LARGE SCALE PHOTOVOLTAIC FACILITIES

‘SOLAR FARMS’

SOLAR POWER AND AGRICULTURE

THE ENGLISH EXPERIENCE

South-West England
Cornwall, Devon, Somerset, Dorset

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TABLE OF CONTENTS

Cover photo: Treworder Farm, Wadebridge, Cornwall, England – September 2014

1. Executive Summary:

Agriculture is based on harnessing energy from the sun by photosynthesis for crops and thus animals. Solar power is based on harnessing energy from the sun by photovoltaic conversion to electricity. Are these two uses in conflict or can they co-exist? Do we need to exchange one form of green energy for another or can we embrace both? Do solar panels rob such quantities of solar energy to make agriculture economically unsustainable or does there remain significant sunlight for plant life to grow? And if so, how can it be harvested? In short, will grass still grow in a field covered with solar cells and can it be harvested by mechanical or animal means?

This report sets out to answer these questions by investigating the experiences of existing solar farms (solar orchards) in England.

Being situated in sunny agricultural fields, solar farms must address the interference of plant growth on the production of photovoltaic electricity. Various methods are available ranging from the elimination of all plant matter to mechanical cutting to animal grazing or a combination of these methods. Our field visits to six solar farms in England, together with interviews of solar project shepherds, grounds maintenance staff, owners and operators has led us to conclude the most effective method of grounds maintenance is a combination of sheep grazing with selective mechanical cutting. The development of solar farms provides us with a special opportunity

1 - To reduce our reliance on carbon based fuels and to
2 – To maintain effective agricultural food production and to
3 – To create a protected habitat for flora and fauna.

The English experience has shown that this is not only possible but is also cost effective and desirable.

2. Introduction:

Recent advances in photovoltaic technology (first discovered by Edmund Becquerel in 1839) and production combined with government subsidies have made feasible the development of large scale `Solar Farms` in many developed countries throughout the world. European countries began embracing the Solar Farm in the early 2000's; currently there are 1,800 megawatts of installed solar power capacity in the United Kingdom with another 2,100 megawatts under development. Canada is now on a similar path with 700 megawatts installed and another 800 megawatts under development.

In accordance with the Ontario Green Energy Act, Samsung Renewable Energy is in the process of developing 1,400 megawatts (MW) of renewable energy of which 300 megawatts will be generated by solar photovoltaic farms. These solar farms will require the use of approximately 1,000 hectares (2,500 acres) of farm land. Provincial agricultural policy now restricts solar farms to class 4, or less, agricultural land. While such land has a lower productivity than class 1, 2 or 3 agricultural lands, it is still economically productive farmland. Corn, soybeans, canola, wheat, oats, barley, hay, cattle and sheep are all commonly found on these lands.

The goal of the Green Energy Act is to produce energy with minimal impact on our natural environment. Solar farms have the potential to lay barren the land, thus defeating this goal. A means of continuing, and perhaps enhancing, the agricultural use of the farmland, while simultaneously producing solar electricity, would more closely meet this goal. Sheep grazing may be an optimal solution as they would both produce meat and wool while keeping the grounds trimmed. However, the experiences of 'solar-sheep' farming in Canada are minimal, if they even exist. In order to determine the feasibility of continuing the agricultural use of the lands, particularly by sheep grazing, the authors travelled to south-western England to study existing solar-sheep farms.

3. The English Experience:

In 2002 the United Kingdom (UK) introduced their Renewables Obligation (RO) program which places an obligation on UK electricity suppliers to source an increasing proportion of the electricity they supply from renewable sources. To facilitate this, the UK government provides subsidies, whereby they purchase the renewable energy at highly attractive rates. This has resulted in the development of a significant number of solar farms and wind turbines; mainly in southwest England.

