Teryl R. Roper, Professor
Dept. of Plants, Soils, and Climate
Utah State University
4820 Old Main Hill
Logan, UT 84322-4820

February 23, 2020

Joseph Cogliano
202 Bay Road
Norton, MA 02766

Re: SMART Program ASTGU Guideline and UMass Carver Experiment

Dear Mr. Cogliano:

I have reviewed the documents you provided via e-mail as listed below:

- 10-17-19 letter from UMass Extension to MDAR (Mass Dept of Ag Resources) regarding the Carver plywood study used to evaluate shading over cranberries.
- 10-21-19 letter from MDAR to DOER (Dept of Energy Resources) regarding the Carver data and the proposed solar development over cranberry bogs in Norton MA.
- 11-13-19 predetermination letter from DOER to NextSun Energy claiming that largely based on the UMass data from the Carver study the Fairland Farm, Norton project "…likely satisfies all criteria set forth in 225 CMR 20.00 to be considered an ASTGU."
- 5-19 UMass Extension fact sheet: Expectations for Cranberry Growth and Productivity under Solar (Photovoltaic) Panels.
- 9-16-2019 predetermination letter denial from Eric Steltzer, DOER to Adam Schumaker of NextSun Energy.
- 10-3-19 email stream between Adam Schumaker and Kaitlin Kelly, DOER regarding summary of revised calculations for Fairland Farm.
- 10-10-19 email stream between Adam Schumaker and Kaitlin Kelly, DOER regarding PAR data spreadsheet.
- 4-26-18 Solar Massachusetts Renewable Target Program: Guideline
- PAR data (July 2019 thru Sept 2019) from NextSun Energy to DOER.
- Norton Shading Calculation data from NextSun Energy to DOER.

Based on the documents I was provided, it appears that for a solar project to qualify to be an Agricultural Solar Tariff Generation Unit, the project must meet each of six criteria. I will comment on the criteria by number.

1. The Solar Tariff Generation Unit will not interfere with the continued use of the land beneath the canopy for agricultural purposes;

   I have not seen complete data from the Carver experiment that speaks to this point for cranberries. The Carver data to date is inadequate to answer this question due to inadequate methodology, lack of sufficient duration of the study and other limitations. A well-funded, well planned three to five-year study would be needed to properly answer whether or not solar collectors over cranberries can meet these criteria.

   For example, the Carver mock-up has more posts than would likely be found in a commercial installation. I would think that the landowner and NextSun Energy would need to show that farm implements can be driven under the installation and that the span between posts is not a hindrance to normal production and harvest activities, including retrieving full bins of harvested fruit by helicopter or by other means. Further, if these properties are normally flooded in the winter the post structures would need to be shown to be able to withstand the potential pressure exerted by the movement of ice during the coldest winter months. Photos and/or video data would need to demonstrate that sufficient clearance is present.

2. The Solar Tariff Generation Unit is designed to optimize a balance between the generation of electricity and the agricultural productive capacity of the soils beneath;

   Although the Carver study was intended to address this question, thus far, it has failed to do so. As reported to date, that study has significant limitations. First, it was begun too late in the season in 2019. The fruit comprising the 2019 crop were already set when shading began. The mock-up is not large enough to prevent indirect solar radiation from coming in from the sides. Apparently, samples for yield data were collected, but have not yet been reported. One would expect the 2019 crop to be unaffected. The full results will be known when shading has reduced light at bud induction, fruit set, and fruit coloring periods over a multi-year period.

   The general principle of agricultural plant productivity is that yield is commensurate with light captured. The critical light measurement is not the instantaneous Photosynthetic Photon Flux Density (PPFD) that is reported by light sensors. This is only a 'flow rate'. What is important is the Daily Light Integral, usually reported as moles of photons m^{-2} day^{-1}. This relates to the total photosynthetic light energy striking a given land area. This should be the basis of decision making about shading, not the instantaneous flux measurements.

   This criterion also assumes that shading has a uniform effect throughout a growing season. We know this is not true for cranberries. Shading during the fruit set period reduced fruit set in two of three years in Wisconsin (Roper et al, 1995). However, in this

study each year shading was imposed in new locations, not repeatedly in the same location as would be true of solar panels. I am not aware of data showing the results of multi-year shading on the same land area for cranberries. Our short-term shading always reduced the carbohydrate concentration in the shaded vines, but carbohydrates recovered after a few weeks of normal illumination. It is not clear what would happen following long-term shading, but it seems likely that the carbon resources of the plants would decline over time.

This criterion rests solely on productivity. That may be too narrow of a consideration for cranberries. In fruit crops, profitability is not solely equal to productivity. Fruit quality measured as fruit size and color are also included. While yield may not be affected, if fruit size and color are reduced, profitability can be significantly reduced. Thus, profitability should be the criterion measured, not just productivity.

