RRSE
Residents for Responsible Solar Energy

October 30, 2020

By Email: doer.smart@mass.gov; eric.steltzer@mass.gov cc: Kathleen.theoharides@mass.gov

Mr. Eric Steltzer
Director – Renewable and Alternative Energy Division
Department of Energy Resources
100 Cambridge Street, Suite 1020
Boston, MA 02114

Re: SMART ASTGU Guideline Comments

Dear Director Steltzer:

On behalf of Residents for Responsible Solar Energy (RRSE), I am submitting this letter to support the public comments submitted by Joseph D. Cogliano on 10/30/20, to the Massachusetts DOER. RRSE respectfully requests answers be provided to our organization as well, to the questions posed by Mr. Cogliano. Please see these referenced documents, enclosed with this letter.

Sincerely,

Kelly Gallagher

Kelly Gallagher
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Norton, MA 02766

202 Bay Road
Norton, MA 02766

October 30, 2020

By e-mail: doer.smart@mass.gov; eric.steltzer@mass.gov cc: Kathleen.theoharides@mass.gov

Mr. Eric Steltzer
Director – Renewable and Alternative Energy Division
Department of Energy Resources
100 Cambridge Street, Suite 1020
Boston, MA 02114

Re: SMART ASTGU Guideline Comments

Dear Director Steltzer:

Prior to finalizing the proposed changes to the ASTGU Guideline, please answer the following questions:

- Why has the Straw Proposal removed many of the changes to the technical and application requirements that were proposed in October 2019?
    - Who drafted the original October 2019 language and what was the basis of those recommendations? What has changed and why?
- Why has ASTGU size been increased from 2 MW AC to 5 MW AC?
    - Who specifically made that decision? What was the basis of the decision to increase project size from the October 2019 proposed 2.5 MW DC to 5 MW AC with a DC Cap of 125% of AC or 6.25 MW DC?
- What agriculturally based evidence and proven results supports the proposed changes to the Guideline and the increase in size to 5 MW AC?
- Why are there no yield requirements in the Straw Proposal? No yield requirements suggest the following:
    - The SMART Program regarding ASTGUs is a sham and solar power generation and not agriculture will be the primary activity on the land where installed.
    - Without a yield requirement, there is no objective agricultural measure to remove a project once built.

    - Because no long-term studies have been done, UMass Agricultural Extension has no idea if any of this will work. Therefore, the people of Massachusetts will pay for the errors of the Baker Administration, the DOER and UMass.

- Why has the DOER not required long term studies to determine the efficacy and impact of ASTGUs prior to approval of proposed projects that may span 30 years?

- Regarding ASTGUs with cranberries, as you know, no long-term studies have been done to show that solar develop over cranberries will work. The Carver plywood experiment, lasting only a few months in 2019, was <u>inadequate</u>, as independent experts have stated. (See attached letters of Professors Vorsa and Roper)

    - Why has the DOER taken no action regarding the proposed long-term study recommended by Professor Roper? (See attached Roper proposal outline)

    - Why hasn't the DOER required solar development companies that wish to develop solar over cranberries to fund a 3 to 5-year study, as recommended by impartial experts, to prove the concept works before implementing 30-year unproven experiments?

    - By not requiring a 3-5 year study prior to approving these projects, this suggests the main purpose is solar development and not continued agricultural use as claimed.

    - What percentage of cranberry farmers considering solar development on producing bogs are attempting to utilize the SMART program as a method of selling out and paying for their retirements as opposed to the promoted claim of continued agriculture being the priority?

- Why hasn't the DOER notified Massachusetts Towns that their large-scale solar bylaws must be amended to allow battery energy storage systems? As you know, large scale battery energy storage systems have not been historically used, and are not necessary, customary, or typical in Massachusetts solar projects. Edicts requiring them from the Baker Administration and unelected regulators will not pass Constitutional review.

