations, and the scale and direction of those impacts, if any. The results of the solar-siting analysis indicate that very few homes, on average, are located around these utility-scale solar installations. On average, we estimate 0.53 homes or fewer are located within 100 feet of the solar installations analyzed in this research. Within three miles, we estimate only 23.84 homes surrounded 10MW facilities, on average. These results suggest the number of homes that could potentially be impacted by the presence of utility-scale solar installations are relatively few. However, as the cumulative numbers of solar installations continues to grow, the number of homes potentially impacted also grows. This is particularly true if installations are located in more dense, urban areas. In addition, the solar-siting analysis suggests that median income surrounding large solar installations may be lower than those surrounding smaller installations. Given the authors' expectations that smaller solar facilities are more likely to be located in urban areas, which typically have higher median incomes, this is not unexpected. However, it brings in questions surrounding the equity of potential property value impacts due to proximity to installations, on the basis of income level.

Results from our survey of residential home assessors show that the majority of respondents believe that proximity to a solar installation has either no impact or a positive impact on home values. However, variation in responses by size of the facility, distance from the home, and the assessor's experience assessing near such an installation previously, all impacted those estimates. Regression analyses suggest that closer proximity to an installation is associated with more negative estimates of property value impacts, as is larger installation size. Prior experience assessing near a solar installation, by contrast, was associated with more conservative estimates of impact. Meanwhile, the median and mode of all estimates of impact was zero, suggesting negative estimates from a few respondents were pulling down the mean. Additionally, the survey results indicate that respondents believe some features of solar installations may be associated with positive impacts. These include a location on land that previously had an unappealing use, or the presence of trees or other visual barriers around the array. Meanwhile, features such as being located on land that previously had an appealing use and higher installations are expected to have a negative impact, according to the respondents.

The results of this research may be of interest to solar developers, public officials, home assessors, and homeowners. In particular, solar developers should be conscientious of potential impacts on property values from their selection of a solar site and potential pushback they may face from homeowners in the process. Public officials are often tasked with approving the proposed locations of new solar installations, and, therefore, would be interested to know about the benefits or adverse consequences of those decisions. Public assessors, meanwhile, are tasked with assessing the value of homes including those located near solar facilities. The results of our survey indicate that very few assessors currently receive any instructions in their professional manual or other training materials surrounding assessments near solar installations. Finally, homeowners have an interest in the value of their home as an asset, and may be inclined to resist any modifications to nearby land use that could hurt their home's value.

This research suggests several policy interventions may be appropriate as additional research is conducted around impacts from solar installations. First, regulations around an installation's appearance and land use may help minimize impacts on property values. For example, incorporating vegetation to block the visibility of solar panels, keeping panels low to the ground, or using land with a previously unappealing use, such as an animal feedlot, may prove helpful. Second, engaging the public in the design process for these installations may help allay homeowner concerns. Third, a consideration of housing density by distance around the proposed facility should help identify the scope of potential impact for any particular facility, with the expectation that greater distance between the facility and the home is likely to see fewer impacts, if any. Finally, the results of our survey suggest a need to provide consistent and thorough instructions to property assessors on when and how to incorporate these installations into their assessment practice. Given the interest of various stakeholders, we expect continued research to better understand whether utility-scale solar causes negative price impacts to be a valuable addition to current amenity and disamenity literature.

References

Anderson, Orell C., MAI, Jack Williamson, and Alexander Wohl, "The Effect of High-Voltage Overhead Transmission Lines on Property Values: A Review of the Literature Since 2010," *The Appraisal Journal*, Summer 2017: 179-193.

Anderson, Soren T. and Sarah E. West. "Open Space, Residential Property Values and Spatial Context." *Regional Science and Urban Economic*s, 2006, 36, 773–89.

Appraisers Forum, "Solar Farms," February 7, 2015, https://appraisersforum.com/forums/threads/solar-farms.205528/

Bolinger, Mark, Joachim Seel, and Kristina Hamachi LaCommare, "Utility-Scale Solar 2016 An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States" Lawrence Berkeley National Laboratory, 2017. https://emp.lbl.gov/utility-scale-solar/

Bond, Michael T., Vicky L. Seiler, and Michael J. Seiler. "Residential Real Estate Prices: A Room with a View." *Journal of Real Estate Research*, 2002, 23, 129–37

Boxall, Peter C., Wing H. Chan, and Melville L. McMillan, "The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Analysis," *Resource and Energy Economics* vol. 27 (3): 248-269. doi: 10.1016/j.reseneeco.2004.11.003

Carlisle, Juliet E., David Solan, Stephanie L. Kane, and Jeffrey Joe. 2016. "Utility-Scale Solar and Public Attitudes Toward Siting: A Critical Examination of Proximity." *Land Use Policy* 58 (2016) 491-501.

Carlisle, Juliet E., Stephanie L. Kane, David Solan, Madelaine Bowman, and Jeffrey C. Joe. 2015. "Public Attitudes Regarding Large-Scale Solar Energy Development in the U.S." *Renewable and Sustainable Energy Reviews* 48: 835-847. doi 10.1016/j.rser.2015.04.047.

Case, Bradford, Peter F. Colwell, Chris Leishman, and Craig Watkins. 2006. "The Impact of Environmental Contamination on Condo Prices: A Hybrid Repeat-Sale/Hedonic Approach." *Real Estate Economics* vol. 34 (1): 77-107. doi 10.1111/j.1540-6229.2006.00160.x.

Davis, Lucas W. 2011. "The Effect of Power Plants on Local Housing Values and Rents." T*he Review of Economics and Statistics* vol. 93 (4): 1391-1402. doi 10.2110.2139/ssrn.144090639/ssrn.1440906.

Des Rosiers, Francois. 2002. "Power Lines, Visual Encumbrance and House Values: A Microspatial Approach to Impact Measurement." *Journal of Real Estate Research* vol. 23 (3): 275-301.

Donnelly-Shores, Patrick. 2013. "What Does 'Utility-Scale Solar' Really Mean?" *Greentech Media*. Accessed October 19, 2017 at https://www.greentechmedia.com/articles/read/what-does-utility-scale-solar-really-mean.

Fehrenbacher, Katie, “Here's Why Solar Farms Are Booming in the U.S.,” *Fortune*, September 12, 2016, http://fortune.com/2016/09/12/solar-panel-farms-boom/

HackettstownLiFE, “Would you buy a house next to a solar farm?” December 2011, http://www.hackettstownlife.com/forum/364576

Hoen, Ben and Carol Atkinson-Palombo. 2016. “Wind Turbines, Amenities and Disamenities: A Study of Home Value Impacts in Densely Populated Massachusetts.” *Journal of Real Estate Research* vol. 38 (4): 473-504. doi 10.5555/0896-5803-38.4.473.

Hoen, B., J. Firestone, J. Rand, D. Elliott, G. Hubner, J. Pohl, R. Wiser, E. Lantz. 2018. “Overall Analysis of Attitudes of 1,705 Wind Power Project Neighbors.” Lawrence Berkeley National Laboratory. Preliminary Results Webinar, January 30, 2018.

Hoen, Ben, Jason P. Brown, Thomas Jackson, Mark A. Thayer, Ryan Wiser, and Peter Cappers. 2015. “Spatial Hedonic Analysis of the Effects of U.S. Wind Energy Facilities on Surrounding Property Values.” *Journal of Real Estate Finance and Economics* 51:22-51. doi 10.1007/s11146-014-9477-9

Hoen, Ben , Ryan Wiser, Peter Cappers, Mark Thayer, and Gautam Sethi. 2009. “The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis.” *Lawrence Berkeley National Lab*. http://eetd.lbl.gov/EA/EMP

Hoen, Ben and Sandra Adomatis, Thomas Jackson, Joshua Graff-Zivin, Mark Thayer, Geoffrey T. Klise and Ryan Wiser. 2017. “Multi-state residential transaction estimates of solar photovoltaic system premiums.” *Renewable Energy Focus* vol. 19-20: 90-103.

Idaho National Laboratory. 2013. “PVMapper: Report on the Second Public Opinion Survey. Prepared for the U.S. Department of Energy. https://inldigitallibrary.inl.gov/sites/sti/sti/5935850.pdf

Kirkland, Richard, “Re: Oakwood Solar Impact Study.” Letter to ESA Renewables LLC, February 12 2016. http://www.orangecountync.gov/departments/planning_and_inspections/Solar%20Impact%20Study.pdf

Lang, Corey and James Opaluch. "Effects of Wind Turbines on Property Values in Rhode Island." University of Rhode Island Department of Environmental and Natural Resource Economics, Kingston, RI. 2013. http://www.energy.ri.gov/documents/Onshore%20Wind/Final%20Property%20Values%20Report.pdf

Lawrence Berkeley National Laboratory. (2017). *Solar Project Tracker Real Estate.*

Locke, Stephen L., "Two Essays On Housing: Using Hedonic and Quasi-Experimental Methods in (Dis)amenity Valuation with Housing Data: The Case of Communication Antennas, and the Value of Brand Name Franchises Compared to Local Real Estate Brokerage Firms" (2013). Theses and Dissertations--Economics. 13.

Loomis, David and Matt Aldeman. 2011. “Wind Farm Implications for School District Revenue.” Center for Renewable Energy Illinois State University. https://renewableenergy.illinoisstate.edu/wind/pubs.php

Loomis, David, Jared Hayden, and Sarah Noll, “Economic Impact- wind energy development in Illinois” Journal of Business Valuation and Economic Loss Analysis vol. 11 (2016) 1 (June): 3-23

Lunetta, Caleb, “Canyon View Estates Residents Continue To Fight Against Solar Farm,” *KHTS Hometown Station* (Santa Clarita, California), October 9, 2017, http://www.hometownstation.com/santa-clarita-latest-news/canyon-view-estates-residents-continue-to-fight-against-solar-farm-video-207723

Manson, Steven, Jonathan Schroeder, David Van Riper, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 12.0. 2015 American Community Survey: 5-Year Data [2011-2015, Block Groups & Larger Areas. Minneapolis: University of Minnesota. 2017. http://doi.org/10.18128/D050.V12.0

Manson, Steven, Jonathan Schroeder, David Van Riper, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 12.0. 2016 American Community Survey: 5-Year Data 2012-2016, Block Groups & Larger Areas. Minneapolis: University of Minnesota. 2017. http://doi.org/10.18128/D050.V12.0

McShane,Chuck, “Can neighborhood opposition cool state's solar push? Experts think not,” *UNC Charlotte Urban Institute*, February 5, 2014, https://ui.uncc.edu/story/solar-farm-nc-planning-zoning-nimby

Muehlenbachs, Lucija, Elisheba Spiller, and Christopher Timmins, “The housing market impacts of shale gas” American Economic Review, 105(12): 3633-59. doi: 10.1257/aer.20140079

New York State PV Trainers Network, “Do solar installations have an impact on property values?” accessed November 5, 2017, https://training.ny-sun.ny.gov/88-resources/faqs/general-faqs/272-do

Realtor.com, “How Will A Large Solar Power Plant Affect Property Values?” October 31, 2011, https://www.realtor.com/advice/how-will-a-large-solar-power-plant-affect-property-values/

Simons, Robert A. and Jesse D. Saginor, “A meta-analysis of the effect of environmental contamination and positive amenities on residential real estate values” Journal of Real Estate Research vol 28, No. 1, 2006. Available at SSRN: https://ssrn.com/abstract=953692

Perea, Austin et al., “Solar Market Insight Report 2016 Year In Review,” *Solar Energy Industries Association*, accessed December 11, 2017 at https://www.seia.org/research-resources/solar-market-insight-report-2016-year-review

U.S. Census Bureau, Population Division, County Population Totals Tables: 2010-2016. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

U.S. Census Bureau American Community Survey 5-Year Estimates. (2015). *Unweighted Sample Housing Units*. Retrieved from https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

U.S. Census Bureau. (2015). *TIGER/Line Shapefiles Census Block Group*. Retrieved from https://www.census.gov/geo/maps-data/data/tiger-line.html\

U.S. Department of the Interior, Bureau of Land Management, and the U.S. Department of Energy. 2010. “Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States” http://solareis.anl.gov/documents/dpeis/.