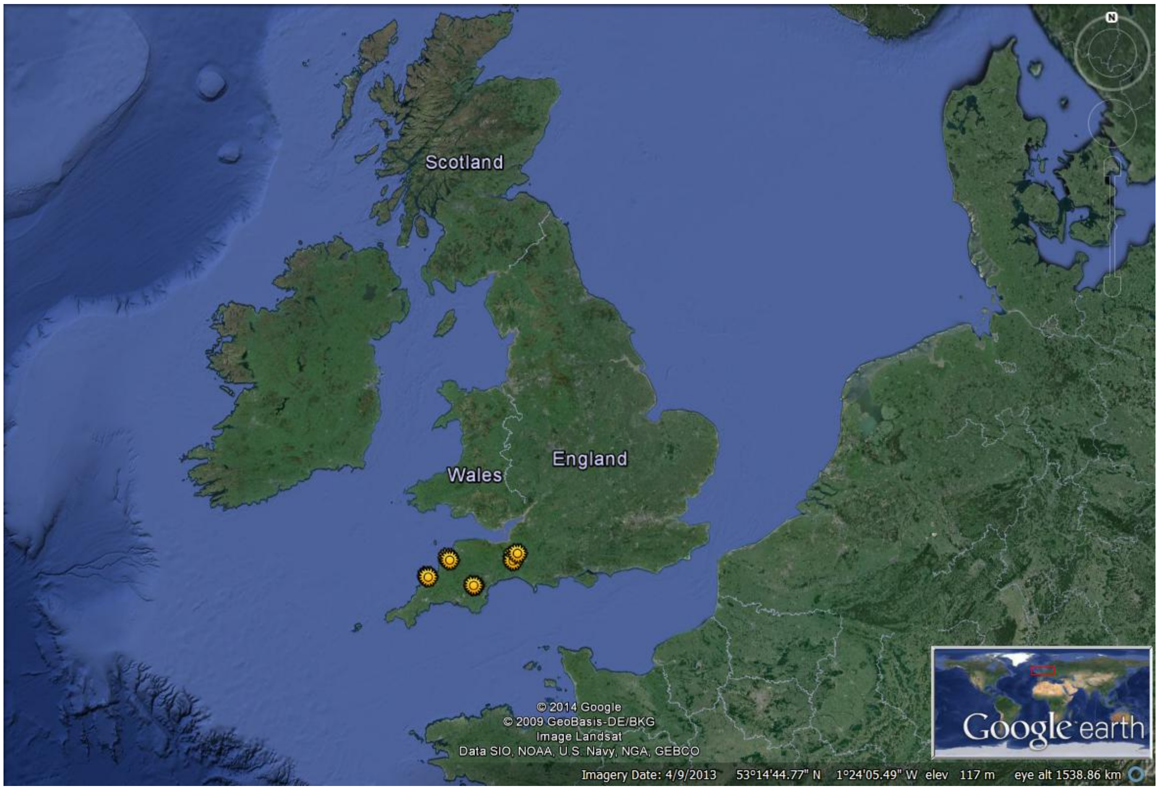
The UK has many restrictions to the development of solar farms, many of which are similar in Canada. The British Renewable Energy Trust has produced a Planning Guide (October 2013) to assist solar farm developers (appended). Solar farms may be located only on lands with a soil classification of 3 or less and local planning approval is required which must include the following studies/statements (not exhaustive):

- Design and Access Statement – design concepts and principles and access issues
- Landscape Visual Impact Statement – perceived visual impact
- Habitat Assessment – species of concern (badgers, etc)
- Flood Risk Assessment
- Community Consultation Report – address the concerns of local people
- Decommissioning Plan – return site to original condition