3. <u>The Solar Tariff Generation Unit is a raised structure allowing for continuous growth of crops underneath the solar photovoltaic modules, with height enough for labor and/or machinery as it relates to tilling, cultivating, soil amendments, harvesting, etc. and grazing animals;</u>

   My response to this criterion is the same as for number 1. Data may exist showing cranberry implements can operate under the canopy, but I have not seen them. However, this raises some other considerations. The Carver data suggests that temperatures may be warmer under the photovoltaic units than away from them. If that is true, then insect and disease pest growth will vary from fields with solar canopy installation to those without. Thus, pest scouting would have to be done separately. Applications of pest control measures would need to be done at different times in covered fields compared to uncovered fields. The need for irrigation may be different in covered fields than for non-covered fields. The need to irrigate for frost protection may be different in uncovered than for covered fields. Thus, the management of pests and soil moisture would, necessarily need to be done separately for covered and uncovered fields. This may not affect productivity, *per se*, but the extra management time would likely affect profitability.

4. <u>Crop(s) to be grown to be provided by the farmer or farm agronomist in conjunction with UMass Amherst agricultural extension services, including compatibility with the design of the agricultural solar system for such factors as crop selection, sunlight percentages, etc.</u>

   While it appears this work is underway, it is not yet complete. A well-done study to address the SMART program criteria for solar development over a perennial crop like cranberries will take at least three years to have data strength to be able to make predictions with confidence. A single year of work is simply insufficient for perennial crops. Further, UMass needs to be given sufficient funding to do this work. They need to engage an environmental biophysicist to help design the experiments and to correctly interpret the data.

5. Annual Reporting to the Department and MDAR of the productivity of the crop(s) and herd, including pounds harvested and/or grazed, herd size growth, success of the crop, potential changes, etc. shall be provided after project implementation and throughout the SMART incentive period;

   Most cranberry growers track yield by production unit: bog/field/bed. However, the data are pretty crude, usually begun as truckloads or bins and knowing the approximate capacity of a truck or bin. The guidance letter gives little direction as to how yield data is to be collected and reported. Will MDAR simply trust producers to report the production per land area of covered and uncovered sites? How geographically proximal should covered and uncovered sites be? Will MDAR be present to verify the data? Will a trusted third party verify the results? Is weight of crop per unit area the only criterion? For cranberries, average fruit size and fruit color of covered and uncovered fields contribute significantly to grower returns, especially if the fruit are destined for fresh sales (as opposed to processing).

   Another question that the landowner may wish to consider is what penalty is assessed if yield is reduced under solar panels. Does the grower only lose the incentive for that year? Are they ineligible for future years? Would the panels have to be removed? Should a reduction in fruit quality of covered vs. uncovered fields be sufficient to lose the incentive? Who 'owns' this risk?

   Therefore, after a proper study is completed, the SMART program guidelines for solar panels over cranberries should be updated with specific parameters to answer these and other questions related to perennial crops.

6. Other system design information, ...

   I've not seen details of the design of the proposed solar system to be installed over cranberry fields. However, other potential problems here include the damage to the vines that will occur through construction as piers, posts, and crossbeams are installed. This will certainly involve driving heavy equipment through the fields. Damage to the vines will be extensive and will take years to recover—in a limited light environment.

The chief weakness of the guidelines for installing solar panels over agricultural lands is that it depends on maintaining 50% of the baseline photosynthetic photon flux, not the daily light integral that would be a measure of total photosynthetic light energy received by the crop canopy. The secondary weakness is that the guidelines deal only with gross yield and disregards crop quality considerations that are critical to profitability in a perennial fruit crop. Third, it is not clear who will determine yield/quality of the crop, what happens if crops actually are reduced subsequent to installation of the solar panel system, and who 'owns' the risk of crop yield declining over time?

Based on my review of the information provided, the SMART program guidelines and the limitations of the Carver experiment I conclude the following:

1. The Carver experiment, as reported to date, is inadequate to answer the questions required to determine if cranberries can be permanently and successfully farmed under solar panels. Properly designed and executed research conducted over three to five years is needed before being able to answer the fundamental questions of this matter.

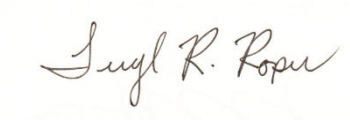
2. The DOER and MDAR should not rely on the current Carver data to determine if projects involving solar collectors over cranberries are eligible for or meet the criteria under the SMART program. In my opinion, the incomplete Carver study data does not support the claim in the 11-13-19 DOER letter that the Fairland Farm, Norton project "…likely satisfies all criteria set forth in 225 CMR 20.00 to be considered an ASTGU."

3. Projects involving large scale solar development over cranberry fields should not be undertaken in Massachusetts until a properly funded study (minimum of 3 to 5 years) has been completed, analyzed, and peer reviewed. Reasonably predictive outcomes are not possible with the current data.

4. The SMART program guidelines require further development and changes for perennial crops such as cranberries.

I hope this document will begin further discussion among the regulatory agencies involved so that good workable policies will be put in place to achieve the renewable energy goals of the Commonwealth of Massachusetts, while not reducing important agricultural productivity. In a separate document, I have outlined some elements of a proper experiment to address these important matters.

Cordially,



Teryl R. Roper, PhD

Literature cited:

Roper, T. R., J. Klueh, and M. Hagidimitriou. 1995. Shading timing and intensity influences fruit set and yield in cranberry. HortScience 30:525-527.