U.S. Energy Information Administration. (2016). *Form EIA-860 detailed data*. Retrieved from https://www.eia.gov/electricity/data/eia860/

West, Emily, “Potential Solar Farm Leads To Neighborhood Dispute,” *The Greeneville Sun* (Greeneville, Tennessee), February 12, 2015, https://www.greenevillesun.com/news/local_news/potential-solar-farm-leads-to-neighborhood-dispute/article_73051742-ff32-5699-9f4e-2e5566ef247f.html

Zillow, “will solar farm in residential zone affect property values” accessed on November 5, 2017, https://www.zillow.com/advice-thread/will-solar-farm-in-residential-zone-affect-property-values/692480/

Appendices

Appendix C.1 - Descriptive Statistics of Analyzed & Actual Utility-Scale Solar Installations

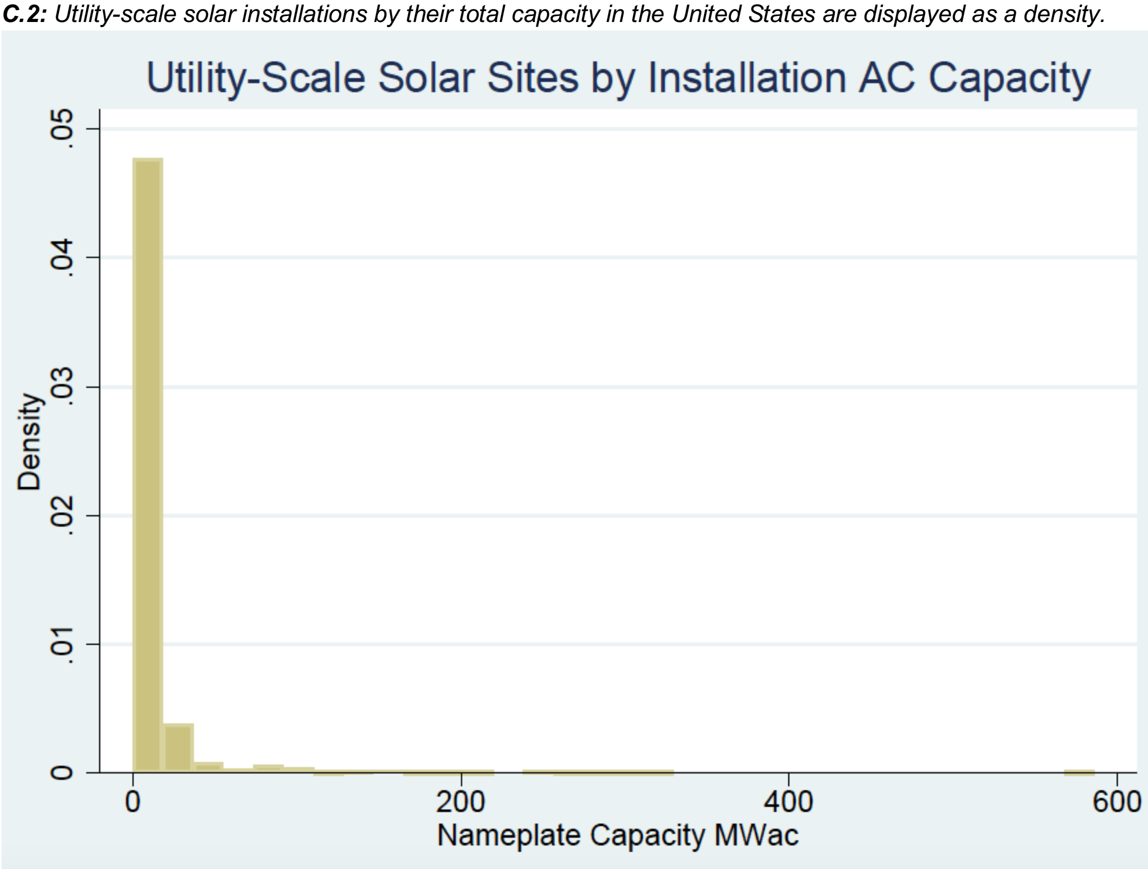
C.1: The table below provides a comparison of the sites used in the analysis (row 1) and the complete number of utility-scale solar (row 2).

Appendix C.1
Descrpitive Statistics of Analyzed and Total Utility-Scale Solar Installations

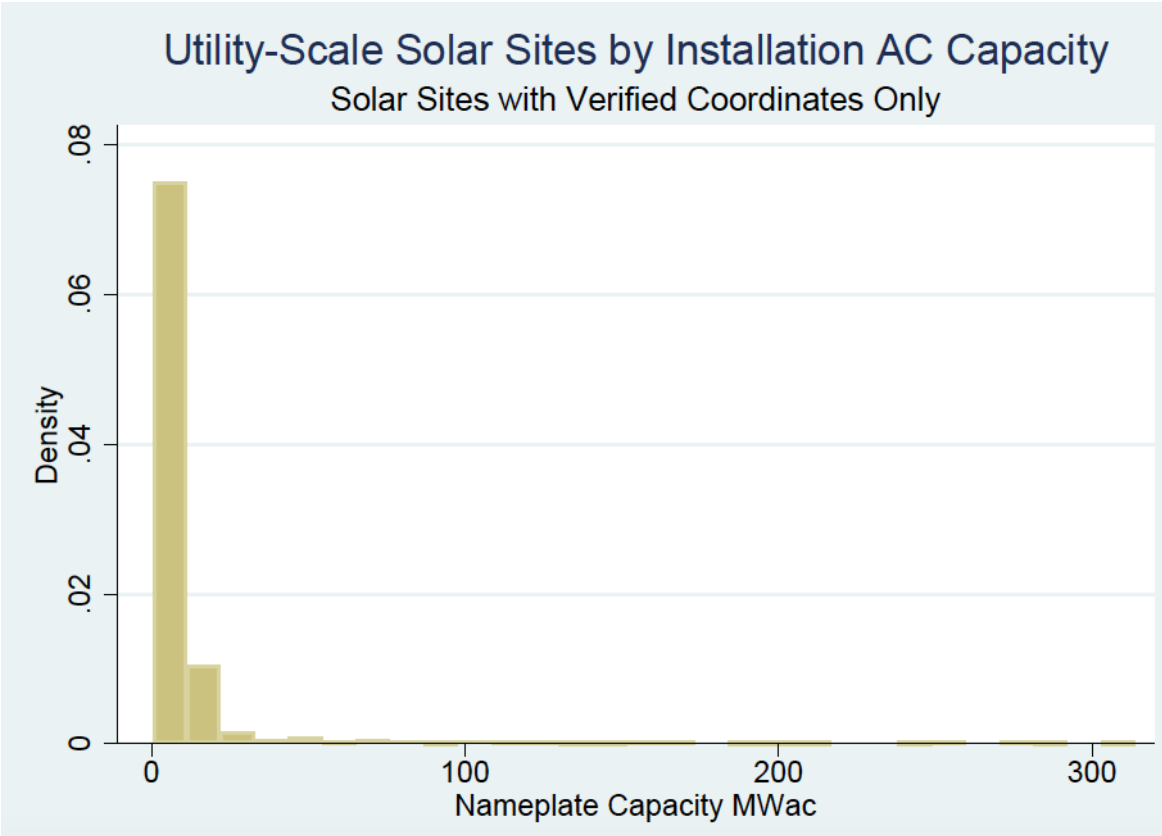
Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max	n
11.3	32.7	0.1	1.6	3.2	5.5	585.9	1805
12.2	32.6	0.4	1.7	4.0	7.0	313.7	956

Appendices C.2 & C.3 - Histograms of Installation Capacity

***C.2:** Utility-scale solar installations by their total capacity in the United States are displayed as a density.*



C.3: *Utility-scale solar facilities by capacity used in this analysis are displayed as a density. Comparison of the two charts shows that this research contained a greater proportion of low capacity facilities.*



Appendix C.4 - Pseudo-Polygon Calculations

C.4: *The table below shows the calculations used to create the pseudo-polygons. The team estimated approximately*

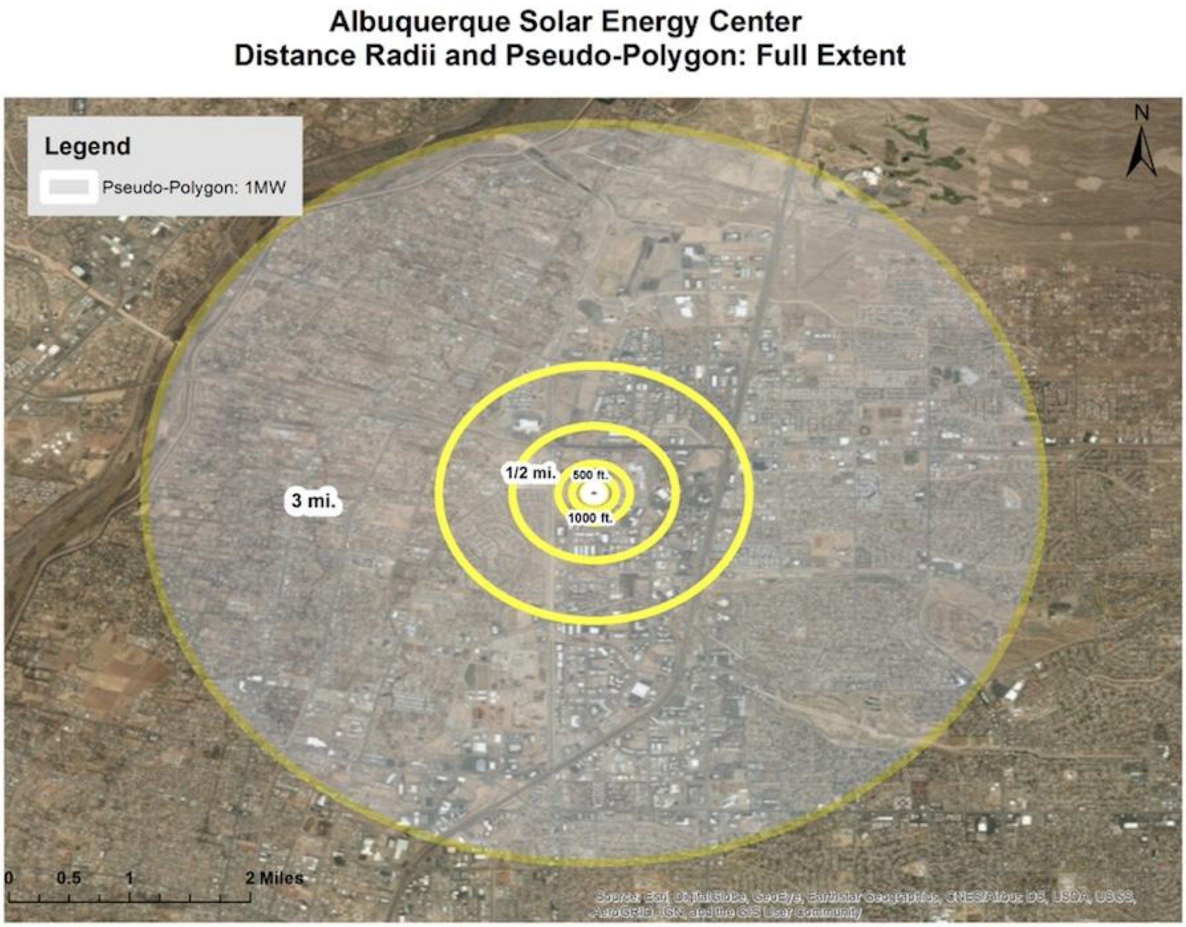
Appendix C.4
Pseudo-Polygon Calculations

Facility Size (MW)	Area (Acre)	Radius (Acre)	Area (sq. ft.)	Radius (ft.)
1	6	1.382	261,360	288.4253
5	30	3.090	1,306,800	644.9385
10	60	4.370	2,613,600	912.0808
20	120	6.180	5,227,200	1,289.88
50	300	9.772	13,068,000	2,039.47
100	600	13.820	26,136,000	2,884.25

Note: *Team assumed 6 acres/MW to estimate the average facility area*

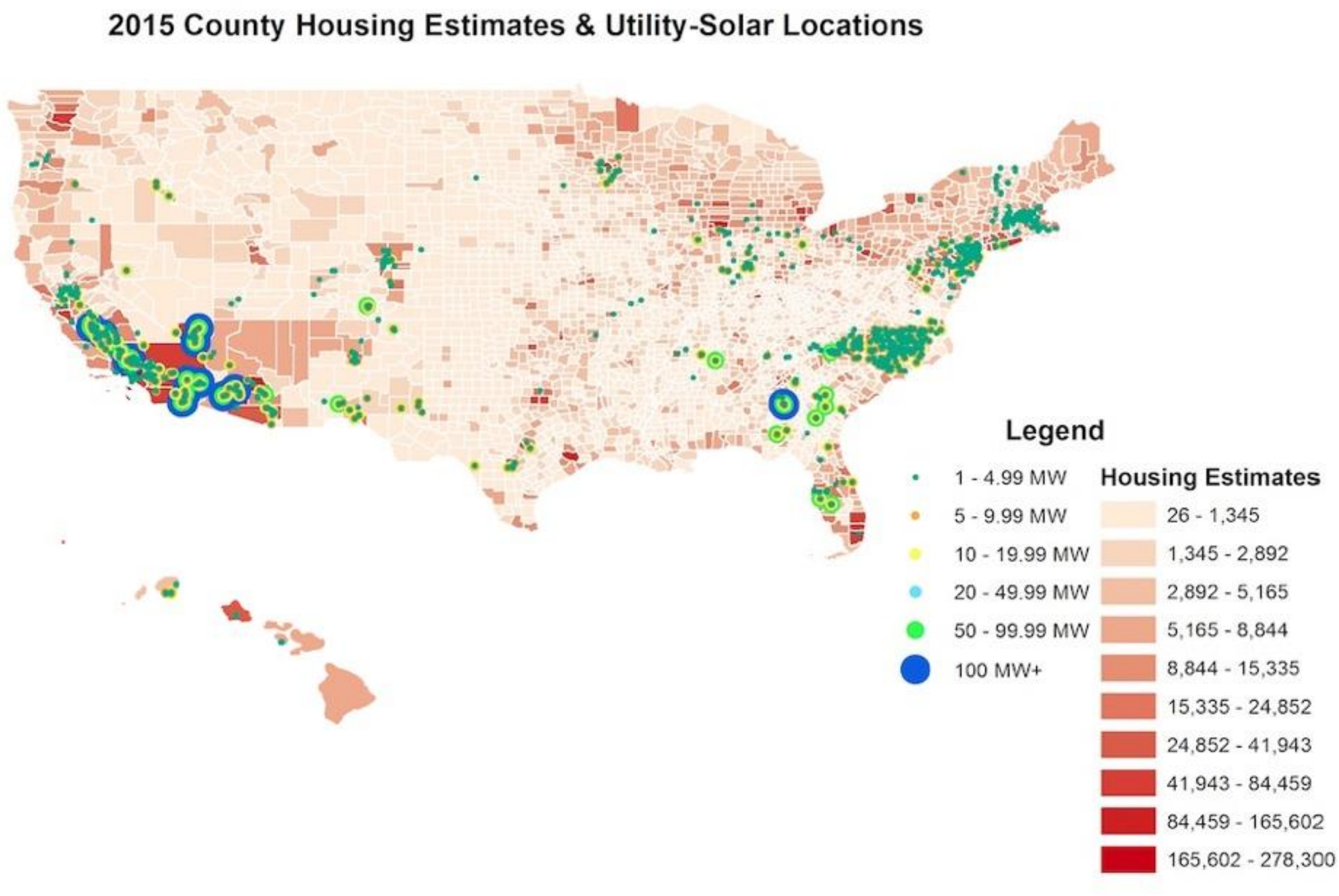
6 acres/MW, which was evidently conservative.

