Agrivoltaic Solutions LLC

Agricultural Integration Plan
Horseshoe Solar

2020

Prepared for:
Horseshoe Solar Energy LLC
One South Wacker Drive, Suite 1800
Chicago, Illinois 60606

Prepared By:
Agrivoltaic Solutions LLC
607-342-6721 & 802-349-6597
www.agrivoltaicsolutions.com

Action Plan for Maintaining Agricultural Productivity at Horseshoe Solar

Invenergy on behalf of Horseshoe Solar Energy LLC has enlisted Agrivoltaic Solutions LLC (AVS) of Ithaca, NY to develop a plan for the integration of farming into the Horseshoe Solar site. AVS will identify and work with local farmers to create a commercial sheep business that can be located at the Horseshoe facility, both performing vegetation maintenance and supporting a standalone agricultural enterprise. This will be a symbiotic model that will enhance the land's agricultural integrity while contributing a stimulus to the regional farm economy. Other non-sheep enterprises that are complementary to solar such as honeybees, hay, and other crops will also be explored although the primary focus will be on solar grazing.

This Agricultural Integration Plan is divided into two sections: the first provides an introduction and background on solar grazing and other co-location practices, while the second details a specific grazing plan tailored to the Horseshoe Solar site.

About Agrivoltaic Solutions

AVS is a team of sheep grazers and farmers with home farms in Cortland, Schuyler, and Tompkins Counties, NY. AVS has experience managing vegetation at solar sites with grazing sheep, plus prior grazing experience and training. The portfolio has expanded to include two additional counties and one additional farmer partner. AVS currently works with a number of family farms in New York to develop business and grazing plans centered around solar co-location.

AVS is directed by Lewis Fox and Lexie Hain. Both business partners attended Cornell University and are experienced farmers. Lexie has owned a farm since 2003 and juggled raising animals with a horticultural business until 2015, at which time she sold the nursery and began investing in sheep and solar grazing. Lewis has managed large scale cow and sheep dairies across New York, and purchased his own sheep in 2017. Both partners cooperate in organizing a grazing network for farmers in the Finger Lakes in addition to owning and grazing with their own flocks. They both serve on the board of the American Solar Grazing Association.

Section I

Introduction and Background on Solar Grazing and Other Co-location Opportunities

What is solar grazing?

Solar grazing is the practice of grazing livestock on solar farms. Sheep are best suited for solar grazing due to their size and behavior; as a result, for the safety of the solar array and for relevance to the Horseshoe Solar project, sheep are the only livestock that would be recommended for grazing under and immediately adjacent to the panels.

Solar grazing is an extension of two different techniques in commercial livestock operations: targeted grazing, and contract or custom grazing.

1. Targeted grazing, is the "carefully controlled grazing of livestock to accomplish specific vegetation management objectives. Under targeted grazing management, livestock are used as a tool for improving land health…" [1]. Targeted grazing techniques include systematic planning, monitoring, and evaluation for vegetation and livestock at sites. Plans are made by the managing farmer or grazier for each location that will be grazed using targeted grazing. Other targeted grazing applications (besides solar grazing) include using livestock to reduce wildland fire danger, perform weed control, and aid in land restoration projects. Current targeted sheep-grazing practices in New York State include the management of suckering in vineyards, undervine cover crops, and grass growth around the vines. Professor Justine Vanden Heuvel at Cornell University is the lead in this area of research at concord grape vineyards.
2. Contract or custom grazing. This is a production system for livestock owners in which they are paid to graze. A written contract defines payment terms and the responsibilities of each party. Contract grazing offers farmers an opportunity to start or expand operations without having to acquire additional land and offers an income stream to livestock owners without many of the costs typically associated with farming. Further, by incentivizing proper pasture management, contract grazing offers landowners, farmers, and regulatory bodies assurance that land is being managed in an environmentally responsible manner, improving the water quality by reducing nutrient runoff, reducing the potential for soil erosion, and improving potential for good wildlife habitats to co-exist at sites[2].

[1] Society for Range Management Blog, Accessed at: www.targetedgrazing.org
[2] Midwest Perennial Forage & Grazing Working Group, Factsheet 1 of 4 in the Contract Grazing Series. 2013. *The Basics of Contract Grazing*. Accessed at: http://www.iowabeefcenter.org/information/ContractGrazing1Basics.pdf

Solar Farms and Vegetation Management

Every solar site operator works within a budget to maintain the Project over its operational lifetime, which includes maintenance of fence and electrical systems, winter snow removal of access roads and/or panels, and vegetation management. The practice of contracting with sheep farmers is increasingly common for solar site operators; it is an attractive alternative to mechanical mowing because it supports agricultural land use, aligns with sustainability mandates, and when managed with good grazing practices, sheep can perform as well as mechanical mowing equipment in both cost and efficiency. Site operators don't need to adjust panel heights but may need to make other discrete accommodations for the grazing operation, such as adjusting the alignment of gates and corridors to promote the easy flow of livestock.[3]

For Horseshoe Solar, sheep would serve the purpose of a vegetation maintenance service that is low impact and allows the site to achieve its energy generation targets by reducing panel shading. It aligns with company sustainability mandates and sheep outperform mechanical mowing equipment when managed using good grazing practices.

Solar grazing is a highly effective form of vegetation management at solar sites. With proper grazing management, 100% vegetation compliance, or total removal of vegetative shading, is to be expected. Sheep, regardless of the breed, can graze under the solar panels and around the posts leaving an evenly clipped set of vegetation. To achieve the same results with mechanical mowers and equipment is expensive, slow work that landscape contractors are otherwise hired to do. The mowing equipment has the added negative impact of stirring up dust and rocks, which can reduce the efficiencies of the solar modules and damage them.

For sheep farmers to become successful solar graziers, they must charge for their services at a price point that meets expectations of solar site operators and provide a level of service that keeps the facility generating energy. They must also work through the specific logistics that a solar site requires as well as navigate the transition to a grass-fed model to the extent it differs from their current practices.

Case Studies: Solar Grazing for Large Scale Solar Projects

Solar grazing has been deployed at solar sites similar to Horseshoe for years. The vegetation on a five-hundred-acre solar array owned by Invenergy in South America is performed with sheep grazing. The sheep provide wool and meat to the South American marketplace. The shepherds are agronomists working for a specialty utility scale solar operations provider. The firm, FRV, is now planning to graze multiple utility-scale sites in Australia.

[3] For a selection of press on this subject covering solar sites around the country please see: https://www.solargrazing.org/news

A similar example at this scale exists in Biscoe, North Carolina, the flagship solar grazing array of Sun Raised Farms. The Montgomery Solar Array, a four-hundred and fifty-acre ground-mounted solar site has been grazed since its opening in 2016. Sheep exclusively graze this site as well as over 1,500 acres of additional ground-mounted solar arrays across the state. The Montgomery Array serves as a teaching facility for Sun Raised Farms' farmers.

