



APPENDIX 15-E

Agrivoltaic Solutions Site Design



Solar Facility Layout and Design Guidelines for Managed Grazing

Prepared for AES Clean Energy

Size of sheep: Size is breed dependent, but on average, adult sheep stand about 36-42" at the tip of their ears and 30-36" tall to the top of the shoulder. They duck under the leading edge of the panels at solar sites with panels as low as 24".

Fencing

Perimeter fences

- Specifications
 - Height is to be determined by FERC or other codes and does not need to be higher than 6' for sheep.
 - Tensioned woven wire ("ag fencing") 12.5 gauge or heavier is acceptable, chain link is always preferable.
 - Chain link requires a bottom tensioning wire above the ground, this is important for keeping sheep inside and predators outside.
 - Woven wire is designed for high-tension installation and will typically not require this additional tensioning wire.
 - Maximum post spacing for woven wire is 15' to ensure proper tension. The most important aspect for grazing sheep is the bottom gap tolerance to the grade. This should be as close to 0" as possible and should be tightly contoured to variations in grade with no openings or gaps. Maximum gap tolerance is 1.5".
 - If possible, bottom of fence should be buried slightly below the soil surface by post-installation grading. Another option for high predator areas is a "predator wrap" of fence material that lays out onto the ground for 6-8" away from the perimeter fence.



Figure 1. Perimeter fencing that follows grade well.

Gates

- Gates will be of the same fencing material as the rest of the fence, in the case of woven wire they will most likely be woven wire over a pipe framework.
- Ideally total gateway will be at least 20' wide, 24' is preferable. This becomes more important for larger groups of animals. Gate width is highly important to be able to safely move larger groups of animals and avoid fence damage and injury to animals and personnel.
- Grade the roadbed under the gates for maximum tolerance of 3" between bottom edge of gate and ground. Avoid large gaps between the roadway shoulder and the gate.
- Gates should swing freely both ways.
- Alignment recommendations:
 - Whenever possible gates between project sections should be lined up, facing one another.
 - Gates do not need to face roads – some interior facing gates will be necessary.
 - Gates should be positioned to allow for the flow of animal traffic from one power block or fenced section to the next. The smooth transit and/or flow of animals is the goal.
- Other gaps in perimeter fence such as culverts or ditch crossings should be covered with steel mesh or "hog panel" material.

Interior fences

- Woven wire fencing will be sufficiently sturdy and cost effective.
 - 42-48" ideal height, but 36" will be acceptable.
 - Standard metal pipe gates are recommended for access road crossings, see below for more interior gate information.
 - For managed grazing programs on large scale solar sites, sheep will be rotated on a schedule through the site in paddocks, or site sub-sections that are broken down with portable or permanent fencing.
 - Paddock size is largely dependent on the site stocking rate described in the managed grazing plan. A rotationally grazed site, or area of site, will be divided into a minimum of 10 grazing paddocks. In many cases, some strategic placement of permanent interior fence greatly helps with creating paddocks and reducing the need for portable fencing installed by the grazing contractor. Permanent paddock fencing is both attractive to potential grazing providers and will reduce operating costs over the long term.
 - The grazing paddock layout will generally fit to the layout of power blocks and roadways, as it is easier to fit fencelines along roads and through gaps between powerblocks. It is difficult to install portable fencing across CAB lines and raised drivelines.
 - The paddocks / interior fencing could be constructed of woven wire mesh, as the perimeter fence.
 - Height: It can shorter: 36" or 42" will suffice.
 - Hot wire not necessary at the top
 - Fence should be connected to the perimeter fences.
 - Interior Paddock Gates: The gates should be planned in the site layout. There will be two types of gates: those for the sheep flock and those to allow general service person passage from one fenced area to the next.
- Sheep gates:
 - Where possible they should line up with interior laneways
 - They should be sized (in length) to allow for the passage of vehicles at roadways
 - Width should be 20-24'; double gateways are recommended.
 - Height is typically no more than 50", should match interior fence type.
 - Gates will need to swing freely in both directions
 - Gate construction should be of wires that are spaced 4" on center or tighter
 - Gaps between gates and posts or gates and ground should
 - not exceed 3".

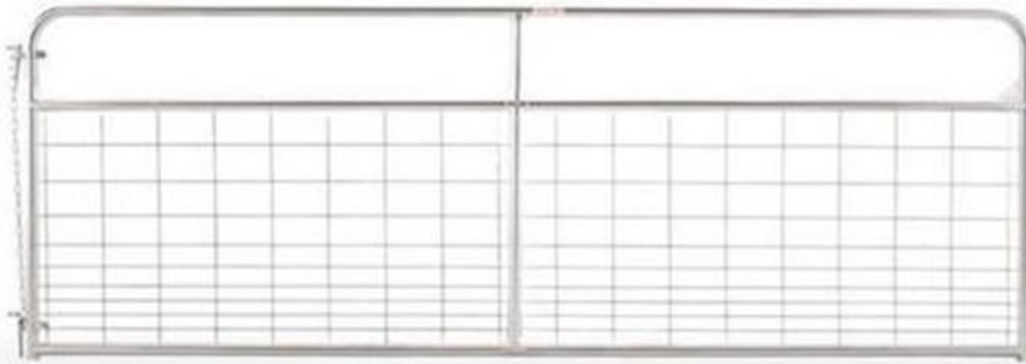


Figure 2. Sheep gates.