Appendix C.5 - Full Extent of Buffer Zones



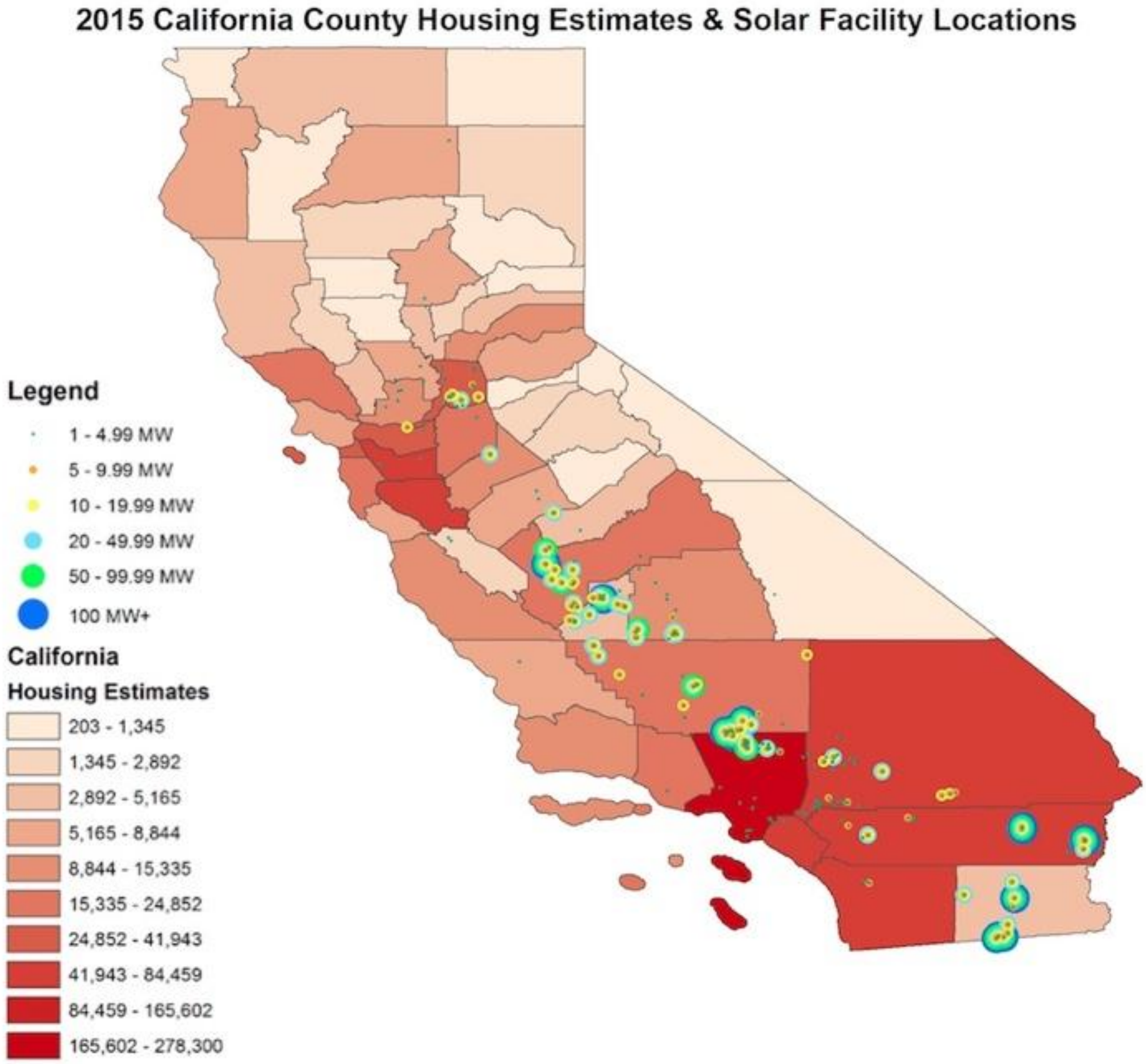
C.5: *A satellite image of the buffers (in yellow) beginning at 100ft (shown at 500ft) out to three miles are shown above. Total and average estimates of homes are made within these buffer zones and select distances.*

Appendix C.6 - Map of Housing Density Near Select Solar Sites in the U.S.



C.6: *A heat map of 2015 population in the United States with the location of utility-solar installations displayed by county. Population data was aggregated at the county level to display U.S. housing density. While block groups provide the most specific data on the location of housing populations, the are often too small to display on a nationwide map.*

Appendix C.7 - Map of Housing Density Near Select Solar Sites in California



C.7: *California housing density with utility-scale solar installations. A heat map of 2015 county population in California underscores that California is a region of high-interest to utility-scale solar research. The state is both populous and contains the most and largest utility-scale solar in the country.*

Appendix C.8 - Total Number of Homes Near Utility-Scale Solar Installations, Extrapolated to 1,805 Installations

C.8: *The table below provides a count of the total number of homes within certain distances of utility-scale solar installations. The following estimates were extrapolated to 1,805 installations using the estimates made with the 956 confirmed utility-scale solar installations.*

Appendix C.8
Extrapolated Total Number of Homes Near Select Utility-Scale Solar Installations in the United States
by Proximity and Installation Size

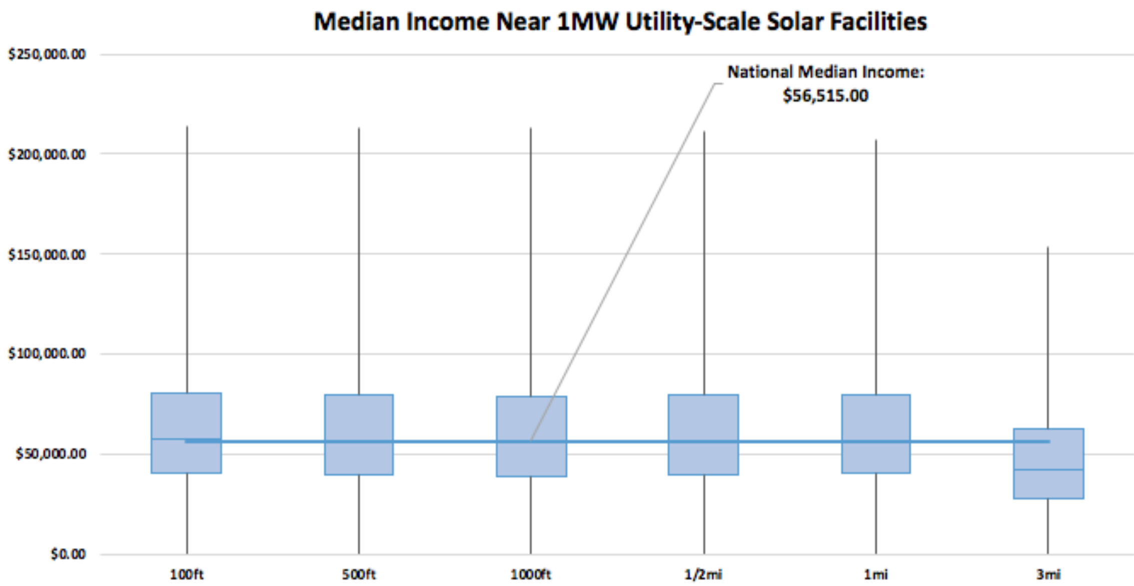
Distance from Installation	Facility Size					
	1 - 4.99MW	5 - 9.99MW	10 - 19.99MW	20 - 49.99MW	50 - 99.99MW	100 MW+
100 feet	348	244	79	77	27	19
500 feet	1,550	592	170	131	39	25
1000 feet	4,421	1,253	368	217	57	32
1/2 mile	26,709	5,187	1,778	828	145	63
1 mile	110,446	18,267	6,324	2,656	385	137
3 miles	1,009,601	165,389	52,834	20,711	3,568	792

Note: These housing counts are inlcusive of estimated homes near 956 utility-scale solar installations with verified coordinates, extrapolated to 1,805 existing solar installations

Sources: U.S. Census Bureau 2012-2016 American Community Survey 5-Year Estimates, Unweighted Sample Housing Units. Solar installation coordinates based on EIA's Form 860 2016 Early Release and Lawrence Berkeley National Lab's proprietary Solar Installation data.

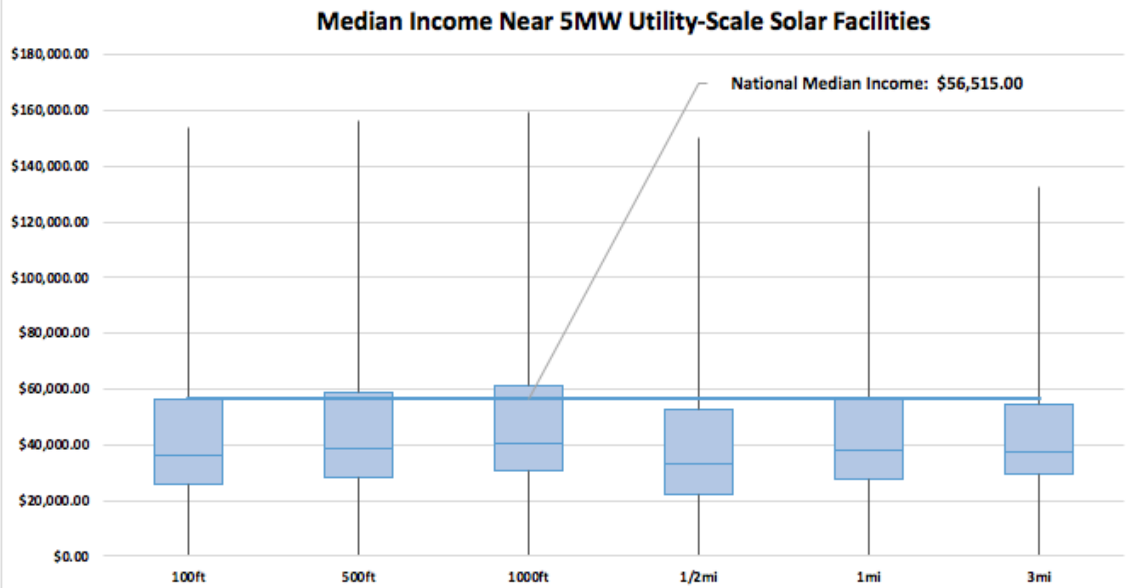
Appendices C.9 - C.19 - Boxplots of Median Income by Installation Size

C.9: *Median income near all 1MW facilities in the United States is shown as box plots. Distance from facility increases from right to left. The national median income is displayed as a horizontal line. The national median income corresponds with the median income near 1MW facilities relatively well. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*



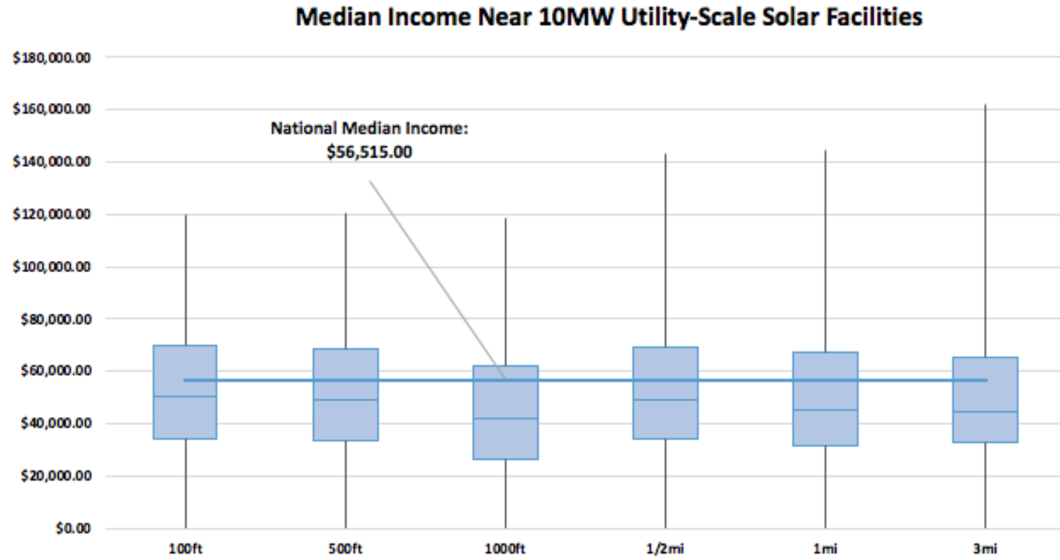
Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