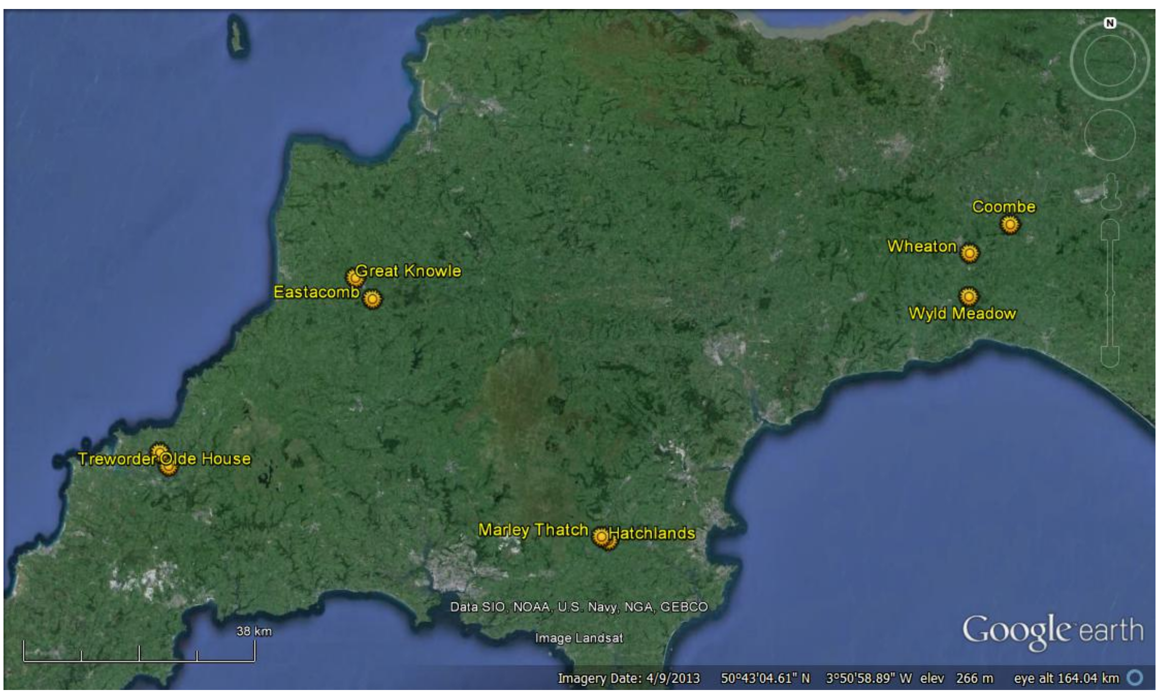
The general design and construction philosophy appears to be to minimize any changes to the ecosystem and to maintain agricultural production. A further incentive to graze sheep is to maintain the agricultural land classification so as to avoid capital gains tax. To help promote the dual use of land the British Renewable Energy Trust has recently (July 2014) produced the Agricultural Good Practices Guide (appended) which details various agricultural uses such as sheep, geese, chickens and hay.

3.1 Sites Visited:

We visited ten different solar farms in four counties developed by six different companies ranging in capacity from 240 kW to 6 MW. The location of these sites is shown on the maps below and an individual photo of each follows. Four of these sites were 'self-built' by the landowner farmer and three of the four spurred the creation of a solar development company. The other six were developed and constructed by larger solar development/operation firms from England, Germany and Spain. In these cases, the land is leased from the farmer/landowner on a 20 to 25 year lease with annual remuneration based on the number of acres in the project. The remuneration varied between £500 and £1,500 per acre ($900 to $2700) and appeared to depend mainly on the value of the government subsidy at the time of project inception and individual negotiations with the landowner. These subsidies have varied between £0.307 and £0.341 per kilowatt hour ($0.55 to 0.62) and now stands at £0.066 ($0.12) per kwh. Electrical operations and maintenance is performed either by the developer or is contracted to a solar operations firm. Grounds maintenance is contracted to the landowner/farmer for the life of the lease with annual remuneration based on site acres. The remuneration rates varied from £95 to £150 per acre ($175-$275). The current value for farmland in southwest England is approximately £4000 to £6000 pounds sterling per acre ($7,000 to $11,000).



Key Map - United Kingdom



Sites Visited - South-West England

Photo 1 - Coombe 1

Photo 2 - Coombe 2

Photo 3 - Eastacombe

Photo 4 - Great Knowle

Photo 5 - Hatchlands

Photo 6 - Marley Thatch

Photo 7 - Olde House

Photo 8 - Treworder

Photo 9 - Wheaton

Photo 10 - Wyld Meadow

3.2 Construction:

- All solar farms were constructed on native ground with no site levelling or re-grading performed. This has resulted in a 'contoured' effect of the panels on some sites. In most cases the existing ground cover was grass in 'long-term lay' (pasture ground) or it was seeded to agricultural grasses after construction. Where the seeding was post construction, both the developer and farmer indicated a preference for an intact sod base during construction for reduced soil erosion and increased traction during wet weather (not being bogged down in mud) and a more uniform ground cover post construction. The one site we visited with no ground rehabilitation now has significant weed growth; some of which is piercing the solar panels (photo 11).