Topaz Solar, a 3,400 acre, 550 MW solar array in the San Joaquin Valley, California, has been grazed since its construction in 2013. The independent farmer and contractor is Frank Iturria, a member of California Fibershed and the California Wool Grower's Association. The site produces 1,000 lambs a year for the market and wool for the specialty carbon-negative California Fibershed cooperative. A full-time site manager and flock herder lives at the site during the grazing season. Frank Iturria is paid a monthly management fee and compensated for sheep transportation and feed bills while on site. Finally, the site has been managed with the dual purposes of conservation grazing and protection for the endangered San Joaquin kit fox, a healthy population of which utilizes the fenced-in solar array as habitat.[4]

Solar operators in Europe have co-located sheep at ground mounted arrays for over 15 years. The French, Spanish, British, and Germans have employed solar grazing for more than ten years. In the case of the British, who have a long history of sheep farming, the critical mass of graziers has increased due to Brexit. Farmers have increased their leases to solar firms in order to stabilize income streams in times of economic uncertainty, and these farmers are already sheep farmers with an eye to maximizing grazable land. The BRE National Solar Centre has published several guides to solar grazing.[5] The largest firm using solar grazing is FRV, a Spanish operations & maintenance firm works in Australia, South American and Europe and uses sheep at its utility scale operations to manage vegetation.

There are a host of grazed solar arrays in North America. The most common among these is when a solar project is built in an agricultural community and the neighboring farmers approach the developer for an opportunity to graze the array with their livestock. Often done with a trial period, individual farmers from New Jersey to Arizona are finding partners in solar firms. Julie Bishop, a full time grazier and owner of Solar Sheep LLC in New Jersey, started her firm 5 years ago exactly this way. She now grazes community solar sites across southern New Jersey with over 750 ewes.

Finally, the other model emerging is one with origins in conservation. Minnesota Native Landscapes and A+ Environmental Restoration, of Florida, are both firms that specialize in vegetation management with specialized goals. Using livestock to achieve these goals was part of their project portfolio. Working with grazing plans, strict regulations around environmental management and sheep was the norm: now solar grazing is too. A+ Environmental Restoration

[4] California State University, Stanislaus Endangered Species Recover Program. 2019. *Response of San Joaquin Kit Foxes to Topaz Solar Farms: Implications for Conservation of Kit Foxes*. Accessed at: http://esrp.csustan.edu/news/pdf/Cypher%20et%20al%202019_Kit%20fox%20response%20to%20Topaz%20Solar%20Farm_CSUS%20ESRP.pdf

[5] www.bre.co.uk/nsc

is currently managing more than 1,500 acres of ground mounted solar for Tampa Bay Electric Company entirely with sheep. It also manages additional solar for Florida Power & Light. Minnesota Native Landscapes is working at a community scale and with the strictest biodiversity and pollinator guidelines in the United States.

Benefits for Farmers

Aside from additional wool, leather, and meat production, solar-grazing farmers can also benefit from access to specialty markets from the sheep products, such as what Sun Raised Foods offers their network of solar graziers in North Carolina, Virginia & Georgia. Sun Raised Farms solar grazed lamb is offered at gourmet outlets, locavore restaurants and through specialty online sales. They generate premium prices and regional market distinction. These marketing channels and market development opportunities exist in New York as well. There is a well-established set of privately and publicly funded opportunities to aid Livingston and Monroe County Farmers in meat from solar-grazed sheep. These include Certified New York Grown, a publicly funded program, and Certified Grassfed, a privately funded designation. Certified Solar Grown Lamb is a planned offering of the American Solar Grazing Association, targeted for 2021.

Solar Grazing: Terms and Contracts

The Cornell University Atkinson Center for a Sustainable Future funded a 2018 study to investigate solar grazing. The relevance for Livingston and Monroe County farmers is:

1. The grazing contracts are typically directly between solar operators and sheep farmers. Less often, the contracts are bid upon by landscaping contractors and then subcontracted to a sheep farmer. This second system has the advantage of being less expensive for the farmers as they don't need to carry the required site insurance. Most landscaping firms carry higher levels of insurance than farmers and meet the criteria set by the solar site owners. In either case, there's a precedent that the farmer can follow.

2. Most farmers who currently solar graze have annual contracts at the solar sites. Some contracts offer automatic renewal and great flexibility for the grazing farmer, with multi-year extensions. This allows the sheep farmers to plan their flock growth and make other management and budgeting decisions.

3. Contracts for solar grazing typically specify a maximum vegetation height and may specify a stocking density of the sheep or a daily rental rate per head.[6]

4. Solar grazing is new enough in New York that the marketplace for solar grazing services is still emerging. Solar site operators expect to pay for vegetation management at sites and budget for this operating expense. Most solar site

[6] Example contracts developed by the American Solar Grazing Association can be found at: https://www.solargrazing.org/farmer-resources

operators will have experience quoting several landscaping services and perhaps even a specialty solar landscaping firm, but only a few companies have experience working with sheep farmers at solar sites. Only a few firms exist that provide solar operations and maintenance services at all. Sheep farmers can capture benefits by working cooperatively with the site operators.

5. The practice of rotational grazing is the recommended best practice for grazing solar arrays. It is the practice of moving livestock to different sections of pasture (in this case, enclosed in the solar array) every set number of days in order to maintain healthy, nutritious forage (food) for the livestock. *Four Steps to Rotational Grazing*, a guide by Penn State Extension, provides the scientific basis and tools by which a farmer can gauge how many sheep are suited to an area at a given time.[7]

Typical stocking rates per acre at solar sites in the northeast US range from about 2 to 4 adult sheep per acre per grazing season. Lambs can be grazed at solar sites, as can mature sheep. For a more exact calculation of appropriate stocking density, the forage density and animal units can be aligned for each site, as they would be for other grazing operations. The other key information required by grazing managers is the maximum vegetation height and/or leading edge of the solar panels, in order to comply with contract requirements and prevent shading.

Solar grazing should have a similar output of sheep products per acre as other pasture-based livestock rearing systems. For business planning purposes, solar graziers should consult grass-fed sheep operations. Specialty operations such as wool production, cheesemaking, or other sheep dairy can be explored on this basis as well. Other specialty product development could also be integrated based on the processing capabilities and the planning capabilities of the grazing operation.

Grazing Guidelines in New York State: As Guidelines for Horseshoe Solar

Successful implementation of solar grazing includes planning and compliance in accordance with relevant regulatory structures. Most of the impacts of grazing with sheep are beneficial, especially if the following guidelines are adhered to or exceeded. There are few actual requirements around typical pasture grazing as most grazing practices are not formally regulated. Most of these guidelines are written to maximize the environmental benefit from the agricultural practice of grazing sheep on pastures.