- Why hasn't the DOER notified the people of Massachusetts of the dangers involved with these battery storage systems, including the risk of thermal runaway and the threat to soil, water, and air from the hazardous materials in their components?

- Why hasn't the DOER prohibited battery energy storage systems in aquifers, areas of critical environmental concern, well protection zones and flood plains? Where is the Baker Administration's and the DOER's concern for the environment?

- Since most agriculture is located in residential areas, why is the Baker Administration and the DOER supporting development of large-scale solar power plants in residential areas in violation of historical zoning for use and without taking into account the future problems being created by poor energy policy decisions?

- Why does the Baker Administration and the DOER continue to promote subsidized large-scale solar development in residential areas, when the present solar and battery technology requires further development and research to be market ready and safe? If present solar technology worked, subsidy would not be necessary.

- What is the total cost of the SMART program and the ASTGU policy to the people of Massachusetts?

- Who is benefiting financially from the SMART program and ASTGU policy?

- What are the impacts from proposed projects using the SMART program and ASTGU policies to the taxpayers, residents, and the environment? Claims of solar being an alternative to fossil fuels must be weighed against cost and negative impact to the people and the environment.

- According to the US Energy Information Administration, the average retail cost of electricity in cents per kw hour in the US is 10.53 cents. Massachusetts average retail cost is 18.5 cents or the 3rd highest in the nation after Hawaii and Alaska.

    - How much of the average cost difference is due to the Baker Administration's alternative energy programs?

- What responsibility will the Baker Administration and the DOER assume for hazards to communities from a battery storage system catastrophe? For example, contamination to well water supplies in residential agricultural areas.

- What have you learned from the problems that California has encountered with their renewable energy programs and what changes are you making to address those concerns with the ASTGU policy proposed in this Straw Proposal?

While I support solar research and development, it appears the so called SMART Agricultural Solar Tariff Generation Units Guideline Straw Proposal was drafted to provide increased subsidized windfall benefits to solar developers and certain landowners, but not to the people of Massachusetts.

Very truly yours,

Joseph Cogliano

Joseph D. Cogliano, Jr.

Enclosures: Professors Vorsa & Roper Letters; Professor Roper Study Outline

DATE: January 18, 2020

TO: Mr. Joseph Cogliano
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FROM: **Nicholi Vorsa**
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Director
P.E. Marucci Center for Blueberry & Cranberry Research & Extension
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Re: UMass Extension - Carver, MA Experiment – Cranberry Production Under Solar Photovoltaic Installation & Fairland Farms, Norton MA – ASTGU Eligibility

I have reviewed the following documents:

- October 17, 2019 UMass Extension letter to Mr. Gerard Kennedy of the Mass Dept. of Agricultural Resources regarding the Carver data and cranberry production under a solar photovoltaic installation.

- October 21, 2019 Mass Dept. of Agricultural Resources letter from Gerry Palano to Kaitlin Kelly of the Mass Dept. of Energy Resources regarding Fairland Farms, Norton MA – ASTGU Eligibility Application.

- November 13, 2019 Dept. of Energy Resources letter from Eric Steltzer to Adam Schumaker of NextSun Energy regarding pre-determination of the Fairland Farms site as an ASTGU.