Photo 11 - Contoured Panels (in Weed Ground)

- Panel height (ground to lower edge) ranged between 300mm and 1500mm, the highest being in a flood zone and the lowest being designed for mechanical grounds maintenance only.

- The panels were arranged in arrays varying (by site) from two panels to four panels wide. The arrays formed rows (approximately 3 metres wide) that ran the width of each field. These rows were separated by avenues approximately five metres (about twice the array’s width). In short, the solar parks have a ‘panel to open ground coverage ratio of about 1 to 2. This design is based on a thirty degree panel inclination and a resulting fifteen degree angle of shade influence to the adjacent row (photo 12).

Photo 12 - Solar Avenue

- The panel rows were supported using either a single post (photo 13) or double post (photo 14) design supporting a transverse girder which in turn supported two to three parallel beams on which transverse joists supported the solar panels. All of these structural members were zinc galvanized steel with two exceptions: 1) the self-built creosoted wood structure at Coombe Farms (photo 15) and the German Belectric built Treworder Farm system which used two parallel wood girders (photo 16).

Photo 13 - Single Post Construction

Photo 14 - Double Post Construction

Photo 15 - Single Post Wood

Photo 16 - Wood Girder

- The supporting posts were driven approximately one metre into the ground using a pile driver. On the Treworder site the posts were set in concrete footings placed in drilled holes due to the slate subsurface conditions.

- The wiring from individual solar panels was run along the central beam (photo 17) where they ran to the end of the row before running underground through a protective sheathing (photo 18) or being combined in a ‘combiner box’ (photo 19). The resulting feeder cable ran down the steel post in a protective plastic sheath and continued underground to a central inverter (photo 20). No overhead cabling was observed.

Photo 17 - Cables Tied to Beam

Photo 18 - Protective Sheathing

Photo 19 - Combiner Box

Photo 20 - Central Inverter Building

- The predominant security fence was a welded wire mess ‘anti-climb’ green powder coated panel fence 2 metres in height (photo 21). One farm opted for green coated chain-link fence also 2 metres high (photo 22) and the three self-built farms each used standard galvanized page wire fencing 1.2 meters tall.

Photo 21 - Anti-Climb Security Fence

Photo 22 - Chain Link Security Fence

- Except for the three self-built farms, a 4-5 metre wide grassed buffer separated the security fence from the property line (photo 23). Either the existing stone and soil hedge ran along the property line or a page wire fence was constructed. The three self-built farms simply used their page wire fence as both the property line fence and the security fence (photo 24). All fences terminated at ground level. It should be noted the largest ground predator in England is the fox.

Photo 23 - Five metre Buffer

Photo 24 - Page Wire Security/Property Fence

- Infra-red security cameras (many of them motion activated and directed) were installed in all of the larger installations.

3.3 Operations:

The operation of each site is monitored by offsite personnel. Sensors installed at critical points within the system send warning signals when there is an unexpected interruption in electrical generation or other operational problems. The appropriate personnel are then sent to the site to investigate and correct the identified fault. Similarly, should the security cameras identify unauthorized personnel within the site either the local constabulary or a private security firm is dispatched. However, experience has shown it is usually more prudent to contact the landowner first as many security indications are false alarms.

The physical cleaning (washing) of the panels was spoken about but not one instance was identified except for one of the smaller self-built systems. This was cleaned using a modified hand held broom during a rain storm. This would prove impractical on larger systems. Normal rainfall was found to provide sufficient cleaning at the other sites. Snow coverage was not considered a maintenance issue as the snowfalls are light and transitory.

Grounds maintenance (grass cutting) was found to be performed by the farmer/landowner on all but one farm. It is not known who performed the grounds maintenance on the one farm in question as neither the landowner or operator was interviewed. However, grounds maintenance was seen to be inadequate as numerous weeds had grown under and through the panels (photo 25). This was likely due to infrequent grass cutting between the panel rows and little or no cutting underneath the panels. The large number of weeds was likely due to there being no grounds rehabilitation performed with the barren corn ground being left to regenerate on its own. No sheep were observed on this site.

Photo 25 - Weeds Piercing Panel Array

Grounds maintenance by grazing sheep was used on seven of the ten solar farms; some of these in combination with mechanical mowing. It is important to note that at least one harvests an annual hay crop and has found the yield loss due to the panels (shading and grounds loss) to be only 30%. It was also found that a density of four sheep to an acre is sustainable and needed for grass control. This confirms that there remains substantial agricultural growth on solar panelled fields. Below is a summary of key points discovered on our visit to the following facilities. Further details are included in appended table.