Recommended assessment for the solar grazier and Invenergy's solar site manager to follow comes from New York State's Agricultural Environmental Management [AEM] Program.[8] This

[7] Penn State Extension, 2000. *Four Steps to Rotational Grazing*. Accessed at: https://extension.psu.edu/four-steps-to-rotational-grazing
[8] New York State AEM Program Core Concepts. Accessed at: https://www.nys-soilandwater.org/aem/aemcc.html

voluntary program administered by New York Soil & Water provides valuable assessment tools that could be applied to the Horseshoe Solar Site.

One such assessment tool is the AEM Tier 2 Worksheet Pasture Management[9]. Specifically, the solar graziers will be encouraged to follow the guidelines for prescribed grazing management. A directory of assessment tools and guidelines for best practice are found on the AEM Tier 2 Information Sheets and Training Modules site.[10] These include resources that could provide solar graziers with incentives and training modules on useful best practices, such as how to store soil carbon through good pasture management and how to best manage nutrients on a farm. An outline of the AEM program steps[11] and a list of AEM planners[12] are found on the project website.

Once the assessments are made, a conservation plan for Horseshoe Solar can be made to develop specific recommendations for best management practices based on the NRCS practice standards and tools. A conservation plan is Tier 3 in the AEM protocol.

The federal Natural Resources Conservation Service (NRCS) hosts a series of resources that would not be required from regulatory standpoint but could serve as resources from a voluntary best-practices standpoint for the solar array. The NRCS Field Office Technical Guide[13], or FOTG can be used as a locally specific, searchable resource.

We do not anticipate that a grazing operation at Horseshoe would require a CAFO permit, which is a permit required for a high animal-density Concentrated Animal Feeding Operation. This is an EPA-administered permit for confined operations, which we do not anticipate at Horseshoe Solar. For a basic outline, see this CAFO brochure[14] and CAFO *Producer's Compliance Guide*[15]. The anticipated number of grazing animals could match some of these numbers but the regulations should not apply due to the other criteria cited.

If these guidelines are adhered to, then AVS anticipates that sheep grazing on long-term perennial forages beneath solar arrays will inherently result in a high level of environmental stewardship with few resource concerns.

Working with Livingston & Monroe County Livestock Farmers and Graziers:

[9] AEM Tier 2 Worksheet *Pasture Management*. Accessed at: https://www.nys-soilandwater.org/aem/forms/PastureManagement.pdf
[10] AEM Technical Tools. Accessed at: https://www.nys-soilandwater.org/aem/techtools.html
[11] AEM Base Funding. Accessed at: https://www.nys-soilandwater.org/aem/basefunding.html
[12] AEM Documents. Accessed at: https://www.nys-soilandwater.org/aem/aemdocuments.html
[13] United States Department of Agriculture, Field Office Technical Guide. Accessed at: https://efotg.sc.egov.usda.gov/#/
[14] United States Environmental Protection Agency, 2002. *Concentrated Animal Feeding Operations, Clean Water Act Requirements*. Accessed at: https://www3.epa.gov/npdes/pubs/cafo_brochure_horse.pdf
[15] EPA, 2013. *Producer's Compliance Guide for CAFOs, Revised Clean Water Act Guidelines for Concentrated Animal Feeding Operations*. Accessed at: https://www3.epa.gov/npdes/pubs/cafo_prod_guide_entire_doc.pdf

AVS Solar Grazing Facility Tours

AVS has used its own contracted solar sites in the Finger Lakes as educational examples for farmers in the Horseshoe Solar region. During the 2019 grazing season (March-November) Agrivoltaic Solutions conducted a series of tours of solar grazing operations in the Finger Lakes of New York State. Tours were offered free of charge, including charter bus, safety gear, and snacks. Tours were advertised to two groups. The first, to the residents and public officials of the towns of Rush and Caledonia, NY: those in the immediate project area. The tours were advertised through multiple channels, including the town halls and direct mailings. Residents were brought to two solar arrays near Geneva, NY. Both tours were given time to walk around these community scale arrays (14 and 25 acres, respectively). These arrays are of modern construction and generally representative of what is planned for Horseshoe Solar. The residents and town officials were given time to see all aspects of the grazing operations at these sites and ask questions of the graziers at Agrivoltaic Solutions LLC.

The second set of tours were to government officials at New York State's Department of Agriculture and Markets, the USDA's Department of Rural Affairs and NYSERDA's Large Scale Renewables Division. This tour was given near Albany, NY at a 14-acre ground-mounted solar array. The solar graziers, who work on a contract with a third party solar firm, were available to answer all questions and tour the site.

A third set of private tours were offered at the Geneva sites on several occasions. These were private tours for interested Livingston County farmers, as mentioned above, and for NYSDAM officials to tour the sites in person and ask questions of the solar graziers during a normal operating period. Three of these tours were given in the summer of 2019.

Tours given by AVS have worked to inform Livingston and Monroe-area farmers and interested business owners on the essential mechanics of a solar grazing operation and to help them in evaluating enterprises that could be located at the Horseshoe project. AVS has connected several interested farmers with other solar graziers in the solar grazing network, and these area farmers traveled to Canada to visit grid scale solar grazed operations. AVS has continued to make tours possible for other those interested in the region to visit grazed solar sites in the Finger Lakes.

For the interested grazier, these tours demonstrate effective wells or water sources, sheep handling areas, and perimeter and interior fencing options. Sheep handling techniques, transportation options, stocking rates and management systems are typically discussed during site visits. The nuances of contracts, insurance, leases, safety compliance and are also discussed. Supporting resources are provided to the farmers. Topics for for pre-construction coordination with the solar developer are also outlined such as seed mix planning, electrical and water access, and gate placements are discussed during most visits. The timing and coordination of such requests can result in major cost and labor savings to all parties.

The fundamentals of vegetation management at solar sites is covered as part of solar site tours. The details of vegetation management could be covered with additional support from grazing

consultants, such as those at publicly funded agencies such as NRCS and USDA, or found privately through grazing consultancies. When finalizing a solar grazing partner, Invenergy and AVS would work with the grazier in either case to ensure comfort with the grazing plans and the vegetation management at the site. Additional details could be covered by connecting potential graziers to the Cornell Sheep Program experts or by arranging with members of that program to lead trainings.

A mix of modern solar technologies are available to see at sites throughout the Finger Lakes and the Southern Tier. Graziers could become familiar with basic solar terminology and array layout through this accessible format. Electrical service personnel from a regional firm could be asked to meet farmers at a site to review questions, terminology, and standard operations at solar arrays. During the course of normal solar array operation electrical service personnel typically overlap with vegetation maintenance contractors.

Finally, solar site seed mixes, questions on vegetation and vegetation management techniques is addressed as part of any future site visits. Complimentary agriculture, with a special focus on pollinator-friendly plantings and commercial level beekeeping is typically discussed as AVS plans to site bee yards at Horseshoe Solar.