C.10: *Median income near all 5MW facilities in the United States is shown as box plots. Distance from facility increases from right to left. The national median income is displayed as a horizontal line. The national median income appears to be higher than that of residents who live in proximity to 5MW utility-scale solar facilities. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*



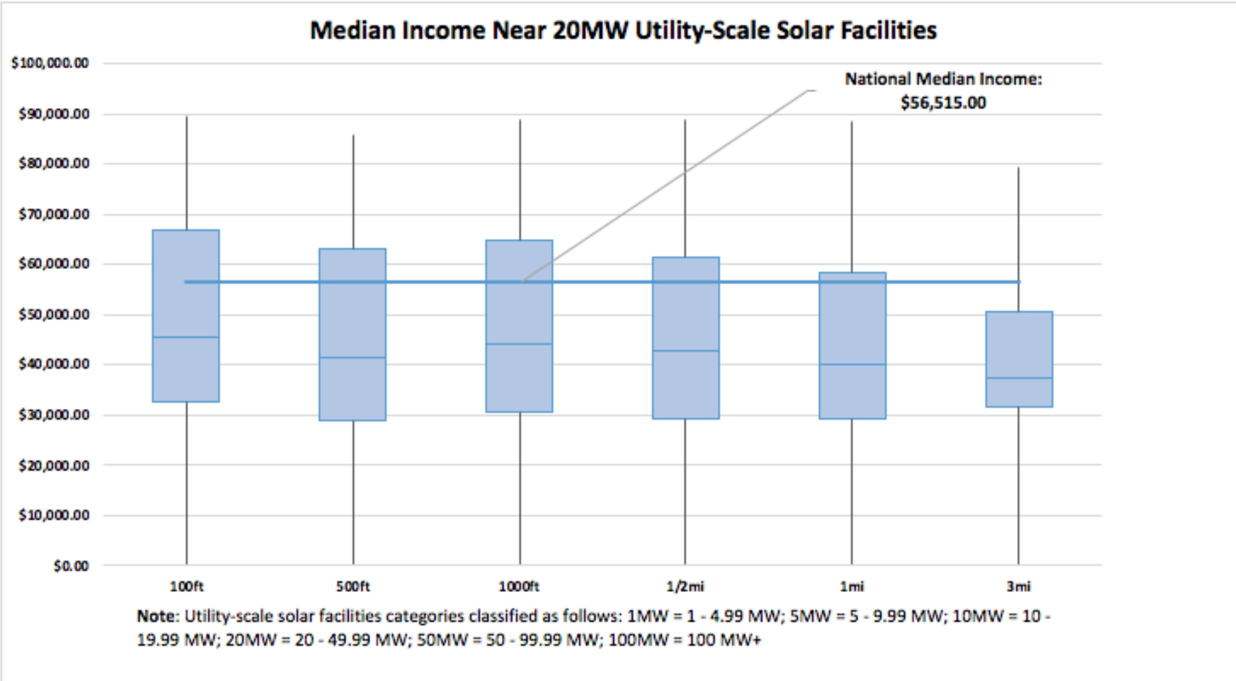
Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

***C.11:** Median income near all 10MW facilities in the United States is shown as box plots. Distance from facility increases from right to left. The national median income is displayed as a horizontal line. The national median income appears to be higher than that of residents who live in proximity to 10MW utility-scale solar facilities. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*

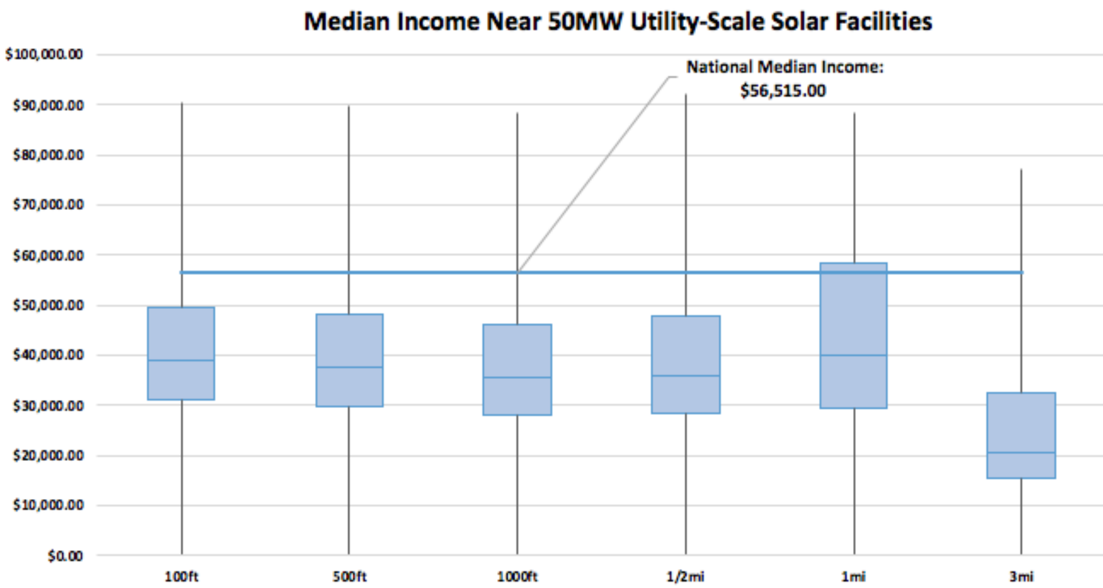


Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

***C.12:** Median income near all 20MW facilities in the United States is shown as box plots. Distance from facility increases from right to left. The national median income is displayed as a horizontal line. The national median income appears to be higher than that of residents who live in proximity to 20MW utility-scale solar facilities. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*

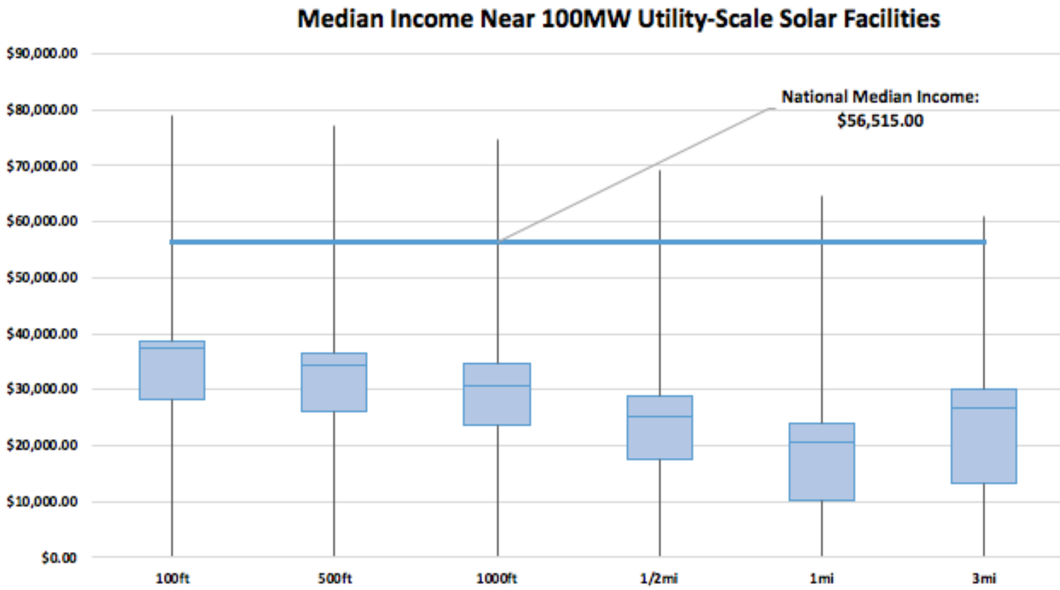


C.13: *Median income near all 50MW facilities in the United States is shown as box plots. Distance from facility increases from right to left. The national median income is displayed as a horizontal line. The national median income appears to be higher than that of residents who live in proximity to 50MW utility-scale solar facilities. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*



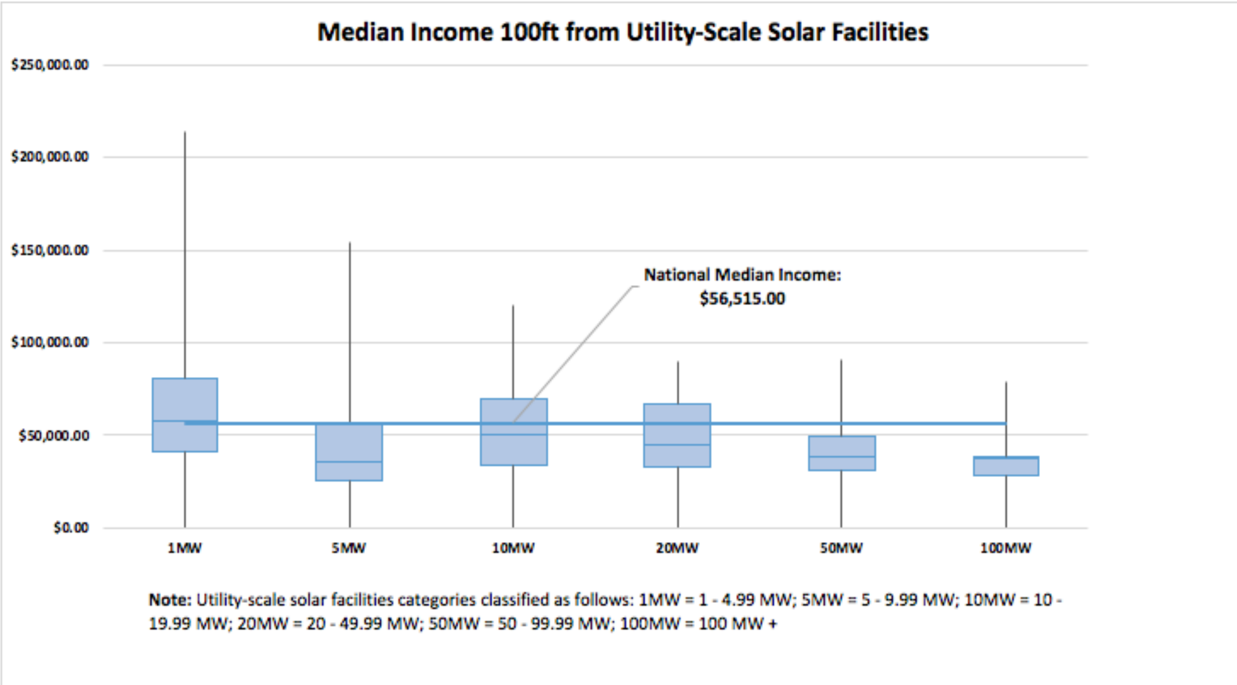
Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

C.14: *Median income near all 100MW facilities in the United States is shown as box plots. Distance from facility increases from right to left. The national median income is displayed as a horizontal line. The national median income appears to be much higher than that of residents who live in proximity to 100MW utility-scale solar facilities. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*

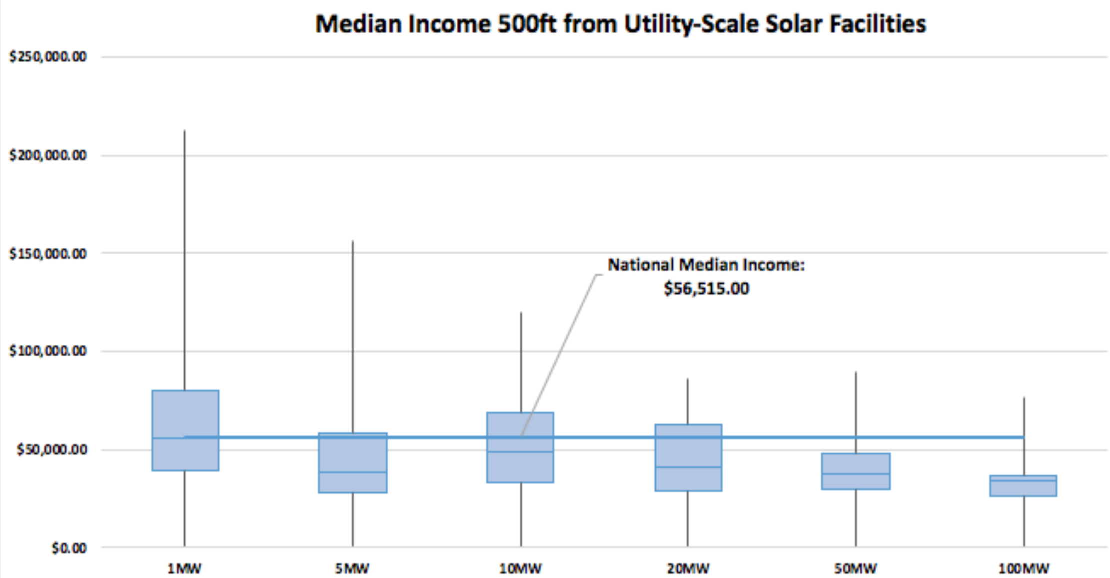


Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

C.15: *Median income 100ft from all facilities in the United States is shown as box plots. Installation size increases from right to left. The national median income is displayed as a horizontal line. The interquartile range for median income appears to roughly decrease as facility size increases. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*