- **Coomb Farm 1** – 7 acres, 1 MW
  Sheep graze on organic certified land – absentee shepherd
  Panels 900mm off ground for sheep
  No known damage of panels or wiring by sheep or to sheep – landowner and operator/owner

- **Coomb Farm 2** – 1 acre, 0.2 MW
  No sheep grazing – unfenced field
  Grass cut two to three times per year – not harvested
  Panels 800mm off ground

- **Eastacomb Farm** – 20 acres, 3.6 MegaWatt:
  Grass cut 2 to 3 times per year. Sheep grazing was requested but low panel height (300mm) deemed too low.
  Grass cutting under panels only partly done since mower access is poor
  Landowner would have preferred more room at ends of rows to turn tractor

- **Great Knowle Farm** – 19 acres, 3.6 MW:
  Sheep graze in winter (December-January) mechanical mowing in summer; harvests hay crop at 70 percent of yield prior to panels
  Resident shepherd
  Panels 300mm off ground but sheep have no difficulty grazing. It should be noted that, even though the panels are only 300mm from the ground, there is no known damage of panels or wiring by sheep or to sheep – landowner and TGC Renewables

- **Hatchlands Farm** – 30 acres, 5.2 MW
  Mechanical plant cutting by unknown agency
  Note excessive weed growth under panels

- **Marley Thatch Farm** – 37 acres, 6.3 MW
  54 grazing sheep. Farmer expressed need to increase flock size to maintain appropriate grass control.
  Grounds cut once per year to control weeds
  Panels 800 mm off ground for sheep
  No known damage of panels or wiring by sheep or to sheep – landowner and TGC Renewables

- **Olde House** – 1 acre, 240 Kilowatt
  Sheep graze throughout
  Panels 900mm off ground
  No known damage of panels or wiring by sheep or to sheep – landowner and operator/owner

- **Treworder Farm** – 36 acres, 5 MW:
  Sheep graze in rotation. One annual mechanical cutting ‘topping’ to cut inedible plants (weeds). Able to cut grass under panels since open two-legged construction permits easy access
  Panels 900mm off ground for sheep
  No known damage of panels or wiring by sheep or to sheep - landowner

- **Wheaton Farm** – 4 acres, 0.8 MW
  Sheep are delivered to farm by absentee shepherd
  Panels 1500mm off ground for floods
  No known damage of panels or wiring by sheep or to sheep – landowner and operator/owner

- **Wyld Meadow** – 25 acres, 4.8 MW
  Sheep graze throughout.
  Grounds topped once per year to control weeds
  Panels 800mm off ground for sheep
  No known damage of panels or wiring by sheep or to sheep – landowner and British Renewable Energy

3.4 Differences between England and Ontario

1) Ontario's climate adds a unique design element not present in England due to our greater snowfall. Drifting winter snows and snowpack depth must be considered in determining the minimum panel height above ground to prevent snow covering the panels.

2) The impact of the recent arrival of non-native coyotes into south-western Ontario should be considered. A perimeter fenced area will provide an ideal habitat for the native marmot (groundhog). The groundhog is a primary food source for coyotes which will dig under fences to hunt them. Buried fencing or the placement of a wide heavy rock barrier will prevent their entry to the solar fields.

3) The rolling glaciated land in south-western Ontario is not unlike that of south-western England. This was accommodated by the panels simply following the land contours. Should any areas be found too steep however, some land re-grading may be necessary. Where this is performed it is important that all existing topsoil be first stripped and then replaced to maintain the lands fertility.

4) The English fields are generally smaller and are bounded by protected hedgerows. This results in smaller solar farms than are possible in Ontario.