Working with Livingston and Monroe County Farmers and Graziers: Benefits to Planning

In the case of a site like Horseshoe Solar, once constructed, a sheep farmer(s) in the area could start or expand operations at the Horseshoe site on the basis that grazing contracts offer a steady, long-term income stream. The farmer(s) can plan a production cycle based on the predictability of the vegetation maintenance contract that Invenergy will sign with them. This income stream will enhance farm profitability and incentivize management focused on vegetation maintenance to specifications set by the solar operator.

The Article 10 permitting process that Horseshoe is undergoing is a multiyear, multistep process that will have the advantage of allowing potential graziers to make plans for farming at Horseshoe Solar. During the time that Horseshoe will be in the Article 10 process, the National Renewable Energy Lab's current co-location research project, called InSPIRE, is scheduled to come to its conclusion. The InSPIRE project is expected to generate data on number of concrete agriculture & solar-compatible enterprises, including solar grazing. Applicable lessons in co-location will be developed from this and information sharing will be relevant to the Livingston and Monroe County farmers and potential graziers. Thus, co-location opportunities can be explored with both the grazier(s) and the developer during the permitting process and be formalized with a site lease before project commissioning. AVS will work directly with interested farmers to develop business plans if they are interested, or at a minimum direct them to the resources for business planning.

AVS will direct interested graziers to draft legal contracts for co-location of agriculture at the site and to review the engineering plans for the Horseshoe site. AVS will also consult in regard to the options for sheep handling facilities or other co-location infrastructure typically employed at solar arrays in other locations. AVS will then provide input to Invenergy on the facility layout regarding agricultural co-location.

AVS may also be involved in support with high level grazing plans, sheep sourcing plans and marketing opportunities for solar-grown specialty products. AVS will commission other soil and vegetation testing, and engage with Cornell Extension, NRCS and the Cornell Sheep Program to provide ongoing support to these farmers.

Vegetation, Voltaic Veggies and Other Growing Opportunities at Solar Sites

The vegetation that is found on most established New York State solar arrays is typical of a hay field. There is no universal standard planting technique or seed mix for the state, but most solar sites are seeded with a low growing blend of plants that includes grasses and legumes. This blend of grasses and legumes typical to solar sites aligns nicely with what most sheep farmers would seed to their pastures, with some local variation in the selections. A grazing-friendly seed blend for Horseshoe Solar will be selected.

The shading from the panels creates opportunity for a more diverse array of plants than might normally found in an open hay field. The solar modules typically drip into this area as well, leading to a moister zone under the panels and drier sunnier alleys between them. One benefit to this is that any grazing animals will have a wider array of food offerings than is typical for a pasture. This gives the solar arrays added resilience in providing forage to grazing animals, which is an advantage that farmers appreciate. A study on this was conducted in Oregon at a solar array, which is informative but due to the difference in the climate between New York and Oregon the research results should not be directly applied to New York solar arrays. [16]

The solar panels proposed at Horseshoe Solar would move slowly throughout the day, following the sun. These single axis trackers will also create microclimates for plant and insect communities due to the shade cast by the modules, such as described above. However, the shade under the panels will not be as dense as in a fixed ground-mount array. The rotation of the panels will shed rain fairly evenly across the ground, which could be advantageous in dry summers.

Tree, shrub and vine seedlings can appear at solar sites when tree seeds are carried by wind, animals or other mechanisms into the site. Sheep can eat young seedlings and set back tree saplings and other taller vegetation, preventing shading of the panels and overgrowth. The

[16] Oregon State University, Chad Higgins. 2018. *Solar Arrays could be used as resources for plant productivity, study shows.Accessed at:* https://today.oregonstate.edu/news/solar-arrays-could-be-used-resources-plant-productivity-study-shows

sheep, when managed properly, will help maintain a meadowlike appearance of perennial grasses, flowers and herbs. The practice of rotational grazing, which is recommended for the health of the livestock, is also the practice that results in the best control of the height of the vegetation. For a good overview of rotational grazing please consult the Pasture Project website[17].

Solar grazing provides the tools to achieve stable, high-yielding pastures at solar sites for many years. It also provides complimentary habitat for pollinator plants and animals. In the United Kingdom a guideline is offered to solar site operators with a specific schedule for grazing to benefit pollinator species. The guide is the BRE National Solar Center's Biodiversity Guidance for Solar Developments[18]. Some states, such as Vermont, offer a guideline to solar developers known as a pollinator scorecard or checklist[19]. One of these scorecards is under development in New York. Good grazing practices, such as those seen at rotationally-grazed solar sites will offer opportunities for co-location of a commercial-level honey operation at Horseshoe Solar.

Bare Honey[20] is a Minnesota based firm that produces solar honey across the Midwest. Its typical business practice is to partner with and train local beekeepers in the techniques for locating bees at solar arrays. It then provides buyers, such as the 56 Brewery in Minneapolis with honey for their solar honey sourced beer. See Growler Magazine's March 29, 2018 event[21] and https://www.bizjournals.com/twincities/news/2018/03/22/56-brewing-launches-craft-ipa-made-with-local-hone.html

An increasing number of cideries, breweries and distilleries use honey in crafting specialty products. This avenue may be explored by Bare Honey LLC for the Horseshoe Solar Project.

Other agricultural uses complimentary with ground mounted solar are largely in the research or trial phases in the United States. In the United Kingdom, there are sucessful poultry operations at solar arrays. The British National Solar Center documents this co-location practice on page 5 of the *Agricultural Good Practice for Solar Farms* at Yeowood Solar Farm and is available as a resource to interested farmers.[22]

The research on agrivoltaics is largely coordinated through a National Renewable Energy Labs project known as InSPIRE. The InSPIRE Project focuses specifically on utility-scale solar and

[17] The Pasture Project. 2016. *Making Sense of the Many Systems of Rotational Grazing*. Accessed at: http://pastureproject.org/pasture-management/rotational-grazing-systems/
[18] BRE (2014) Biodiversity Guidance for Solar Developments. Eds G E Parker and L Greene. *BRE National Solar Centre Biodiversity Guidance for Solar Developments*. Accessed at: https://www.bre.co.uk/filelibrary/pdf/Brochures/NSC-Biodiversity-Guidance.pdf
[19] Pollinator Friendly Solar Initiative of Vermont. 2018. *Solar Site Habitat Scorecard*. Accessed at: https://www.uvm.edu/sites/default/files/Agriculture/Pollinator_Solar_Scorecard_FORM.pdf
[20] Bare Honey.2013.Accessed at: www.barehoney.com
[21] *Unveiling the World's First Beer with Solar Honey*. Accessed at: https://growlermag.com/event/unveiling-worlds-first-beer-solar-honey/
[22] BRE (2014) *Agricultural Good Practice for Solar Farms* Ed J Scurlock. Accessed at: https://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/NSC_-Guid_Agricultural-good-practice-for-SFs_0914.pdf

land use issues and is conducting research at a number of test plots across the country on co-location.[23]

The InSPIRE project will attempt to capture the work that is funded by NREL as well as monitor the work being done by research institutions in their network. One exciting project in New York is the grazing of the Cornell University sheep flock by the Cornell Sheep Program alongside closely monitored pollinator plants & insects by members of the Cornell Entomology Department. This will be one among many projects upcoming in the next few years exploring the co-location potential of agriculture and solar in the United States. The Inspire Guidebook will offer management guidelines populated by its findings, so will be the a publicly available resource for solar and agricultural leaders to utilize.