Background

The American cranberry is an evergreen woody perennial, having a trailing stoloniferous vine. Flowers are typically borne on indeterminate ascending vertical stems referred to colloquially as “uprights,” which arise from stolons, and are referred to as “runners.” The requirement of an acidic media or soil (maximum pH 5.5) limits the American cranberry’s adaptation. Having a fine root system lacking root hairs, it is best suited to soils such as sands, loamy sands, and organic soils consisting of coarse peat or muck. Cranberry, being a temperate woody perennial with normal growth and flowering in spring, requires a minimum of 800–1000 hours of winter-chilling (~0–10 °C) to fulfill the winter dormancy requirement. Inflorescence buds, having 5–7 florets, are formed in late summer and fall, mostly at the apex of the vertical stems with upward facing adaxial leaf surfaces. For the subsequent year's crop, in regions having moderate to severe winter freezes, e.g., Wisconsin, New Jersey, and Massachusetts, inflorescence buds and leaf tissues are typically protected with a "winter flood," which can span from December to April. Spring growth typically initiates in mid to late April, with flowering initiating in mid to late June and terminating by mid-July. Vertical shoots, i.e. uprights, can be defined as fruiting (having a floral inflorescence bud or 'non-fruiting' with vegetative bud only. Depending on both cultivar and environment, the proportion of uprights fruiting in a given area of subsequent years varies. Non-fruiting uprights of a given year are expected to form floral buds for the subsequent year's crop. For fruit set, cranberry requires insect pollination, which occurs with mostly hymenopteran insects. Growers typically supply honeybee colonies to supplant pollination. Commercial cultivars are highly self-fertile and do not require nor appear to benefit from cross-pollination for seed set nor fruit set (Sarracino and Vorsa 1991). In the northern hemisphere the majority of fruit development occurs during August, with seed maturation occurring in September. Early maturing varieties, e.g., 'Ben Lear', 'HyRed', 'Crimson Queen', typically begin to ripen in early September, and later maturing varieties, e.g., 'Stevens', in October.

Multiple year assessment of cranberry's response to environmental factors

Cranberry is a woody perennial setting fruit typically in mid-June to mid-July, with fruit sizing and development through August, and has concurrent primordial inflorescence bud set developing during late-summer early fall for subsequent season's cropping. Thus, it has been noted that management, e,g., plant nutrition, and crop load, as well as climatic conditions, etc. of a given year, likely impact the following season's, 'next years', productivity. Like with many woody perennials biennial fruit bearing is a well noted phenomenon in cranberry. In fact, environmental effects such as plant nutrition, climatic stresses and cropping of a given year, can influence plant parameters well into the future (3-5 years). Effects of a nitrogen fertilization experiment (Davenport and Vorsa 1999) were noted in high nitrogen treatment plots exhibiting 'second bloom' three years following treatment years (Vorsa, unpublished data). In contrast to annual crop species, e.g., corn, where one year's conditions do not impact future cropping, multiple years are needed to assess plant habit and productivity in cranberry following management treatments. It might be suspected that shading cranberry over time will result in reduced fruit bud set and encourage transition to greater stolon production, and thus lower productivity. For example, shading during a given year may affect the formation of floral bud set on fruiting and non-fruiting uprights that will be realized, predictably reduced, the following year. Note: uniformity is required for agronomic efficiency.

Effect of shading and saturating radiation level

Few studies regarding the effects of shading in cranberry have been published. A study published by Roper et al. (1995), studied shading at various time points (1-month spans) during the growth phase of cranberry through pre-bloom to harvest of current season's response, using shade cloth. The effect of shading treatments were found to reduce non-structural carbohydrate concentrations but did not always reduce fruit set or yield the treatment year. No data was presented for effects in subsequent years. Kumudini (2004) reported that depending on temperature, maximum photosynthesis (P max) was ≈10 or 12 µmol CO 2/m 2/s (net photosynthesis) and the saturating radiation level was estimated to be 600 to 800 µmol·m-2·s-1. Note: the UMass Extension report used 500 µmol·m-2·s-1 as the threshold. Based on the referenced publication by Kumudini, (2004), the 500 µmol·m-2·s-1 threshold may underestimate the maximum saturating radiation level that cranberry can utilize, thus the value underestimates cranberry's photosynthetic full potential. Thus, one would need long term empirical data to determine if the 500 µmol·m-2·s-1 threshold is valid.

Farm management issues anticipated with solar structures

1) Structures will impede fertilization, fungicide, insecticide application/uniformity.
2) Structures will impede irrigation uniformity.
3) Not apparent efficient method on how the fruit harvest will be carried out.
4) Insect IPM sweeping impeded?
5) An efficient method of sand application, 'sanding', a standard cultural management technique in cranberry, is not obvious.
6) Fertilization distribution will likely be impacted by rain distribution by structures. Drip edge will elute fertilizer whereas little if no elution under the solar structures.