4. Findings:

Our findings support our premise that it is feasible to maintain a viable agricultural use of the lands within a solar farm. Furthermore, the grazing of sheep beneath the panels is a benefit to the operations of the solar farm for the following reasons:

1) reduces required mechanical mowing, thereby reducing the probability of impact damage to panels
2) provides better growth control under panels as sheep clip grass close to columns under panels
3) provides better security as shepherd visits site daily
4) maintains the philosophy of 'green' energy as the solar farm continues to produce agricultural product

To permit sheep to graze it is prudent to ensure the following design features:

1) Raise the panels to a minimum of 800mm from the ground. However, an increased height will be required to accommodate snowpack depth (400mm-500mm) and drifting accumulations
2) Ensure that all cables are protected as they enter the ground. However, this should be done to protect the cables from mower impact and other ground animals
3) Install a predator proof fence to prevent the entry of coyotes. This may be a wise precaution for all fields.
4) Provide for the installation of livestock watering facilities (underground water lines).

Further design elements that were suggested include:

1) Ensure an adequate area at the ends of each avenue to permit an easy turning radius for tractors. While motion controlled security cameras are helpful, their sensitivity can lead to numerous false alarms. The operators were glad that there was a daily farmer presence to confirm such sightings.
2) Ensure the grounds are seeded in pasture before construction begins
3) Use low compaction construction vehicles to limit soil compaction which increase storm water runoff
4) Place geo-textile mats on existing topsoil and under all constructed temporary roads to permit ease of future rehabilitation
5) Use anti-climb panel fencing (pg. 12 BRE Planning Guide) for security fencing instead of the penitentiary type three strand barbed wire fence
6) An increased population of butterflies and other wildlife such as foxes and hares (not seen in 30 years) was observed within the protected security fence. These did not appear to cause any adverse impact to operations and are seen as a corollary benefit to the solar farm. This concept could be developed by designing features to encourage species at risk such as the monarch butterfly and honey bee.

5. Conclusions:

It was found the use of grazing sheep is beneficial to the continued operation of solar farms on agricultural land. Sheep have caused no injurious effects to the solar equipment and the solar equipment has caused no injurious effects to the sheep, according to the seven shepherds and four operators. The dual use of the land for both agriculture and solar electricity generation is both feasible and beneficial in reducing the use of non-renewable carbon based fuels.

APPENDICES

Acknowledgements:

We would like to thank the following people and companies for being so generous with their time and lucid with their tongues. But more importantly, for being so friendly to the four curious Canadians. The information and suggestions they have given us will serve well to introduce a strong agricultural component to Canadian solar farms.

Clive & Jo Sage	Wyld Meadow	landowner/farmer
Mark Wheaton	Wheaton	landowner/farmer/Solar Southwest Ltd.
Kevin Dan	Coombe	farmer/operator/Solar Southwest Ltd.
Marcus Dixon	Wyld Meadow	British Solar Renewables
Oliver Dixon	Wyld Meadow	British Solar Renewables
Chris Sowerbutts	Wyld Meadow	British Solar Renewables
David Tatershall	Wyld Meadow	Corbin Supporting Solar
Tony Colborne	Wyld Meadow	Corbin Supporting Solar
Linda & Geoff Petherick	Eastacoomb	landowner/farmer
Elwyn Cleave	Great Knowle	landowner/farmer
Andrew & Sean Hawkey	Treworder, Olde House	landowner/farmer/operator
John & Richard Buckpitt	Marley Thatch	landowner/farmer
Roy Anber	Marley Thatch, Eastacoomb, Great Knowle	TGC Renewables
Leila Winterbotom	Marley Thatch, Eastacoomb, Great Knowle	Lightsource Solar

Solar Power Sites Visited, September 8-12, 2014

Name	Coombe 1	Coombe 2	Eastacomb	Great Knowle
Location	Crewkerne, Somerset	Crewkerne, Somerset	Holsworthy, Devon	Pyworthy, Devon
Landowner	Coombe Farms	Coombe Farms	Petherick Family	Cleave family
Developer	Coombe Farms	Coombe Farms	TGC Renewables	TGC Renewables
Operator	Coombe Farms	Coombe Farms	Lightsource	Lightsource
Grounds Maintenance	Coombe Farms landowner - company	Coombe Farms landowner - company	Petherick Family landowner-farmer	Cleave family landowner-farmer
Acres	7	1	20	19
MegaWatts	1	0.2	3.6	3.6
Structure	steel - double leg - driven	wood - single leg - driven	steel - double - driven	steel - double leg - driven
Panel Height	800 mm	900 mm	300 mm	300 mm
Operation Date	2011	2011	summer 2012	July 2012
Agricultural use	sheep - hired	possibly hay	hay	sheep & hay@70%yield
Security Fence	2m anti-climb	none	2m chain link	2m anti-climb
Buffer	none	none	5 metres	5 metres
Cover	grasses	grasses	grasses	grasses
average site inspections	weekly?	weekly?	weekly	daily/weekly
Site Condition	fair - organic farm, many weeds	good	very good	very good