If agrivoltaic vegetables look promising, and a local farmer shows interest in a commodity crop, the teams at Invenergy and AVS would consider a pilot project at the site. However, there are no plans for any informal trials with vegetables at HSS at this time.

[23] For the full project scope read here (start on page 5 for details, and page 8 for a graphic illustration): https://drive.google.com/file/d/1Fg5k6qC_149ZfTnu4DJn9LbHeAYKGQw6/view?usp=sharing

Section II

Horseshoe Solar Grazing Plan

Introduction

Ground-mounted solar sites are uniquely suited to serve as grazing areas or be subdivided into grazing paddocks in a pasture rotation with sheep. The perimeter fencing serves as predator deterrent, the solar panels provide shading and shelter for inhabitants, and the area beneath the arrays provide palatable pasture species for ruminant nutrition. In turn, rotationally grazed sheep provide adequate and comparatively cheap vegetation management while improving the ground cover, thus reducing erosion and run-off. This sustains an agricultural use of land that can add to the viability of farming communities.

There are a series of more technical guidelines and additional resources that have aided in the creation of a grazing regime at Horseshoe Solar. *Prescribed Grazing on Pasturelands* outlines some arguments for a thoughtful approach to grazing for solar graziers and serves as a valuable resource for gauging initial stocking densities for a solar grazing site.[24]

Terms

Project: The Horseshoe Solar Project, a 180 MW ground mounted solar array in Livingston and Monroe Counties.

Section: The perimeter fencing of the Project creates the opportunity to divide the project into smaller areas for planning the sheep rotation based on the fencing that is already planned for the Project. The Project has 8 subdivisions known as sections. Each section will, as explored below, be 25 to 281 acres. One separate sheep flock will be assigned to each section by a flock manager. The precise number of sheep in a section may be adjusted over the season according to the flock manager. The flock is sized to be enough sheep to cover the entire section in a full rotation. A full rotation is +/- 40 days.

Permanently Fenced Array: Sections are subdivided into contiguous groups of panels by perimeter fencing creating individual permanently fenced arrays. The entire group of permanently fenced arrays forms one contiguous block of fenced panel areas.

Paddock or Grazing Paddock: This is the smallest unit under discussion. It is a grazing unit created by the design of this Prescribed Grazing Plan. Their individual average size for Horseshoe is projected at 6 acres.

The Invenergy Horseshoe Solar project, located in Livingston and Monroe Counties, NY, is planned for approximately 1,300 acres. Sheep grazing will be used to control vegetation at the Project site in order to:

- Prevent panel shading from vegetation,
- Control and remove invasive and unpalatable plant species,
- Avoid the growth of brush and woody species under the solar panels,
- Maintain a diverse forage population to support optimal sheep nutrition,
- Encourage flowering forb and plant species to maximize pollinator habitat,
- Maximize the amounts of sequestered soil carbon through increasing top-soil amount and root matter, and
- control erosion.

To achieve these goals a rotational grazing system will be implemented. Rotational grazing is a technique where animals are moved as one group, from one pastured area ("paddock") to the next (Hodgson, 1979). Only one paddock is grazed at any given time throughout the rotation, while the other paddocks are given a rest period to achieve pasture regrowth. Compared to set-stock grazing, rotational grazing inhibits weed growth, improves the health of pasture, sustains healthy vegetation, and improves sheep health. The grazing interval is the amount of time between a flock leaving a paddock and returning after the rest period.

Development of Horseshoe's Vegetation Maintenance Contract

Development of the vegetation maintenance contract is being conducted in two phases. The first phase is complete.

- Phase One: Invenergy and AVS offered an Indicative RFP, designed especially to encourage farmers to engage in the process, and develop site-specific budgets & logistics plans. The agricultural community was widely notified of this opportunity. Phase One was a non-binding market assessment designed to verify the interested candidates and their qualifications and allow for bids on subsets of the project area for vegetation management. The RFP was issued in November 2019 and a site visit was held for interested parties. AVS then followed up with interested bidders and held information sessions.
    - 8 indicative bids were received. Five were grazing only, one included a plan to transition from mowing to sheep, and another provided a mowing alternative to a grazing bid for a total of 7 solar grazing bids. Only one bidder provided a mowing-only quote.
    - AVS advised Invenergy that the bids for solar grazing were qualified bidders.
    - The bidders were largely local with several regional bidders.
    - The bidders each bid a minimum of one section.
    - The majority of the bidders were farmers from the region.

- Phase Two is designed to be a binding process that results in a multiyear contract for vegetation maintenance at Horseshoe Solar. Phase Two will be conducted based on the project schedule, but aimed at giving farmers enough time to firm up their sheep management plan before the completion of project construction.

Rotation planning:
This plan is guided by principles found in the New York State Soil & Water Conservation Agricultural Environmental Management Tier 2: Pasture Management Worksheet. "Pastures should be managed to ensure optimum forage production, not only for the economic well-being of the agricultural operation, but for soil health, the prevention of soil erosion and water quality, through controlled access and reduced runoff." Additionally, Prescribed Grazing Management, which is the nature of this document, is defined as "the controlled harvest of vegetation by grazing or browsing animals managed with the intent to achieve a specific objective" (https://www.nys-soilandwater.org/aem/techtools.html). The objective in this case is to manage the vegetation at the solar array with grazing sheep using a planned rotation. Additional objectives, which form the spirit of this document, are located in the AEM Tier 2 land stewardship goals (https://www.nys-soilandwater.org/aem/aemcc.html).

The Horseshoe Solar Project was assessed for a planned grazing rotation based on the preliminary panel layout. This layout was subdivided in the civil drawings by agricultural or chain link perimeter fencing into 8 different spatially connected sections (**Error! Reference source not found.**). Each of these fenced sections are further subdivided into individually fenced areas, again, with agricultural or chain link fence. The grazing plan requires these additional subdivisions to facilitate rest time and growth time for the vegetation at the solar array. Rest time and growth rates of vegetation are the fundamental elements around which rotational grazing are planned.