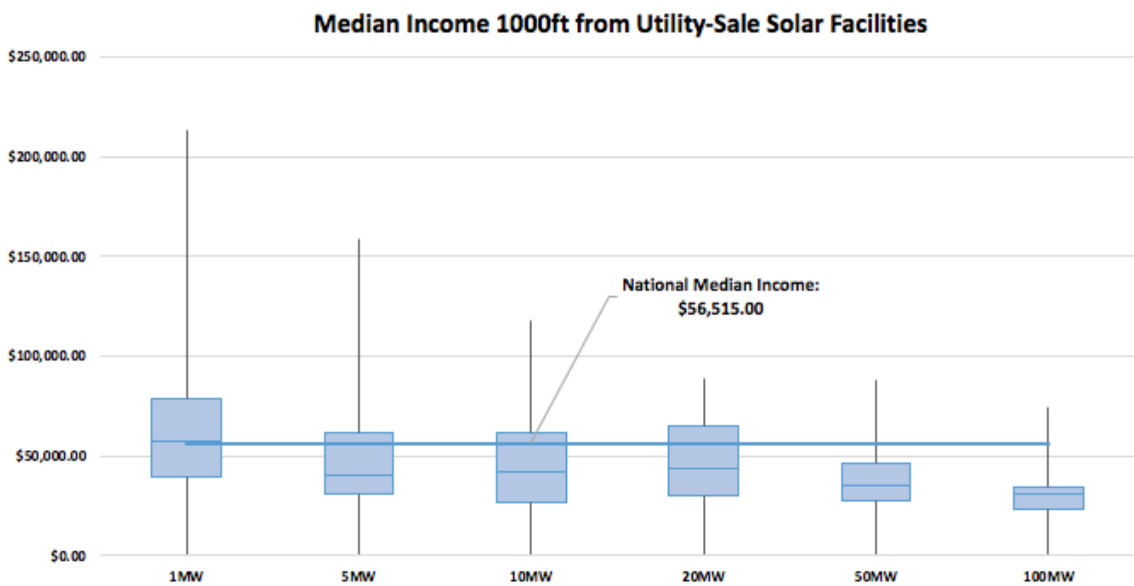


C.16: *Median income 500ft from all facilities in the United States is shown as box plots. Installation size increases from right to left. The national median income is displayed as a horizontal line. The interquartile range for median income appears to roughly decrease as facility size increases. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*



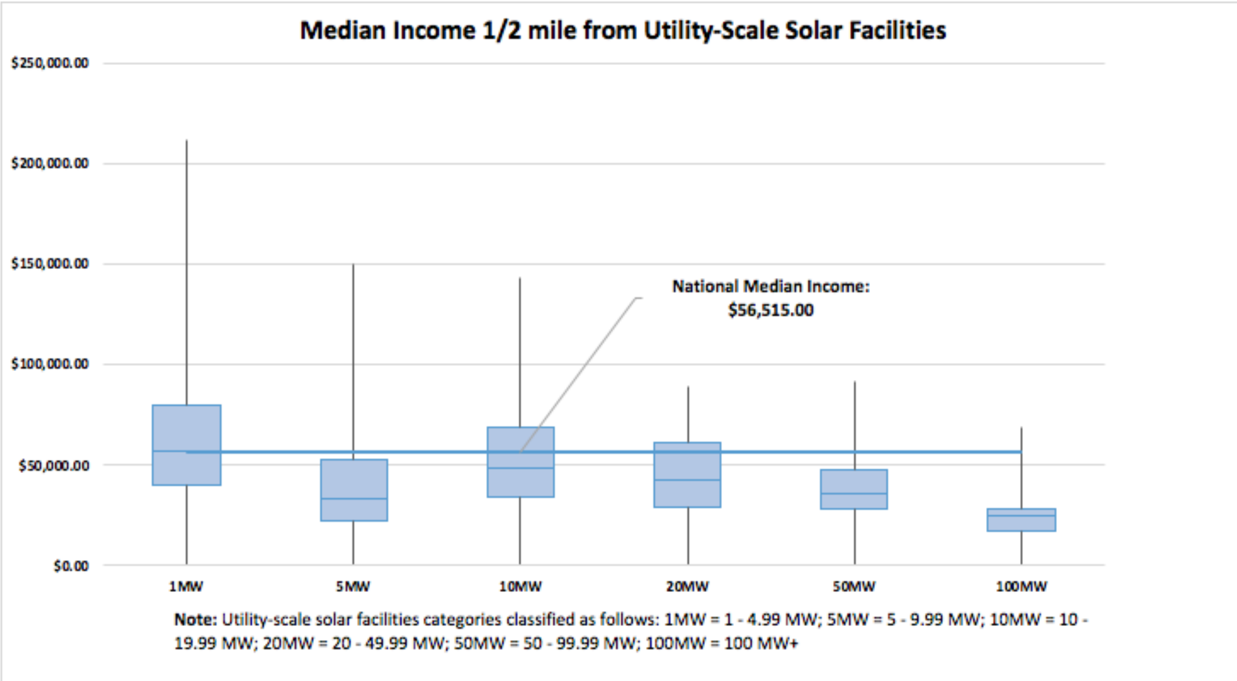
Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

C.17: *Median income 1,000ft from all facilities in the United States is shown as box plots. Installation size increases from right to left. The national median income is displayed as a horizontal line. The interquartile range for median income appears to roughly decrease as facility size increases. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*

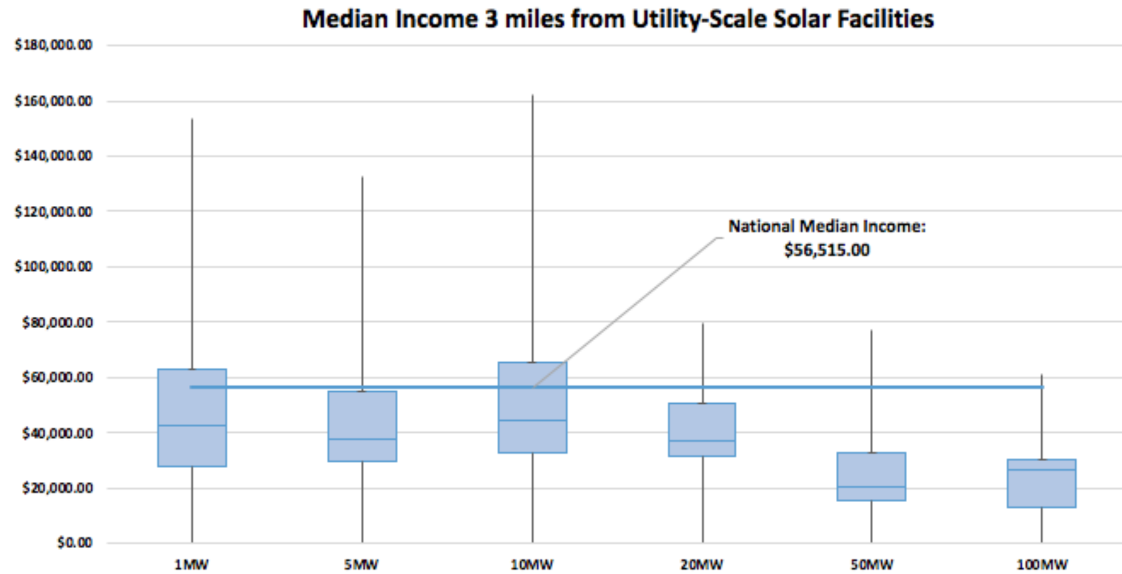


Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5MW = 5 - 9.99 MW; 10MW = 10 - 19.99 MW; 20MW = 20 - 49.99 MW; 50MW = 50 - 99.99 MW; 100MW = 100 MW+

C.18: *Median income half a mile from all facilities in the United States is shown as box plots. Installation size increases from right to left. The national median income is displayed as a horizontal line. The interquartile range for median income appears to roughly decrease as facility size increases. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*



C.19: *Median income three miles from all facilities in the United States is shown as box plots. Installation size increases from right to left. The national median income is displayed as a horizontal line. The interquartile range for median income appears to roughly decrease as facility size increases. Extreme minimums were caused by unreported median income by about 3 percent of block groups, which affected the weighted sum calculations.*



Note: Utility-scale solar facilities categories classified as follows: 1MW = 1 - 4.99 MW; 5 MW = 5 - 9.99 MW; 10MW = 10 - 19.99; 20MW = 20 - 49.99 MW; 50 MW = 50 - 99.99 MW; 100MW = 100 MW+

Appendix C.20 - Median Income Near Solar Facilities

C.20: *The table below provides estimates of median income by facility size and distance from a solar facility.*

Appendix C.20
Median Income Near Select Utility-Scale Solar Installations in the United States
by Proximity and Installation Size

Facility Type & Distance	Median Income				
	Min	1st Quartile	Median	3rd Quartile	Max
1 MW					
100 ft	$ 36	$ 41,047	$ 57,729	$ 80,801	$ 213,688
500 ft	$ 860	$ 40,622	$ 57,109	$ 80,608	$ 213,688
1000 ft	$ 355	$ 39,778	$ 57,600	$ 79,467	$ 213,688
1/2 mile	$ 27	$ 40,299	$ 57,296	$ 79,983	$ 211,761
1 mile	$ 128	$ 40,949	$ 56,887	$ 79,848	$ 206,895
3 miles	$ 17,139	$ 44,831	$ 59,579	$ 80,339	$ 170,451
5 MW					
100 ft	$ 6,114	$ 31,901	$ 42,188	$ 62,289	$ 159,833
500 ft	$ 3,531	$ 31,882	$ 42,120	$ 62,289	$ 159,833
1000 ft	$ 767	$ 31,572	$ 41,548	$ 62,111	$ 159,833
1/2 mile	$ 9,479	$ 31,810	$ 42,770	$ 62,089	$ 159,783
1 mile	$ 4,621	$ 32,490	$ 42,563	$ 61,549	$ 157,272
3 miles	$ 5,400	$ 35,226	$ 43,080	$ 60,130	$ 138,211
10 MW					
100 ft	$ 2,162	$ 36,467	$ 52,234	$ 72,143	$ 122,061
500 ft	$ 3,229	$ 36,467	$ 52,159	$ 71,828	$ 123,411
1000 ft	$ 9,984	$ 36,467	$ 51,856	$ 71,828	$ 128,343
1/2 mile	$ 1,998	$ 36,402	$ 50,788	$ 71,157	$ 145,389
1 mile	$ 4,135	$ 35,730	$ 49,397	$ 71,564	$ 148,741
3 miles	$ 3,548	$ 36,121	$ 47,984	$ 69,120	$ 165,564
20 MW					
100 ft	$ 517	$ 33,335	$ 45,888	$ 67,378	$ 90,134
500 ft	$ 4,347	$ 33,416	$ 45,860	$ 67,378	$ 90,134
1000 ft	$ 1,274	$ 31,882	$ 45,500	$ 66,006	$ 90,134
1/2 mile	$ 1,130	$ 30,424	$ 43,882	$ 62,489	$ 90,025
1 mile	$ 1,046	$ 30,482	$ 41,179	$ 59,530	$ 89,594
3 miles	$ 3,835	$ 35,420	$ 41,090	$ 54,269	$ 83,252
50 MW					
100 ft	$ 40	$ 31,338	$ 38,929	$ 49,581	$ 90,505
500 ft	$ 1,425	$ 31,305	$ 38,929	$ 49,581	$ 91,194
1000 ft	$ 3,333	$ 31,277	$ 38,929	$ 49,581	$ 91,907
1/2 mile	$ 1,156	$ 29,679	$ 37,009	$ 49,076	$ 93,230
1 mile	$ 59	$ 28,622	$ 34,223	$ 48,405	$ 94,386
3 miles	$ 13,508	$ 29,061	$ 34,270	$ 46,109	$ 90,734
100 MW					
100 ft	$ 1,344	$ 29,444	$ 38,834	$ 39,889	$ 80,383
500 ft	$ 3,312	$ 29,444	$ 37,725	$ 39,870	$ 80,383
1000 ft	$ 5,632	$ 29,444	$ 36,467	$ 40,249	$ 80,383
1/2 mile	$ 11,146	$ 28,649	$ 36,467	$ 39,870	$ 80,383
1 mile	$ 15,869	$ 26,115	$ 36,467	$ 39,870	$ 80,383
3 miles	$ 9,767	$ 22,936	$ 36,467	$ 39,870	$ 70,747

Note: These estimates are based on the median income in areas surrounding 956 utility-scale solar installations with verified coordinates. It does include all known utility-scale solar installations in the United States.

Sources: IPUMS National Historical Geographic Information System: Version 12.0. 2015 American Community Survey: 5-Year Data [2011-2015, Block Groups & Larger Areas], Minneapolis: University of Minnesota. 2017.
Solar installation coordinates based on EIA's Form 860 2016 Early Release and Lawrence Berkeley National Lab's proprietary Solar Installation data.

Appendix D.1: Survey Instrument

University of Texas - Lawrence Berkeley National Lab Solar Installations and Property Values Study

Hello and thank you for taking the time to participate in our survey on property values near solar installations. Below is a consent form with information about our study. We appreciate your feedback.

Identification of Investigator and Purpose of Study

Thank you for participating in this research study, entitled "Property-Value Impacts Near Utility-Scale Solar Installations." The study is being conducted by Dr. Varun Rai, Leila Al-Hamoodah, Eugenie Schieve, and Kavita Koppa at the LBJ School of Public Affairs of The University of Texas at Austin, PO Box Y, Austin, TX, 78713. You can reach the team via email at varun.rai@mail.utexas.edu.