Potential physiological issues

1) Fruit ripening/coloring will likely be affected, i.e. reduced.
2) Yield, flower bud set, flowering, fruit set will be reduced, particularly in subsequent years.
3) Stolon biomass will increase, requiring increased pruning.

Carver, MA Experiment

The data and methods of the Carver experiment are wholly inadequate to assess the impact of PV structures on the physiology of the cranberry plant, and how the structures will impact farming operations, i.e., management such as uniformity of irrigation, fertilization, pesticide application, sanding, and harvest efficiency. The preliminary 'experiment' was flawed to assess effect on the plant through the entire growing season, being it appears the reading was taken at only a one time point.

The 'solar photovoltaic (PV) units' as described, and being deployed July 3, 2019 in the 'Stevens' cranberry bed and where sensors monitoring environmental impacts were deployed August 27, 2019 to assess putative impact of the structures on cranberry operation: The assumption is that the installation of a PV and readings was to make a determination on the impact on photosynthesis. However, the report states that "…photosynthetic measurements were only taken on one day". One issue is that since the sun angle continuously changes through the growing season (April – September), the estimate of total season's photosynthesis output with this experiment's shading would be an unreliable estimate. There are two issues to consider: 1) one is the impact on the physiology of the plant, and 2) the impact of the structures on cranberry management (operations). Briefly, the design of this experiment is wholly inadequate as to assess the physiological impact on the plant, either the year (2019) the data were taken or the longer impact of cranberry agriculture (for reasons discussed previously). The 'experiment' is inadequate from a number of aspects including: the structures were installed too late (July 3rd) towards the end of 'fruit set' season. Note: The UMass report acknowledges this "…We do not have data for spring…". The cranberry plant would have initiated growth in April/May synthesizing carbohydrates which would impact fruit set (crop productivity) for that season. Furthermore, the impact of the shading is likely to have a profound effect on the subsequent year's (2020) crop. As stated in the UMass report that "…is critical to understand that the analysis presented…and our interpretation of data presented…is based was preliminary in nature…on this limited review". The physiological impacts of these structures on commercial cranberry production cannot be determined from this data. Moreover, the methods used were severely flawed to assess this.

In addition, the 'experiment' utilized only 3 panels, whereas it is assumed the entire bed would be utilized. It would seem there would be more shading as one moves away from the summer solstice and from the effects of multiple rows of panels. Although it is stated in the UMass report that the" …commercial PV panels will transmit a portion of light…" there is no determination on the effect of impact on the light spectrum. The limitations of the presented data expressed on page 3 of the October 17, 2019 letter to MDAR are significant.

<u>Assessment of "In order to qualify for an Agricultural Solar Tariff Generation Unit adder under 225 CMR 20.00, the Project must satisfy all five components of the special provisions for Agricultural Solar Tariff Generation Units detailed in 225 CMR 20.06(1)(d) …."</u>

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

   As presented the structures will interfere with continued use of the land. The structures will interfere with irrigation, fertilization, pesticide application, sanding, and harvest efficiency.

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*;

   As presented the structures will interfere with the agricultural productive capacity (e.g. nutrition and water distribution) of the soils beneath by affecting the physiology of the plant since farming operations (uniformity) will be impacted. Therefore, agricultural productive capacity is likely to be severely reduced.

3. *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*;

   As presented the structures will interfere with continued use of the land. The structures will interfere with irrigation, fertilization, pesticide application, sanding, and harvest efficiency.

4. *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 percentage, etc.*;

   Inadequate assessment although crop productivity will degrade over time (current season as well as subsequent years).