This grazing plan assumes that there will be 8 managed flocks of sheep across the Horseshoe Project. Each one of the 8 sections will be grazed by a separate flock and enrolled into a separate grazing rotation. The following nomenclature is used to describe the specific localities of the grazing rotation:

Project → Section → Permanently Fenced Array → Grazing Paddock

For utility scale solar projects such as Horseshoe, a sheep rotation for each section of the project is planned, resulting in one separate sheep flock per section. The flock is sized to be enough sheep to cover the entire section in a full rotation, i.e. for Section 1, the amount of sheep needed to graze 112 acres in a +/-40 day rotation. The precise number of sheep in a section may be adjusted over the season according to the flock manager. The precise number of planned sheep per section can be found in Table 1. Grazing Plan Invenergy Horseshoe Solar.
Each individual section of the Horseshoe Project is not directly connected but spatially separated by roads, wetlands, woods or residential zones. The advantage to a flock manager of considering each section individually is threefold:

1. The flock remains within one section and can potentially be moved with minimal trucking;
2. The size of each flock remains manageable within the fenced sections; and
3. The individual sections can be administered individually, i.e. bid on and subsequently managed by different farmers during the RFP process.

The grazing plan requires additional division of the solar array into smaller grazing units. These grazing units, known as paddocks, are created by using the planned permanent perimeter fencing and portable, battery charged Electronet® fencing. The Electronet® is a portable fence that is a product familiar to farmers in in the grazing community. It is a white, lightweight fence that is energized using a portable battery, battery/solar, or 110V power supply. This fencing is simple to power on/off and will only be located inside the fenced areas. Its use is to facilitate grazing inside the permanently fenced areas only.

The Electronet® will be installed by the grazing manager according to the grazing plan. It will allow for an optimal use of the permanent fencing to form some paddock walls while others will be formed entirely by lengths of portable fencing. It is a versatile product that will allow the grazing manager a high level of control over the vegetation. The interior, portable, battery charged Electronet® fencing would allow for a simple, logical rotation.

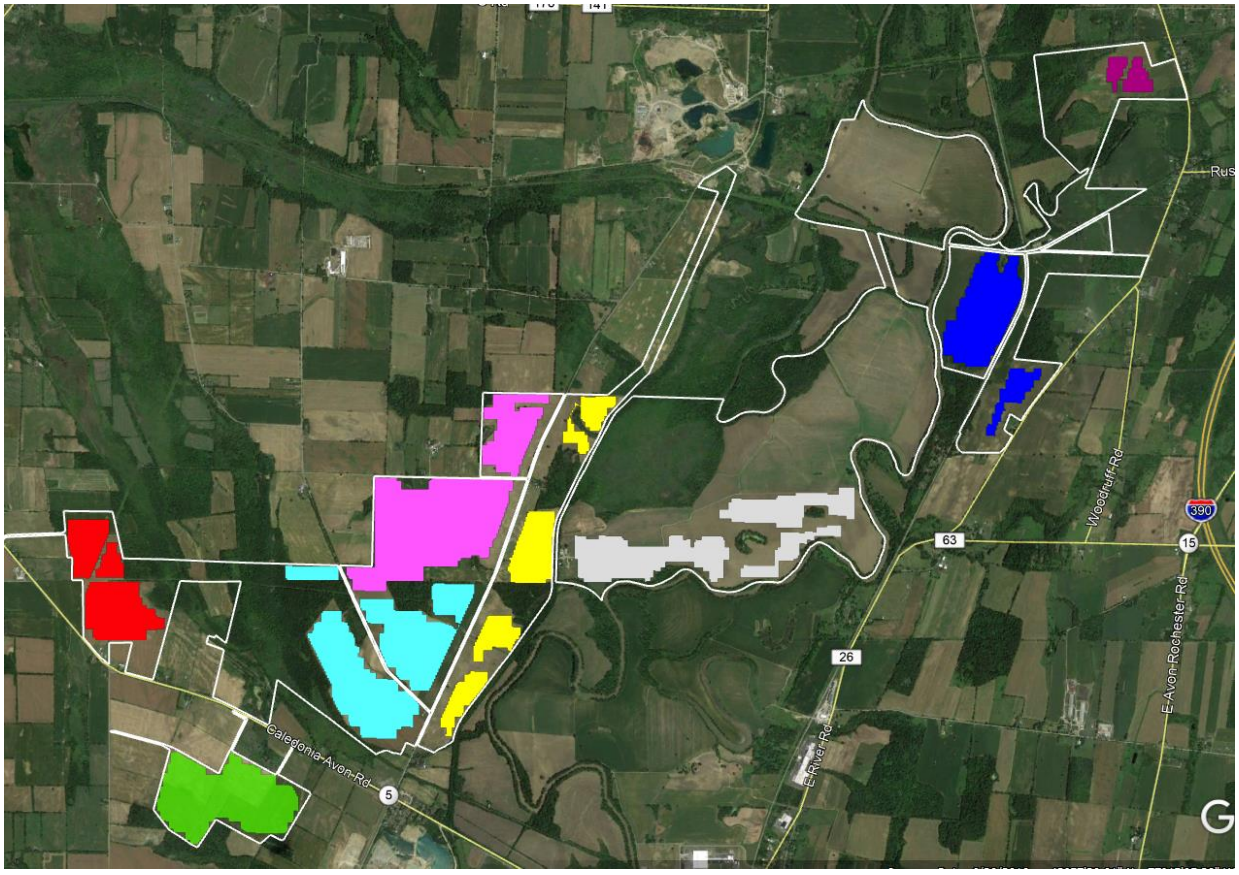


Figure 1. Horseshoe Project Site Layout with Distinctly Colored Sections

- Section 1 (111.8 acres) → 3 permanently fenced arrays → 10 grazing paddocks
- Section 2 (153.0 acres) → 1 permanently fenced arrays → 10 grazing paddocks
- Section 3 (249.7 acres) → 4 permanently fenced arrays → 12 grazing paddocks
- Section 4 (281.6 acres) → 2 permanently fenced arrays → 12 grazing paddocks
- Section 5 (122.0 acres) → 5 permanently fenced arrays → 11 grazing paddocks
- Section 6 (179.2 acres) → 3 permanently fenced arrays → 10 grazing paddocks
- Section 7 (125.3 acres) → 2 permanently fenced arrays → 10 grazing paddocks
- Section 8 (25 acres) → 2 permanently fenced arrays → 10 grazing paddocks

The grazing paddock calculations are based on the total number of sheep per section and a targeted number of days per graze (four days or less). The targeted days to graze are the key factor guiding each grazing paddock's planned acreage. The grazing paddock's size uniquely determines the overall number of possible grazing paddocks within each array and, ultimately, section. Together with the rest period this determines the grazing rotation.

The number of grazing paddocks in each permanently fenced array is dependent on a unique set of factors. The number depends on the size and layout of the permanently fenced arrays, the panel orientation, and the space used for access roads, inverter pads, and other non-forage producing areas. These specifics can be determined considering each array separately.