Solar Power Sites

Name	Hatchlands	Marley Thatch	Olde House
Location	Haberton, Devon	South Brent, Devon	Wadebridge, Cornwall
Landowner		Buckpitt family	Hawkey family
Developer	Orta Solar	TGC Renewables	Hawkey family
Operator	Lightsource	Lightsource	Hawkey family
Grounds Maintenance	Martifer Solar? non-landowner - company	Buckpitt family landowner-farmer	Hawkey family landowner-farmer-operator
Acres	30	37	1
MegaWatts	5.2	6.3	0.25
Structure	steel - single leg	steel - double - driven	steel - double - driven
Panel Height	300 mm	800 mm	800 mm
Operation Date	December 2012	January 2013	2011
Agricultural use	none	sheep & hay	sheep
Security Fence	2m anti-climb	2m anti-climb	1.2 m page wire
Buffer	5 metres	5 metres	5 metres
Cover	corn stuble	grasses	clover/rye grasses
average site inspections	1-6 per year	daily	daily
Site Condition	poor - weeds through panels, local complaints	very good	excellent

Solar Power Sites

Name	Treworder	Wheaton	Wyld Meadow
Location	Wadebridge, Cornwall	Chard Junction, Somerset	Bridport, Dorset
Landowner	Hawkey family	J.B. Wheaton & Sons	Sage Family
Developer	Belectric	J.B. Wheaton & Sons	British Solar Renewables
Operator	Belectric	J.B. Wheaton & Sons	BSR
Grounds Maintenance	Hawkey family landowner-farmer	J.B. Wheaton & Sons landowner - company	Sage Family landowner-farmer
Acres	36	4	25
MegaWatts	5	0.8	4.8
Structure	steel - double leg - drilled	steel - double - driven	wood - single leg - driven
Panel Height	900 mm	1500 mm	800 mm
Operation Date	March 2013	2011	July 2012
Agricultural use	sheep	sheep - hired	sheep
Security Fence	2m anti-climb	1.2m page wire	2m anti-climb
Buffer	5 metres	none	5 metres
Cover	grasses	grasses	grasses
average site inspections	daily	daily/weekly	daily
Site Condition	excellent	good	excellent

Some Questions and Answers

1. How will the sheep be housed? Will there be sheds or pens on part of the solar farm?

The sheep will be housed in existing farm buildings which are all outside the solar project security fence. Some temporary internal fencing will be required to allow efficient sheep grazing through sequential rotating land use.

2. What other livestock may be included? (one of the references mentions dogs or donkeys for the protection of the sheep)?

None. There will be no other livestock or animals living with the sheep. During daily inspections and occasional musterings the shepherd may use his trained sheep herding dog to gather and move the sheep. The need for guard donkeys or guard dogs is eliminated with the installation of the predator proof fencing.

3. What issues might there be with a guard dog or other guard animal interacting or reacting with the solar staff or visiting maintenance contractors? (Since these maintenance personnel are not the guard animal's handlers, they may be viewed as intruders by the guard animal).

None. There will be no guard dogs or guard animals.

4. Will the farmer be checking on the sheep daily?

Yes. Such daily presence will also benefit the security of the solar farm.

5. Will the sheep be at the solar farm year round or housed elsewhere during the winter?

The sheep will be grazing within the security fence only during the active growing season. This is usually mid April to late October; roughly six months. The sheep will be housed offsite for the balance of the year and will be fed stored feed.

6. Will the presence of the flock draw predators to the solar farm which may pose a concern or danger to the solar staff?

No. The existing sheep predator, the coyote (commonly known as the `brush-wolf`), currently roams freely on all farms within the solar project area. The coyote's prey includes sheep, calves, geese, chickens, marmots, dogs, cats and many other animals. Predator proof fencing will prevent the coyotes from roaming on the solar farm fields and, for this reason, such fencing should be considered for all solar fields

7. Will the farmer's staff keep the flock out of the way when routine maintenance needs to be done on the solar equipment or will the solar staff have to do this?