- Person gates
 - Should be placed to allow the easy flow of workers around the site.
 - Width likely 48"
 - Height is typically standard at 50"

Electrical access

- Providing the sheep farmers with access to 110v and/or 220 v power would be helpful.
- One box of outlets per powerblock or interior paddock is recommended.
- Shepherds will have limited use for this electricity: typically, it is to power a low voltage fence within a paddock or it would be to pump water. An example of the low voltage Electronet® fence is provided here, by Premier 1, the major manufacturer of this product line.

Wiring/Racking

- Good wire management is of paramount importance. Wiring should be neatly tucked and secured, with no large loops or dangles. Loose wiring not only can be caught by sheep, but also poses risks to mowing and trimming equipment.
- Conduit and sleeves are useful for wire control, as are zip ties.
- It is recommended that CAB cabling on grazed sites be installed 24-32" above the ground to allow sheep to easily pass underneath without excessive rubbing or swinging. CAB has been widely used successfully on grazed sites, even when installed lower than this, but considerable care should be taken to ensure good wire management, especially when wires are joined into the CAB system.
- It should be noted that sheep may swing or push on the CAB system as they pass through. It may be worth looking at options for heavier gauge CAB support cable and hanger brackets in the long term.



Figure 3. Sheep passing under CAB cabling.



Figure 4. Good wire management on module-module connectors.



Figure 5. Poor wire management on CAB system, has caused sheep entanglement.

Water

- The sheep will need fresh drinking water in every site paddock. Water requirements are highly weather dependent but at peak will be in the range of 1-2 gallons per sheep per day for mature sheep.
- Water can be delivered through the site using aboveground flexible $\frac{3}{4}$ "-1" poly water line. These lines are best laid along site roadways or along fencelines and are easily drained to avoid freezing in winter. These will be fitted with spigots at regular intervals to allow water tanks to be moved from paddock to paddock as the sheep move through the site.
- Ideally, water should be sourced from on-site wells or municipal hookup if available. As a temporary measure, water can be trucked to holding tanks which feed into the delivery lines. Solar pressure pumps are a good solution for wells or tanks that offer flexibility in location and cost efficiency.
- Sheep are selective about water sources and will avoid dirty or brackish water. Pond sources of water may be an acceptable source to pump from in some instances but it is important to note that the dry periods of the summer are when sheep water needs are highest and are also often when pond levels are low and water muddy.
- Sheep should always be fenced out of ponds and other surface water to avoid manure contamination. This is best done with a permanent fence of the same type as recommended for permanent paddock fencing.

Sheep Exclusion

Equipment Pads

- Sheep are naturally curious, and while they do not pose a risk of damage to site equipment pads, they often find them attractive places to gather at and sleep on. This can lead to large amounts of manure collection and a nuisance to service personnel. Equipment pads should have simple exclusion fences placed around them with gates for technician access. Height and material can be the same as the interior paddock fencing, or even simple metal gates can be set up around the exclusion area.



Figure 6. Simple exclusion fence around equipment pad.

Winter Housing

- The sheep will need winter housing off site or adjacent to the site. Sheep will not overwinter in Upstate NY otherwise. Generally, sheep will be off-site between November and May.

Handling Systems

- Periodically catching sheep and penning them into a small area is an essential part of good shepherding. This can be particularly challenging on solar sites where spaces are large and visibility is limited. Most shepherds will want their own handling system – typically a portable affair- installed from time to time at parts of a solar array. It is however possible to allow for more permanent structures to live at sites. They need not interfere with the racking or other site layout plans and can be placed off to the side in an area unusable for anything else.

Hay and Forage Production

General Requirements

- Forage production can be a useful tool for managing seasonal variation in vegetation growth on-site while producing a store-able agricultural product. This can be in the form of dry hay or semi-dry silage.
- Hay and forage can be made both inside the rows of panels and outside of the power blocks but inside of the perimeter fence.
- For hay making in between panel rows, equipment must be able to make single direction passes all the way down the rows and turn around at the end. This requires panel rows to be unobstructed by CAB cabling, cable trays, drivelines or other impediments. It also requires sufficient space (Roughly 50-70' minimum depending on equipment) for turning at the end rows.
- Hay and forage production outside of the rows in portions of the site inside the perimeter fence with larger open areas is less complex.
- Hay production is less advisable on steep sites for safety and liability reasons.
- Successfully producing hay on-site will largely be dependent on needs, equipment resources and abilities of the partner farmer.





Figure 7, 8, 9. Mowing and round baling hay on site.