Permanently fenced array (ac) / Grazing paddock size (ac) = Number of paddocks (#)
Grazing interval (days) / Number of paddocks (#) = Grazing days per paddock (days)

The amount of time the sheep will spend in a given area and how often the sheep should be moved should be considered through the lens of forage regrowth. To allow for optimal vegetative regrowth, the time any flock spends in any one grazing paddock should not exceed 4 days. The regrowth of forage species starts after 4 days of being grazed. Furthermore, a 4-day maximum grazing period reduces fecal matter contamination, minimizes the creation of sacrifice areas, and improves pasture hygiene.

The rest period for a given grazed area is largely guided by management for the sheep flock's health. The rest period can be considered the window during which the sheep are not present and the space is given a rest.

The pasture rest period (time between grazing periods) in the US Northeast should not be less than 40 days to minimize internal parasite pressure for sheep. Internal parasites are a health risk to the sheep but not to humans. Internal parasites of sheep are not zoonotic, but a threat only to the health of sheep. This health risk to sheep is minimized by following the following prescriptive grazing plan.

A common internal parasite specific to ruminates is the stomach nematode H. contortus or barber pole worm. It has a life cycle of 40 days, thus a clean pasture can only be achieved with rest periods of 40+ days to avoid reinfection through ingestion of larvae. However, with effective grazing regimens with parasite-resistant sheep flocks, exceptions can be made by the flock manager if the vegetation pressure is too high to adhere to a 40-day rest period before re-grazing.

Summary
A flock will flow on a rotation through each section of the solar site, eating vegetation with the given area and moving at the direction of the flock manager.

The recommended grazing period for any given area of a solar array is not to exceed 4 days. The flock manager may determine that the right grazing period for the sheep is just a few hours or a full 4 days. This decision is determined typically by the quantity of vegetation available and other pasture or flock management goals, which is further explained below. It is recommended that the sheep not return to this same grazed area for 40 or more days. This 40-day rest is recommended typically to allow the sheep to graze pastures and stay healthy.

Other details to consider when planning for solar grazing:
In newly commissioned solar sites, full vegetation coverage cannot be expected in the first 1-2 years. Additionally, access roads, inverter pads and other site infrastructure will reduce the overall vegetation cover. AVS estimates that initial vegetation for new NY solar sites lies between 65 and 85% coverage. This number should be estimated and considered separately for each individual paddock. This number will be adjusted as reseeding efforts take effect.

As the land cover prior to solar was either hay fields, crop fields, marginal pastures or brush areas, the vegetation coverage within paddocks is expected to be heterogeneous. Therefore, vegetation sampling should be performed in order to determine sheep stocking rate and density, which is a requirement prior to establishing a grazing rotation. Tabular dry matter and nutrient values as they are published for uniform stands of established crops, hay field or other, are not adequate for evaluating solar array site vegetation for grazing. A detailed organic matter (OM) vegetation sampling protocol is published on the American Solar Grazing Association (ASGA) website. The grazing rotation will largely depend on the amount of forage dry matter (DM) growing within the individual areas. Vegetation sampling at intervals to analyze the nutritional value of the forage should be performed.

Forage analysis laboratories such as Dairy One provide detailed analyses that can be used to calculate the available DM per grazing paddock from submitted OM samples. Dry matter is a

percent of total percent plant weight minus water content. These DM values are necessary to establish the amount of available feed for sheep, and eventually the sheep stocking rate and density. Typically, pasture DM values in the Northeastern US for well-maintained pastures are between 18-25% of total plant weight, depending on the season. Pasture utilization should be between 70 and 85% to ensure optimal regrowth and animal nutrition. Thus, pasture refusals (uneaten vegetation remaining after grazing) should be part of the calculation and should be between 15% and 35%.

It is recommended to graze uniform animal groups that are either dry (non-lactating) ewes, open (non-pregnant) ewes, ewes in their early stages of pregnancy, yearling ewes or growing lambs of at least 60 lb. (or alternatively, 50% of their mature body weight in case of small breeds). In the case of groups of growing lambs, the lambs should be of the same sex or the males should be castrated.

Depending on the breed and uniformity of the group of sheep, an average weight for the individual animals in the flock can be determined.

Error! Reference source not found. gives an overview of BW (body weight) and feed intake across popular Northeastern sheep breeds. According to NRC nutritional requirements for small ruminants (NRC, 2007), daily DM consumption per animal can be estimated as a percentage of bodyweight.

Table 2. Body weight and feed intake

Breed	**Stage of production**	**Body weight, lbs**	**Feed intake, DM %BW**	**Feed intake, lbs DM**
Katahdin hair sheep	Growing lamb, 50% mature BW	65	2.5	1.6
	Yearling	110	3.0	3.3
	Open, dry ewe	130	3.5	4.6
Polypay composite	Growing lamb, 50% mature BW	80	2.5	2.0
	Yearling	130	3.0	3.9
	Open, dry ewe	160	3.5	5.6
Texel	Growing lamb, 50% mature BW	90	2.5	2.3
	Yearling	150	3.0	4.5
	Open, dry ewe	180	3.5	6.3

These calculations can be used to determine the optimal number of sheep per paddock according to body weight and stage of production. By using this with the chosen grazing rotation days (or grazing interval), the stocking rate (the necessary sheep number for the calculated

grazing time within each paddock) can be calculated. Once the stocking rate is determined, a grazing plan can be established (see **Error! Reference source not found.**).

Forage Species:
Soil testing should be performed at the Horseshoe Solar site before the commencement of grazing. The soil testing will inform the exact species suitable for seeding on the site. A typical pasture blend for solar sites would include a 60-70% grasses [2-4 species that are regionally adapted, meet solar site height criteria and are selected for grazing suitability], 30% legumes [2-4 species that meet the above criteria} and up to 10% forbs [broadleaf plants that are tolerant to grazing, regionally adapted, non-toxic to sheep and contribute to the site's biodiversity]. In addition to this various establishment species may be recommended to reduce soil erosion and serve as nurse crops for the perennial solar site pasture mix, above.

Table 3. Grazing Plan Invenergy Horseshoe Solar

Item	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Total Project
Section size, ac	112	153	250	281	122	179	152	25	1274
Individually fenced arrays, #	3	1	4	2	5	3	2	2	22
Grazing paddocks, #	10	10	12	12	11	10	10	10	85
Grazing paddocks, ac	11	15	21	23	11	18	13	2.5	
Grazing interval, days	45	45	45	45	45	45	45	45	
Grazing days per paddock	4.5	4.5	3.75	3.75	4.1	4.5	4.5	4.5	
Grazeable area per section % and ac	75% 83.9	75% 114.75	75% 187.3	75% 211.2	75% 9.5	75% 134.4	75% 94	75% 18.75	
Organic matter per yard², lbs	2	2	2	2	2	2	2	2	
Dry matter % and per yard², lbs	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4	18% 0.4	
Dry matter per ac, lbs	1742	1742	1742	1742	1742	1742	1742	1742	
Sheep weight, lbs	160	160	160	160	160	160	160	160	
DM intake % body weight and lbs	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	3.5% 5.6	
Total acreage	112	153	250	282	122	179	152	25	1274
Total sheep	402	551	899	1014	439	645	548	90	4588
Stocking rate	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6

Typically, well managed Northeast pastures can achieve yields above 2,500 lbs DM per acre. The yield in the grazing plan draft above is substantially lower; it is expected that the solar array pastures will take time after establishment to reach their potential. It is necessary to plan a grazing rotation prior to the grazing season, which would be used to guide a flock manager's rotation plan. The flock manager would then use his/her own experience and observation to decide daily if the rotation plan is reasonable and responsible, and to make necessary adjustments in rotation days and stocking rates.