This task will not be necessary by either staff. Sheep are inherently afraid of man as they are a prey animal. It is unlikely the sheep will be seen by the maintenance staff, let-alone interact with them. However, should there be occasions of major solar work tasks, the shepherd will muster and temporarily remove the sheep from the work site.

8. What additional training may be required by the solar staff because the flock is present?

Two main items:

1) All solar staff must always close the gates to prevent sheep escape and predator entry.
2) Inform solar staff that sheep are benign animals (afraid of humans) and will naturally move away (run) from them.

The shepherd would be pleased to offer training to all solar staff.

9. What training will be required by the farmer's staff before entering the solar farm?

Other than the usual training in animal husbandry, safety and operational training will be required. Much of this will be provided by the shepherd; to the level of his knowledge of solar farms. Any other required training should be provided by the solar project's owner-operators

10. Will the farmer's staff be given access to the solar farm even if solar staff is not present?

Yes, provided they have received the proper training since daily flock inspections are required.

11. How will the sheep droppings be handled and what, if any, issues will the droppings cause under industrial worker health and safety regulations?

The sheep droppings are an important and required nutrient fertilizer for the grass. As a grazing animal, their droppings will be distributed throughout the fields in low density. Sheep are a desert based animal that survive with little water intake. Thus, their droppings have a dry, pelleted nature that degrade rapidly into the ground with rainfall and sunshine. The area immediately adjacent to the watering stations may contain a higher density which will be collected and removed by the shepherd.

12. If the solar farm is considered an industrial site, the practices allowed at an agricultural farm may not apply and more stringent industrial health and safety regulations may be applied to protect the solar staff.

The Occupational Health and Safety Act applies to all workers in Ontario . This act must be followed by all workers, including the shepherd, grounds maintenance staff and solar staff. It is permitted to apply agricultural manure on industrial land for the purposes of growing a crop by following the required agricultural nutrient management guidelines. This is a frequent practice. However, should there be any additional health and safety requirements, these should be investigated and incorporated.

13. Will there still be a need for mowing the solar farm (there may be weeds the sheep don't eat) and how is the flock managed during a mowing?

Yes, but only on an as-need basis. The sheep will maintain a low height grass level. However, during periods of high grass growth rate (Spring) mowing may be required. Further, thistles and other inedible plant growth will need to be controlled.

14. What additional protections, if any, may be needed to keep the sheep from damaging any wires or cables?

A well designed site should require no special modifications. We have identified four design elements for consideration:

1) Physical damage of the panels by rubbing sheep will require the panels to be a minimum of 900mm above grade. However, snow pack accumulation will likely require a similar design height.
2) Physical damage and of the wiring. All wires should be neatly secured to the panel structure at a height for easy maintenance by solar staff. This design consideration will also prevent the sheep from contact with the wires
3) Physical damage of main wiring as it enters the ground and any low mounted panels. These wires should be protected from human and equipment contact by encasing in piping or tubing. This will also serve to protect it from the sheep.
4) The installation of a security fence will facilitate the natural evolution of a unique ecosystem, particularly suitable to marmots (groundhogs). These marmot colonies will attract predators, including the coyote given that the marmot has become a food staple of the coyote. Extending the security fence below grade will prevent the coyote packs from accessing the solar farms. This fence will also protect the sheep.

While not part of the solar design, provision should be made for the installation of buried water lines in the larger fields for watering sheep.

It should be noted that, even on solar farms with low mounted panels and hanging wires, no damage to the solar equipment or to the sheep has been observed by the farmer or by the solar staff.

14. The lawyers and insurance consultants will need to get involved in the liability of the flock or farmer's help damaging the solar farm equipment or any damage or injury to the flock or farmer's staff when they are within the solar farm.

It is very important that all stakeholders are knowledgeable about agricultural practices and solar PV requirements. We recommend that the lawyers and insurers become educated about current agricultural practices relating to all forms of grounds maintenance, including sheep grazing, mechanical cutting, manual extraction/trimming and herbicide use.

As a active member of the Large Flock Organisation, we would be pleased to offer our expertise for this training.