The purpose of this research study is to examine the effects of utility-scale solar installations on residential property values. Your participation in the study will contribute to a better understanding of how these effects, if they exist, are incorporated into property value assessment. You are free to contact the research team at the above email address to discuss the study. You must be at least 18 years old to participate.

If you agree to participate:

- You will complete a survey about if and how utility-scale solar installations affect property values.
- The survey will take approximately 10 to 15 minutes of your time.
- You will not be compensated for your participation.

Risks/Benefits/Confidentiality of Data

There are no known risks to participation in this survey. There will be no costs to you for participating, nor will you be compensated. Your email address will be kept during the data collection phase for tracking purposes, and to share final results with you if you indicate you want them. A limited number of research team members will have access to the data during data collection and analysis. Personally identifying information, including email address, will be stripped from the final dataset. Email addresses will not be shared.

Participation or Withdrawal

Your participation in this survey is voluntary. You may decline to answer any question and you have the right to withdraw from participation at any time. Withdrawal will not affect your relationship with The University of Texas in any way. If you do not want to participate you may close your browser window at any time to exit the survey. If you do not want to receive any more reminders about the survey, please click the opt-out link in the invitation email you received.

Contacts

If you have any questions about the study or need to update your email address, send an email to varun.rai@mail.utexas.edu. This study has been reviewed by The University of Texas at Austin Institutional Review Board and the study number is [STUDY NUMBER].

Your Rights as a Research Participant

If you have questions about your rights or are dissatisfied at any time with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email at orsc@uts.cc.utexas.edu.

This page serves as your formal consent to participate in this study. Please print a copy of this page for your records. If you agree to participate in this study, click indicate your consent below.

Please indicate your consent to participate in this survey.

◯ **I consent** to participate in this survey

◯ I **do not** consent to participate in this survey

Thank you for taking the time to complete this survey. This survey is intended for individuals who are currently or were recently employed as a home assessor or home appraiser in the United States for the public sector. We recommend completing this survey on a laptop or desktop computer, rather than on a phone or tablet.

While completing this survey, please consider the following definitions as used in this survey:

1. **Utility-scale solar installations** include any ground-mounted photovoltaic (PV) solar arrays that sell electricity to a utility rather than providing electricity for residential use. These installations can be of any size but utility-scale are typically considered to be at least 1 megawatt (MW), which may cover between 5 and 9 acres of land per MW. See the images below for examples of utility-scale solar installations.
2. **Assessment** refers to the process of assessing or appraising the value of a home for the public sector.
3. **Assessment value or appraisal value** refers to the monetary value public assessors or public appraisers estimate for a home. For the purposes of this survey, assessment value and appraisal value may be referred to simply as "value". Impacts on home prices refer to monetary impacts (i.e. a change in the value of the home).

   If you have any questions while completing the survey, please contact varun.rai@mail.utexas.edu. Thank you for your time.

Examples of utility-scale solar installations in the United States.

We would like to know more about the role in which you assess homes. Which of the following best describes you?

- ◯ I am **currently** an assessor or appraiser for the public sector (i.e. I am employed by a county or town to perform assessments)
- ◯ I was **formerly** an assessor or appraiser for the public sector
- ◯ I have **never** been an assessor or appraiser for the public sector
- ◯ I prefer not to answer

How many years of experience do you or did you have in assessing for the public sector? *Please indicate the number of years only in your response. For example, please indicate "9" rather than "nine" or "9 years."*

____

What was the approximate date of the most recent residential assessment you completed?

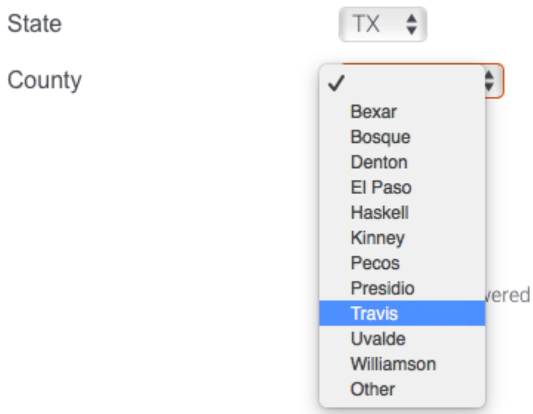
Year 2015

Month ✓

January
February
March
April
May
June
July
August
September
October
November
December

Powered by

In which state and county (or county equivalent) are/were you most recently employed as an assessor or appraiser for the public sector?



Because you selected "other", please indicate the county (or county equivalent) you are or were most recently employed as an assessor or appraiser for the public sector?

____

To the best of your knowledge, approximately how many utility-scale solar installations are currently operating in the county (or county equivalent) where you are/were most recently employed as an assessor for the public sector?
Please indicate the number of installations only in your response. For example, please indicate "5" rather than "five" or "about five."

____

Does your professional manual or do your professional training materials provide instructions regarding assessing home values that are located near a utility-scale solar installation?

◯ Yes

◯ No

◯ I don't know

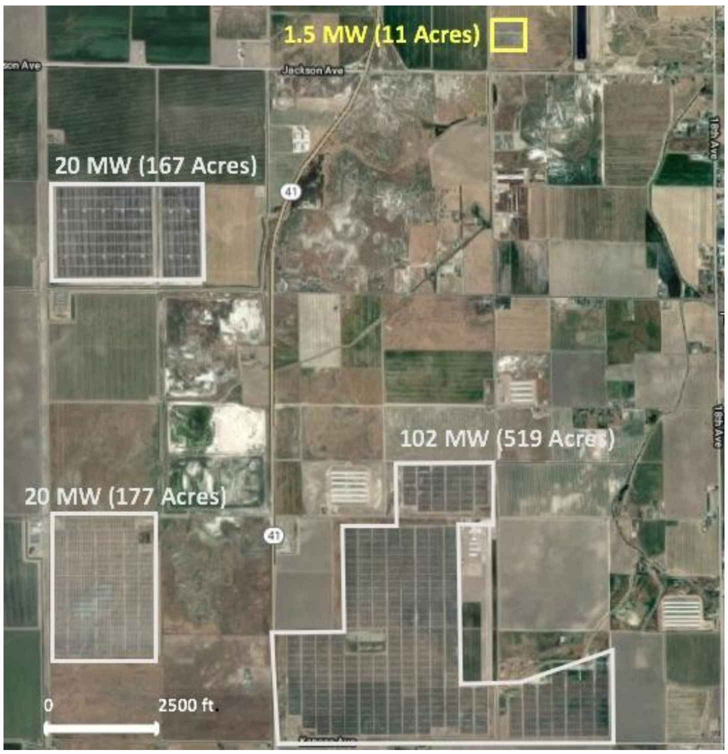
◯ I don't have a manual or other professional materials

◯ I prefer not to answer

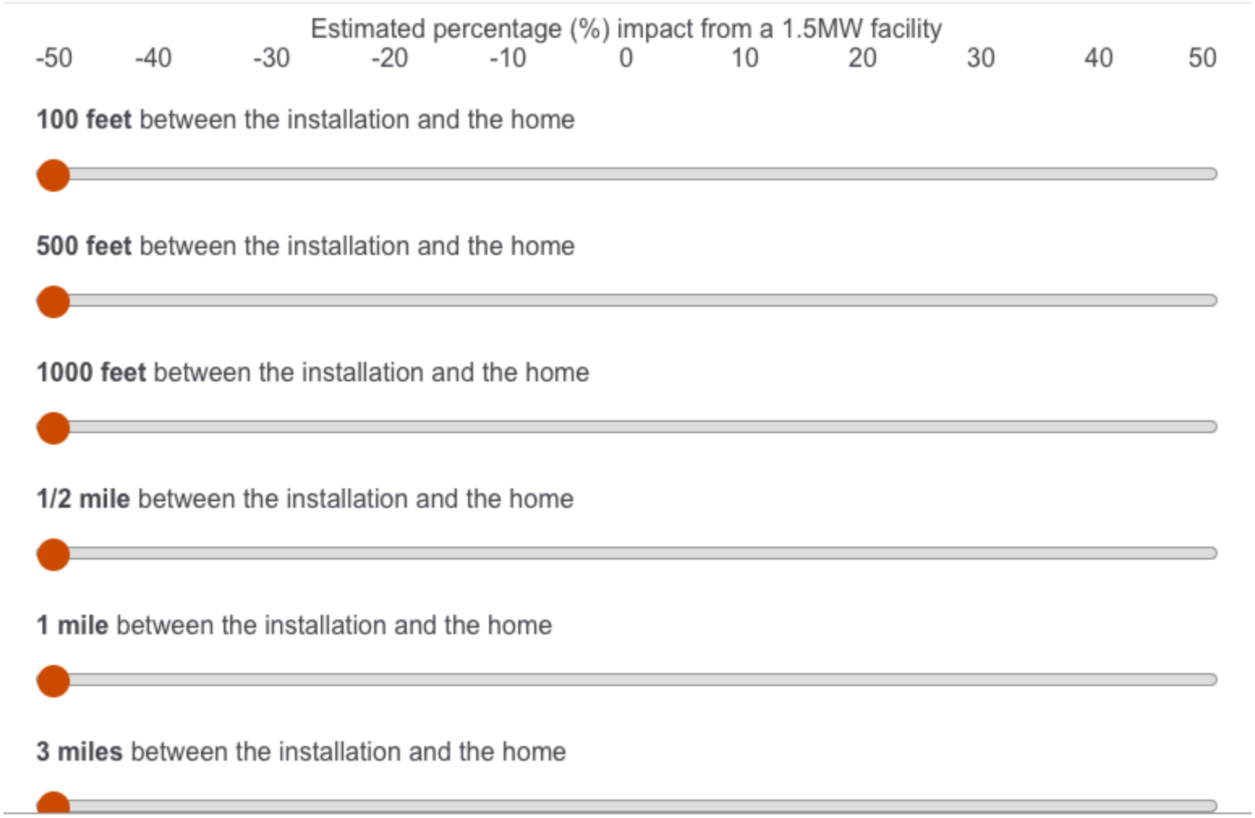
Part I: 1.5MW Facilities

Please use the sliders below to estimate if and how the presence of a **1.5MW** utility-scale solar installation would impact a nearby home's assessment value **in percentage terms**. Please do so at the varying distances between the home and the nearest solar panel.

1.5MW utility-scale solar installations may cover between 7.5 to 13.5 acres. For an example of a 1.5MW solar installation, please refer to the image below.



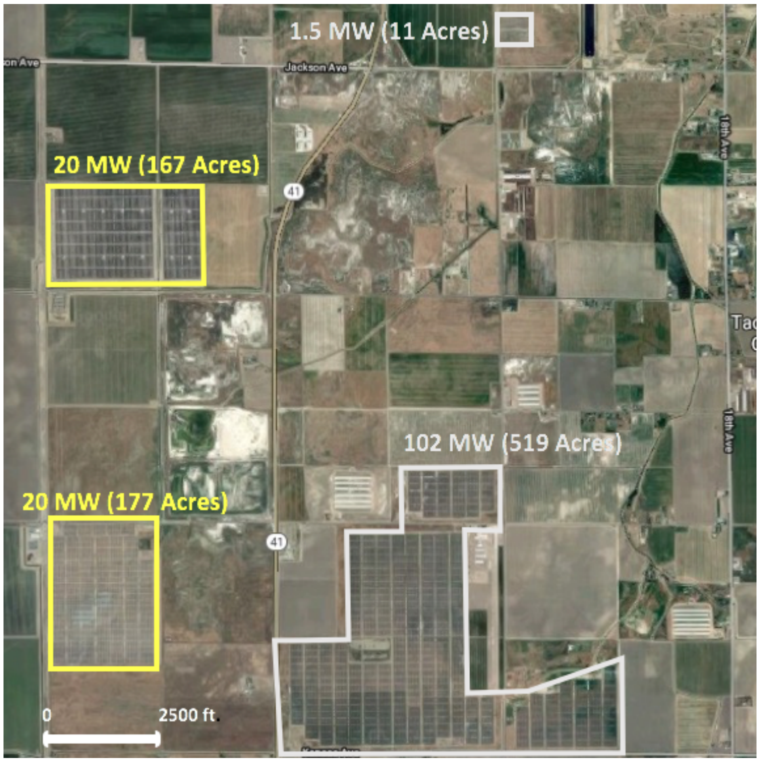
- Please indicate a value of **0** if the value of the home would not be impacted in any way by the presence of a 1.5MW solar installation at a given distance, in percent terms.
- Please indicate the corresponding value **greater than 0** if the value of the home would increase by the presence of a 1.5MW solar installation at a given distance, in percent terms.
- Please indicate the corresponding value **less than 0** if the value of the home would decrease by the presence of a 1.5MW solar installation at a given distance, in percent terms.