Two examples of common adjustments to rotation plans include: First, in late spring after rain events and with the warming weather, stocking rates may have to be increased to be able to clear the vegetation growth. Secondly, in the summer, sheep may have to be moved from paddock to paddock faster than they were in spring or fall due to the slowed growth of dormant cool-season vegetation.

Flock management across the Project:
Regardless of season, free access to clean and fresh water is crucial for animal welfare (NRC, 2007). Site-specific amenities like well water or connection to municipal water lines are ideal, but transported water is typical of solar grazing operations. For sheep of the recommended production stages (non-lactating and > 60 lbs growing lambs), water requirements are very low in spring and fall. This will change in the hot and dry summer months, when the forage DM is high and the pastures mature. The ample shade created by the solar panels tends to reduce consumption on sites, but the table below can be referenced when planning water sourcing (Ontario Ministry of Agriculture, Food & Rural Affairs, http://www.omafra.gov.on.ca/english/engineer/facts/07-023.htm#5).

Animal Type	Weight Range (kg)	Water Requirement Range[a] (L/day)	Average Typical Water Use[b] (L/day)
Feeder lamb	27-50	3.6-5.2	4.4
Gestating meat ewe/ram	80	4.0-6.5	5.25
Lactating meat ewe plus unweaned offspring	80+	9.0-10.5	10
Gestating dairy ewe/ram	90	4.4-7.1	5.75
Lactating dairy ewe	90	9.4-11.4	10.4

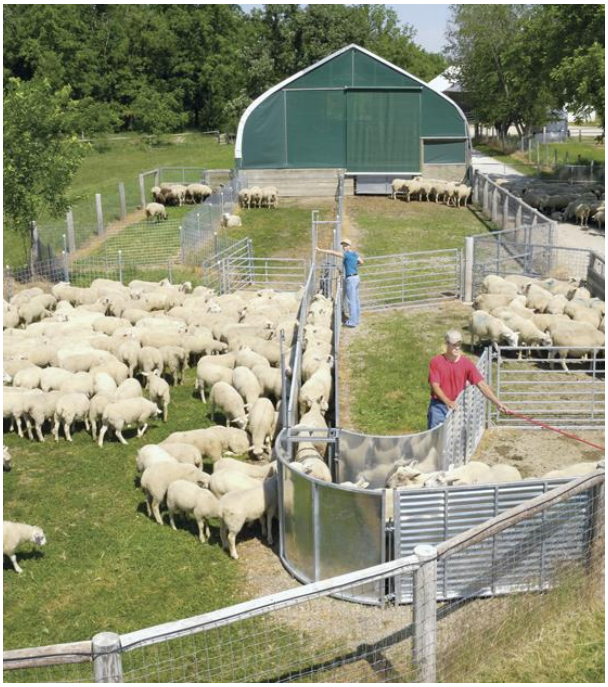
Water Consumption by Sheep(7)

[a] A result of the animals' environment and management.
[b] Typical consumption over a year on a daily basis under average agricultural conditions in Ontario.

Granulated mineral feed must be freely available and contain adequate concentrations (Cargill, 2019). This is an important animal welfare and nutritional requirement that cannot be overstated. Mineral feed should be offered in troughs that can be moved with the flock according to the rotation and rotation days. Mineral feed is specially blended and commercially available for sheep producers.

Sheep will be visually inspected on every rotation day by the flock manager. Moving the flock(s) to their next paddock is a great time to seek out, monitor, and treat sheep.

A closer inspection of each member of the flock is recommended at regular intervals (every 6 weeks on site). This inspection is only possible with the use of a handling system. Handling systems for sheep can be portable or permanent. A well thought-out handling system will be an essential tool for the flock manager.



Portable systems can be collapsible and transported on a trailer. The possibility to gather the flock(s) to perform management tasks at any given time throughout the grazing season must be ensured. The system must allow gathering, leading in a single-file line through a treatment chute, stopping, and sorting of sheep. There are several commercial manufacturers of these systems available in the US, including Sydell, Premier 1 and D-S livestock.

Animal health and well-being:

Each spring, before the flocks begin the grazing season, certain protocols are recommended to ensure they are in optimal health before their work at the solar site begins.

Sheep care and protocols should include, and can be done in a handling system chute:

- Feet must be checked and trimmed

- Ear tags replaced or added, in compliance with USDA regulations
- Wool sheep must be shorn
- Wool sheep should be tail-docked (shortly after birth).
- Body-condition scored before moving on site. This is a measurement that can easily be performed in a chute on-site and is part of normal management chores. It provides information about the nutritional and health status of any animal on site and can be used to adjust the grazing rotation.
- Sheep should be individually handled and scored using the FAMACHA (FAffa MAlan CHArt) protocol, a visual inspection of the blood vessels under the lower eyelid. FAMACHA scoring is a standard practice in the sheep industry developed in South Africa to promote more effective practices for management of internal parasites that cause anemia and, sometimes, mortality.
- In compliance with FAMACHA protocols, sheep that score high should be treated with a commercially available de-wormer 24 hours prior to entering the pastures every season. Prior to being moved onto the solar site, the sheep should be kept in a dry-lot and be fed hay after deworming. This practice prevents reinfection of the sheep.

Approximately every six weeks at the solar array the flocks should be run through the handling systems with the following objectives:

- FAMACHA (Wyk and Bath, 2002),
- 5-point checks (Bath and van Wyk, 2009) and parasite monitoring or treatment.

Additional vegetation management services that should be considered part of the job of the flock manager:

- Spot mowing and weed treatment
- Spot-reseeding if any bare areas emerge
- Pasture fertility management

Conclusion:

A successful grazing rotation on large solar sites with sheep is based on the following:

- Initial, planned grazing rotation
- Experience and ability to observe when the rotation days and stocking density must be adjusted throughout the season
- A well-managed and clean, healthy flock deployed on pasture
- Stringent treatment protocols for flock specific health issues
- Fulfilled nutritional requirements
- Access to mineral feed and clean and fresh water 24/7
- Pasture hygiene (limited fecal contamination, moving of high frequency areas like water and mineral)

- Health checks on every rotation day
- Well-designed handling systems for 6-week animal checks and parasite monitoring and treatment

Literature

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