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; and*

   N/A

<u>Conclusion</u>

The UMass Extension Carver, MA ‘experiment’ does not provide the necessary data to make a reasonable ‘Assessment’ of whether cranberry culture with these PV structures “…*will not interfere with the continued use of the land beneath the canopy for agricultural purposes”.* Moreover, it is impossible to make a determination due to the limitations, e.g. lack of necessary scale of the ‘experiment’ and the insufficient duration regarding the long-term viability of cranberry crops under solar photovoltaic installations. Based on the expectations of the SMART program, the data from the Carver ‘experiment’ is inadequate to support eligibility or qualification for a project involving solar installation over cranberry crops under the SMART program. A minimum 4 to 5-year study is required, as well as increased scale, to determine the impacts to cranberry crops from solar photovoltaic installations. The bed management issues also need to be addressed.

Very truly yours,

Nicholi Vorsa

Enclosures: Self and Cross Fertility in Cranberry (Sarracino and Vorsa 1991), Shading Timing and Intensity Influences Fruit Set and Yield in Cranberry (Roper et al 1995), Effects of Radiation and Temperature on Cranberry Photosynthesis (Kumudini 2004)

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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. 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;

   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. 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.

   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.

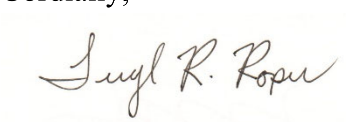
2. The DOER and MDAR should not rely on the current Carver data to determine if projects involving solar collectors over cranberries are eligible for or meet the criteria under the SMART program. In my opinion, the incomplete Carver study data does not support the claim in the 11-13-19 DOER letter that 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.

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February 24, 2020

Joseph Cogliano
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Re: A Study Involving Cranberry Growth and Productivity under Solar Panels

Dear Mr. Cogliano:

I was contacted by you in January 2020 to review research information and policy documents concerning placing solar panels over cranberry plantings in Massachusetts. As for my background, I am currently a Professor of Horticulture at Utah State University. I hold BS and MS degrees in Botany from Brigham Young University and a PhD in Horticulture from Washington State University. I worked as a Professor for 20 years at the University of Wisconsin-Madison. During those 20 years I worked extensively with the cranberry industry both in Wisconsin and across the country. I have published numerous peer reviewed papers dealing with cranberry productivity, especially regarding the physiology of cranberry yield. I left Wisconsin because Utah is home and to be closer to family.

I have reviewed the study regarding the effects of solar panels over cranberry fields that was recently begun by the University of Massachusetts Cranberry Experiment Station. From what I read, the study is incomplete and some data remain to be analyzed, interpreted, and reported. Further, their letter did not provide any data tables with statistical analysis to give an idea of the variability of their data. Clearly, this was a preliminary report. However, rather than critique this study, below I have outlined an experiment that would better answer the questions of whether cranberries can still be both productive and profitable if covered by solar panels. Research of this type needs to include an environmental biophysicist on the team to ensure the data are collected and interpreted correctly.

1. In order to be successful, the research needs to have devoted funding. If done well, the study can be estimated to cost more than-$150,000. This would include installation of solar panels or surrogates, instrumentation, collection of field data, data interpretation, and publication. The study will require a substantial amount of staff and scientist labor. The solar company and the landowner have the burden of proof to show a solar installation would not adversely affect an underlying crop. It is not reasonable to require or to expect scientists at the Massachusetts Cranberry Experiment Station to do quality work without sufficient funding.

2. The solar company and landowner should be responsible for installing a portion of the proposed solar collection system. This would include the posts, piers, crossbeams, wiring, connections, and panels. The model should replicate as closely as possible what would eventually be installed, should commercial solar collectors over cranberries be shown to work effectively as planned. The mockup should be extensive, comprising perhaps an acre. Perhaps old non-functional panels could be used as this would be as close to 'real world' as possible. If the ultimate installation is to be solar tracking, it would be best if this feature could be installed in the trial. This would also demonstrate the construction that would need to take place during installation. The experiment should be done in at least three locations in southeastern Massachusetts. Replication is essential to data interpretation.