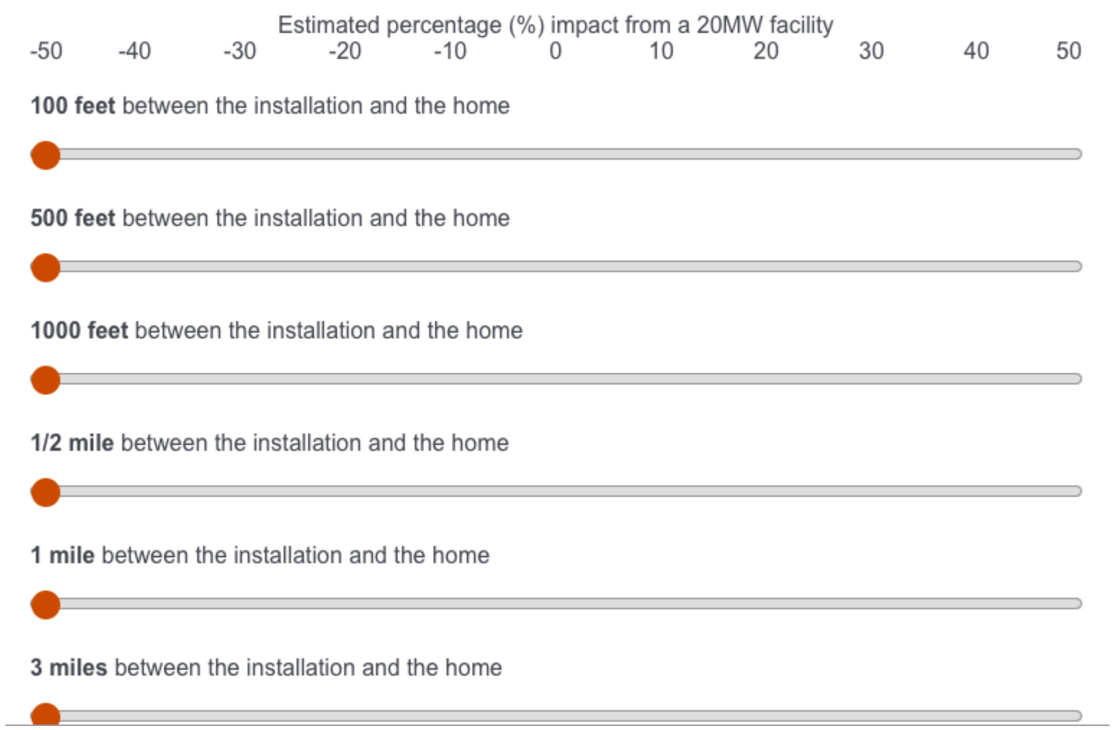
Part II: 20MW Facilities

Please use the sliders below to estimate if and how the presence of a utility-scale solar installation of 20MW would impact a nearby home's assessment value in percentage terms. Please do so at the varying distances between the home and the nearest solar panel.

Utility-scale solar installations of 20MW may cover 100 to 180 acres. For an example of a solar installation of 20MW, please refer to the image below.



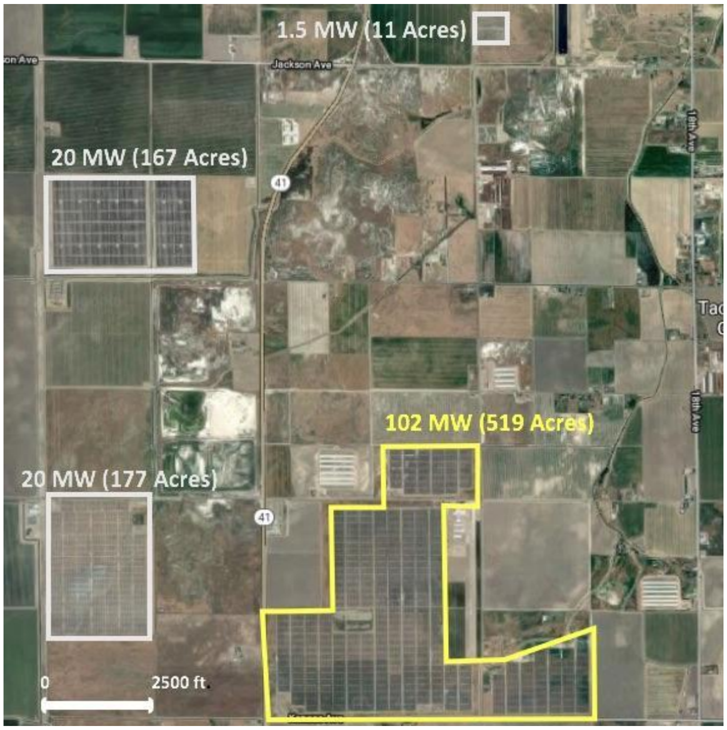
- Please indicate a value of **0** if the value of the home would not be impacted in any way by the presence of a 20MW solar installation at a given distance, in percent terms.
- Please indicate the corresponding value **greater than 0** if the value of the home would increase by the presence of a 20MW solar installation at a given distance, in percent terms.
- Please indicate the corresponding value **less than 0** if the value of the home would decrease by the presence of a 20MW solar installation at a given distance, in percent terms.



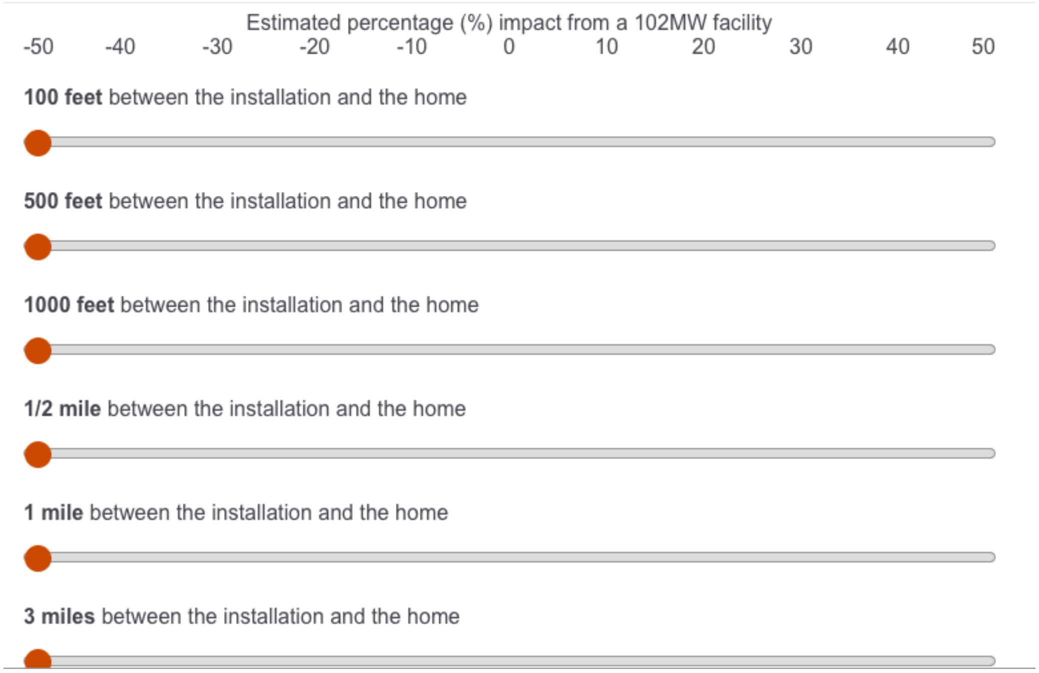
Part III: 102MW Facilities

Please use the sliders below to estimate if and how the presence of a **102MW** utility-scale solar installation would impact a nearby home's assessment value in percentage terms. Please do so at the varying distances between the home and the nearest solar panel.

Utility-scale solar installations 102MW may cover 510 to 918 acres. For an example of a 102MW solar installation, please refer to the image below.



- Please indicate a value of **0** if the value of the home would not be impacted in any way by the presence of a 102MW solar installation at a given distance, in percent terms.
- Please indicate the corresponding value **greater than 0** if the value of the home would increase by the presence of a 102MW solar installation at a given distance, in percent terms.
- Please indicate the corresponding value **less than 0** if the value of the home would decrease by the presence of a 102MW solar installation at a given distance, in percent terms.



Do you have any other comments on the value impacts from proximity to utility-scale solar installations?

____

Please indicate whether the following features or aspects of a utility-scale installation would have a positive or negative impact on nearby residential property values:

	Strongly negative	Negative	No effect	Positive	Strongly positive
Panels that move to track the sun's position	○	○	○	○	○
Increase in the installation's size	○	○	○	○	○
Increase in the height of the panels from the ground	○	○	○	○	○
Presence of visual barriers around the solar array (e.g. trees, hedges, fence, etc.)	○	○	○	○	○
Mountainous topography surrounding the installation	○	○	○	○	○
Flat topography surrounding the installation	○	○	○	○	○
New infrastructure associated with the installation (e.g. power lines)	○	○	○	○	○

Have you assessed a home near a utility-scale solar installation?

○ Yes

○ No

○ Other (please explain) ____________________

○ I prefer not to answer

Have you adjusted for the value of a home based on the presence of a utility-scale solar installation in the past?

- ◯ Yes
- ◯ No
- ◯ Other (please explain) ____________________
- ◯ I prefer not to answer

Do you have any comments on your experience assessing homes near utility-scale solar installations that you would like to share?

____

In general, what is your opinion of solar energy in the U.S.?

- ◯ Extremely positive
- ◯ Somewhat positive
- ◯ Neither positive nor negative
- ◯ Somewhat negative
- ◯ Extremely negative
- ◯ I prefer not to answer

Is there anything in this survey that we should clarify or that you would like to comment on?
This will help us refine our survey to ensure it is as clear as possible.

____

Would you like to be informed via email of the results of this research upon study completion?

- ○ Yes
- ○ No

May we follow up with you via email if we need to clarify your survey responses?

- ○ Yes
- ○ No

What is your email address?
Your email address will not be shared and will be used for survey validation and related communication purposes only.

____

Are you ready to submit?
If you are done with the survey, please click the forward button below. If not, please use the back button at the bottom of the screen to return to your previous answers.

Appendix D.2 - Responses by Geographic Region and Question

Appendix D.2: *The above table indicates where respondents come from for each question, as well as the number of respondents per question.*

Respondents by Geographic Region

State	Years of Experience n = 36	Last Assess. Date n = 35	Perceived Install. Count n = 33	Solar PV in Prof. Manual n = 34	Estimates of PV Impacts (%) n = 18	Impact of Solar Features n = 19	Near Assessed Near Solar? n = 22	Adjusted Near Solar? n = 22	Opinion of Solar n = 23
AZ	X	X	--	--	--	--	--	--	--
CO	X	X	X	X	--	--	--	--	--
CT	X	X	X	X	X	X	X	X	X
FL	X	X	X	X	X	X	X	X	X
GA	X	X	X	X	X	--	--	--	--
HI	X	--	X	X	X	X	X	X	X
IA	X	X	X	X	X	X	X	X	X
ID	X	X	X	X	--	--	--	--	--
IL	X	X	X	X	--	--	--	--	--
IN	X	X	X	X	X	X	X	X	X
MA	X	X	X	X	X	X	X	X	X
MD	X	X	X	X	--	--	X	--	X
MN	X	X	X	X	X	X	X	X	X
NC	X	X	X	X	X	X	X	X	X
NJ	X	X	X	X	X	X	X	X	X
NM	X	X	X	X	--	X	X	X	X
NV	X	X	X	X	--	--	--	--	--
OR	X	X	X	X	--	--	X	X	--
SC	X	X	X	X	--	X	X	X	X
UT	X	X	X	X	X	X	X	X	X
VA	X	X	X	X	X	X	X	X	X
VT	X	X	X	X	--	--	--	--	--
WI	X	X	X	X	--	--	X	X	X

Appendix D.3 - Descriptive Statistics for Estimates of Property Value Impacts (%)

Table B.1: *The below table contains descriptive statistics on all respondents' estimates of home value impacts due to proximity to solar installation. These impacts were estimated at several distances between the home and the installation, and for three facility sizes. The table also includes p-values from t-tests measuring whether the mean of responses was statistically different than zero.*

Estimates of Impact on Property Values from Solar Installations by Size and Distance (%)

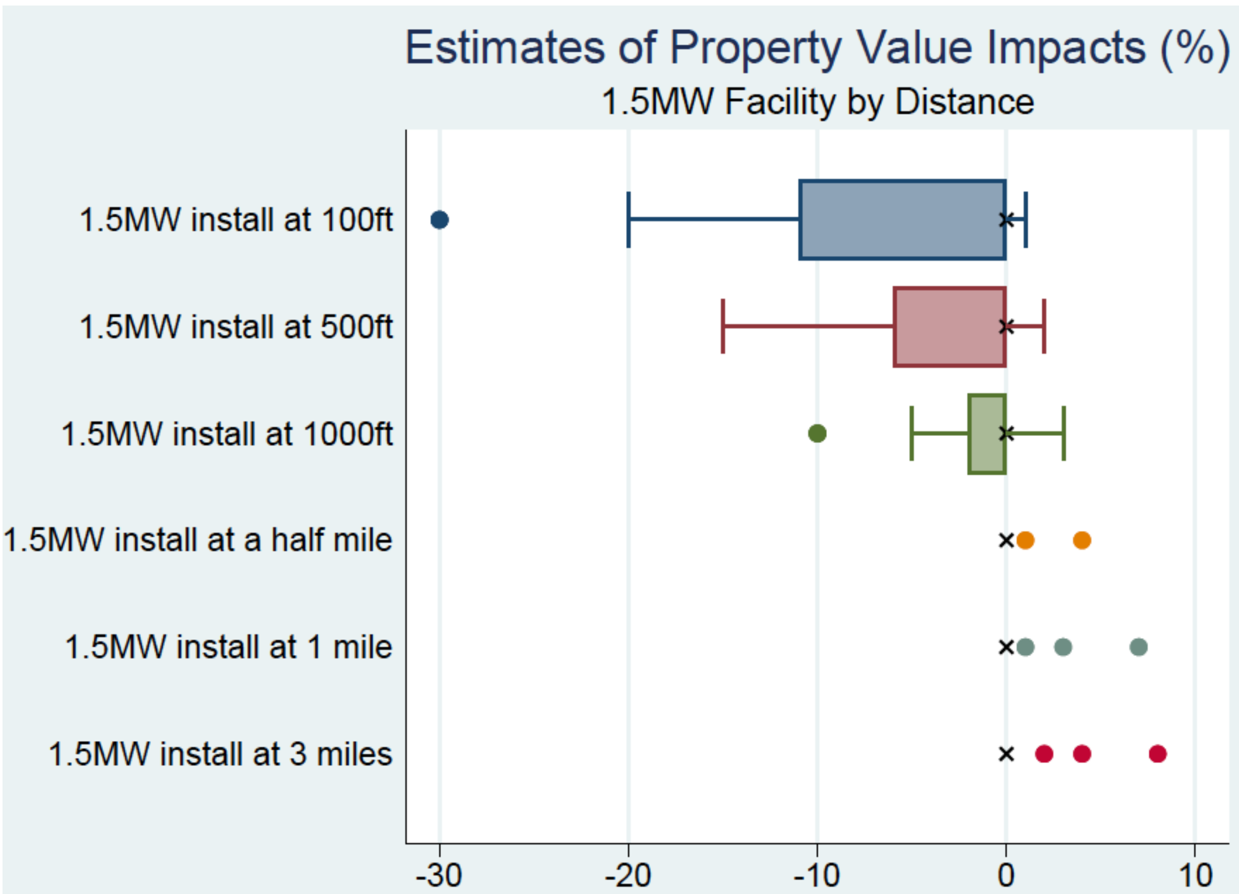
	Mean	Standard Deviation	Min	10th Percentile	Median	90th Percentile	Max	t-test p-value	n
1.5 Megawatts									
100 feet	-7.0	10.7	-30	-30	0	1	1	0.016 **	17
500 feet	-3.2	5.6	-15	-15	0	1	2	0.025 **	18
1000 feet	-1.6	3.6	-10	-10	0	1	3	0.084 *	18
1/2 mile	0.3	1.0	0	0	0	1	4	0.236	18
1 mile	0.6	1.8	0	0	0	3	7	0.158	18
3 miles	0.8	2.1	0	0	0	4	8	0.130	18
20 Megawatts									
100 feet	-10.2	13.9	-40	-30	0	1	5	0.006 **	18
500 feet	-6.4	8.8	-20	-20	0	1	5	0.007 **	18
1000 feet	-3.2	5.5	-15	-15	0	0	1	0.023 **	18
1/2 mile	-1.1	3.5	-10	-10	0	1	3	0.201	18
1 mile	0.2	2.0	-5	0	0	2	6	0.636	18
3 miles	0.6	1.9	0	0	0	2	8	0.193	18
102 Megawatts									
100 feet	-9.8	14.1	-32	-30	0	0	10	0.011 **	17
500 feet	-8.3	11.8	-30	-25	0	0	10	0.008 **	18
1000 feet	-5.7	8.3	-25	-20	0	0	0	0.010 **	18
1/2 mile	-2.7	5.5	-20	-10	0	0	1	0.052 *	18
1 mile	-1.2	4.2	-15	-10	0	1	2	0.236	18
3 miles	0.0	3.1	-10	0	0	2	8	1.000	18

Notes: t-tests test the mean against the null hypothesis of zero
** significant at the 5% level, * significant at the 10% level

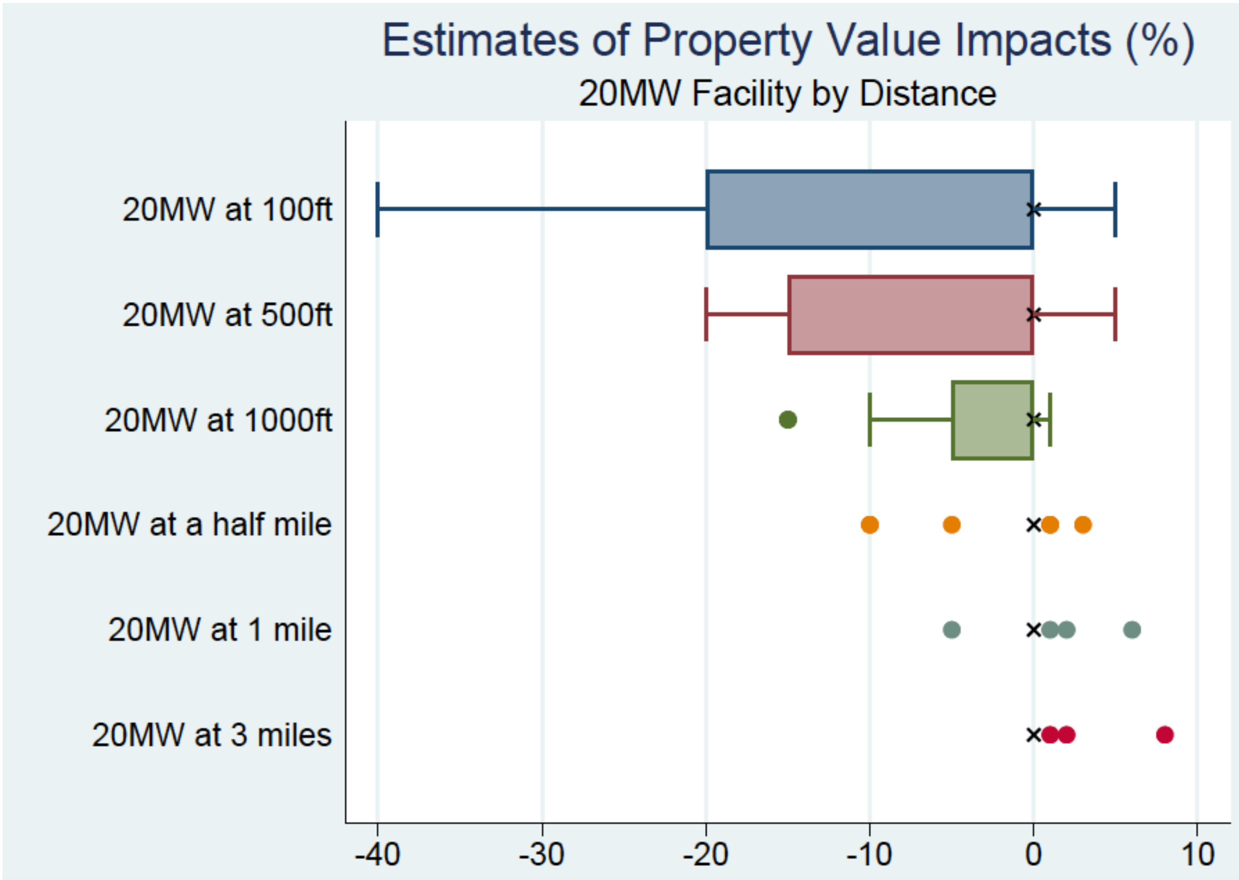
Appendices D.4 - D.6 - Estimates of Property Value Impacts in Boxplots

The following boxplots provide additional information on the variation in survey responses for estimates of property value impacts by facility size and distance.

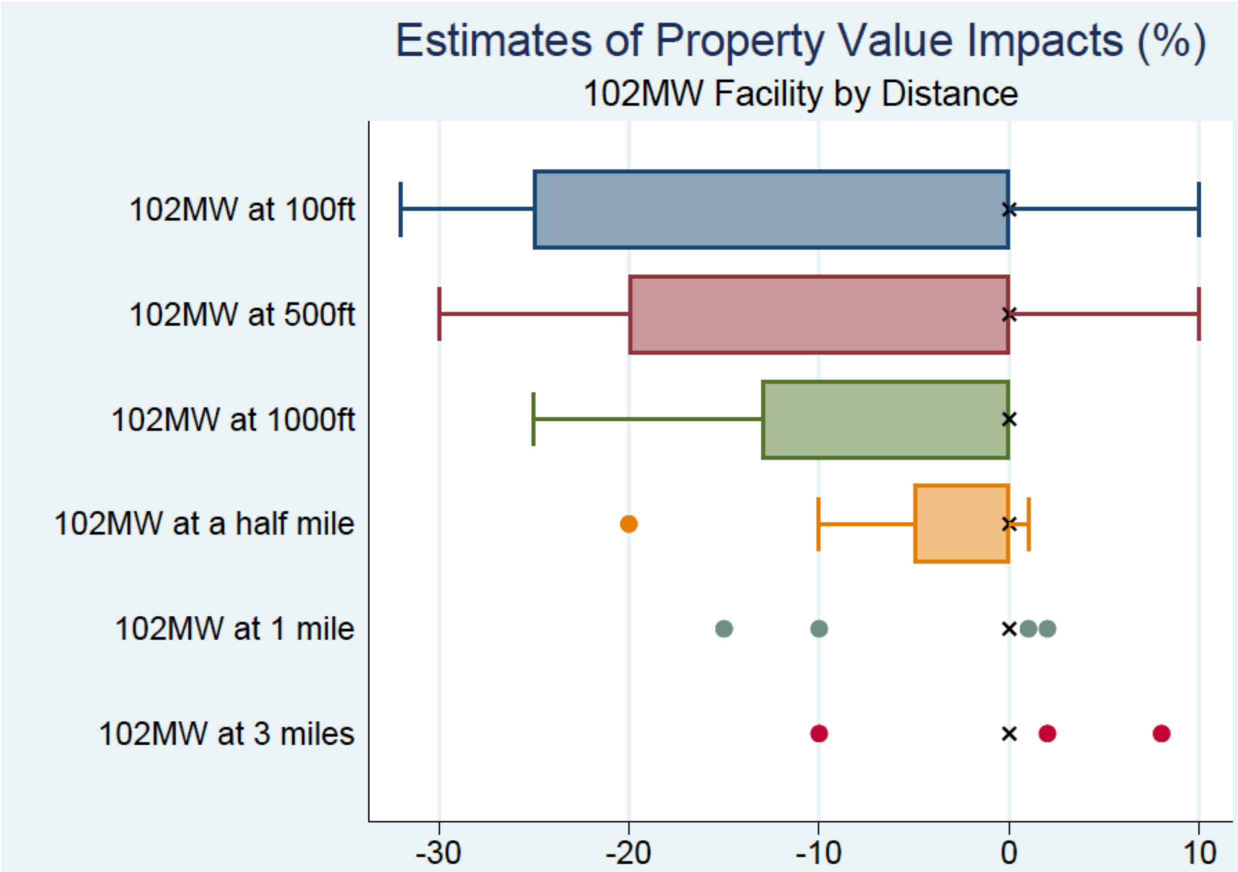
Appendix D.4: *The below boxplots indicate the range of estimates from survey respondents for property value impacts near a 1.5MW facility. The median is indicated with an "X".*



Appendix D.5: *The below boxplots indicate the range of estimates from survey respondents for property value impacts near a 20MW facility. The median is indicated with an "X".*



Appendix D.6: *The below boxplots indicate the range of estimates from survey respondents for property value impacts near a 102MW facility. The median is indicated with an "X".*



Appendix D.7 - Estimating Property Value Impacts in Dollar Terms ($)

To estimate property value impacts in dollar terms, we pulled county-level median home value from the U.S. Census Bureau's 2016 American Community Survey. The below table converts the estimates of property value impacts provided by survey respondents into dollars, based on the median home value in each respondent's county. If this impact were the true impact and the home values were the same for the whole county, then the results suggest that being located 100 feet from a 20MW solar installation would be associated with a $26,252 decline in home value, on average. By contrast, living three miles from a 1.5MW installation would be associated with an average $1,098 gain in value. Of course, variations in median home values and effect sizes across the United States could lead to significant differences by region.

Table: *The below table provides descriptive statistics on the estimate of home value impact translated into dollars. The dollar impacts are estimated by multiplying each respondent's estimate of impact (%) with the median home price in their county.*

Estimates of Property Values Impacts($) by Size and Distance

	Median	Mean	Min	Max	St. Dev.	n
1.5 Megawatts						
100 feet	$0	-$18,874	-$98,760	$1,613	$31,621	17
500 feet	$0	-$9,926	-$74,070	$3,226	$19,841	18
1000 feet	$0	-$5,787	-$49,380	$4,839	$13,427	18
1/2 mile	$0	$411	$0	$6,452	$1,524	18
1 mile	$0	$877	$0	$9,989	$2,547	18
3 miles	$0	$1,098	$0	$11,416	$3,008	18
20 Megawatts						
100 feet	$0	-$26,252	-$119,400	$6,330	$40,673	18
500 feet	$0	-$17,230	-$76,600	$6,330	$27,051	18
1000 feet	$0	-$9,842	-$59,700	$951	$18,367	18
1/2 mile	$0	-$3,475	-$39,800	$4,281	$10,398	18
1 mile	$0	-$398	-$19,900	$8,562	$5,301	18
3 miles	$0	$866	$0	$11,416	$2,745	18
102 Megawatts						
100 feet	$0	-$24,136	-$119,400	$12,660	$38,859	17
500 feet	$0	-$20,998	-$79,600	$12,660	$31,354	18
1000 feet	$0	-$14,961	-$61,950	$0	$23,540	18
1/2 mile	$0	-$6,971	-$49,560	$951	$14,704	18
1 mile	$0	-$4,065	-$39,800	$2,854	$12,549	18
3 miles	$0	-$637	-$24,780	$11,416	$6,601	18