3. Instrumentation: Quantum sensors (measuring light between 400 and 700 nm) should be installed to measure light incident on the cranberry canopy. Point sensors would be acceptable, but line sensors would be preferred. Four to six sensors should be placed in a grid pattern under the solar panels with the top of the sensors at the top of the canopy. These should be near the middle of the installation to avoid 'leakage' of diffuse light from outside away from the panels. Thermocouples or thermistors should be placed near each light sensor. An identical array of light and temperature sensors should be placed well away from the solar panel installation where the panels would not provide shade, probably on an adjacent field. Data would be collected by a datalogger and could be transmitted via cell modem or through regular downloads to a laptop. The light incident on the sensors should be summed daily to determine the total solar radiation between 400 and 700 nm incident on the area under the solar panels and in the nearby unshaded area (daily light integral) through at least three complete growing seasons. This is reported as moles of photons m^{-2} d^{-1}. Then a regression is made comparing daily light integral with yield of shaded and unshaded areas.

4. Each year in the spring, eight individual square foot areas will be identified under the solar panels and not under the solar panels at each site. In the fall just before regular harvest, the uprights from within each square foot will be cut and taken to a laboratory for measurement. For each square foot sample, the following data will be collected: total number of uprights, number of fruiting uprights, number of fruit per fruiting upright, total fruit number, total fruit weight, and length of new growth per upright. A subsample of fruit will be analyzed for total anthocyanins. Data from this analysis will be subjected to analysis of variance to see if growth and fruiting vary between shaded and unshaded locations at each of the three sites. This is the most important part of the project.

5. Collection of the data in points three and four should continue for at least three years. We would not expect to see differences in year one. The year-one crop is produced as a result of buds that were produced the prior year. If differences are found, they would be found in years two or three and beyond.

6. The landowner will need to demonstrate, with video cameras recording the efforts, that farm implements can be operated under the panels. This would include fertilizer

applicators, pest control equipment, irrigation equipment, and harvest equipment. The time recorded to navigate posts should be noted compared to uncovered areas.

I would note a couple of concerns about how the data are interpreted. For the light measurements, the important information is not the light striking the canopy at a given point, it is the summation or integration of the total light incident over time (daily light integral). In every other temperate fruit crop with which I am familiar, yield per acre is nearly linearly related to light captured by the crop canopy. If light incident on the crop is reduced, reductions in yield will almost surely follow. Further, the time of shading is also important. The most critical time for shading to reduce yield is in the immediate post-bloom period. This is when fruit are set. Unfortunately, the 2019 Carver study did not impose shading until July. By that time fruit set had already occurred. Thus, no impact on yield by shading would have been expected for 2019.

Another question that could be asked is whether the newest hybrid cultivars from New Jersey respond the same to prolonged shading as older cultivars such as Ben Lear, Early Black, and Howes, or older hybrids like Stevens.

Based on my research and years of experience with the cranberry industry, I speculate shading from solar panels will cause three things to happen. First, the vines will become 'leggy'. The uprights will elongate trying to find light to capture. That was clearly obvious in my shading studies in the early 1990's in Wisconsin. Second, the percentage of uprights that become fruiting uprights will decline over time. Third, fruit color is going to be reduced. Fruit color in cranberries is a function of sunlight and cool temperatures, especially at night. It may well remain warmer under the panels both daytime and nighttime and this will delay or reduce fruit color. When fruit are delivered to a receiving station a subsample is taken and anthocyanin content is measured. Fruit that does not meet minimum color standards is rejected by handlers.

For the record, I don't have a vested interest in the Massachusetts cranberry industry. I have not worked with the industry for about 12 years. I receive no current financial support from the industry. My only reason for becoming involved in this matter is that I strongly believe that important decisions should be based on good science. I hope this research outline will lead to good science being done as a proper study will benefit the cranberry growers and the people of Massachusetts.

Cordially,

Teryl R. Roper

Teryl R. Roper, PhD

Relevant Literature:

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