DAVID Y. IGE
Governor

JOSH GREEN
Lt. Governor

JAMES J. NAKATANI
Executive Director

STATE OF HAWAII
AGRIBUSINESS DEVELOPMENT CORPORATION
235 S. Beretania Street, Room 205
Honolulu, HI 96813
Phone: (808) 586-0186 Fax: (808) 586-0189

April 30, 2021

Mr. Raymond Young, Acting Branch Chief
City and County of Honolulu
Department of Planning and Permitting
650 South King Street, 7th Floor
Honolulu, Hawaii 96813

Dear Mr. Young:

Subject: Mahi Solar Project
Project No. 2020/SUP-7

We are writing in response to your notice dated April 9, 2021, regarding the Special Use Permit Application by Mahi Solar, LLC for the Mahi Solar Project. The Agribusiness Development Corporation has no comments on the subject project.

Thank you for the opportunity to provide comments.

Sincerely,

James J. Nakatani
Executive Director

E-mailed to RYoung at 6:32pm on 5/10/21 and cc'd to TKraintz @ 10:19 on 5/11/21

HAWAII STATE ENERGY OFFICE
STATE OF HAWAII

DAVID Y. IGE
GOVERNOR

SCOTT J. GLENN
CHIEF ENERGY OFFICER

235 South Beretania Street, 5th Floor, Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Telephone: (808) 587-3807
Fax: (808) 586-2536
Web: energy.hawaii.gov

May 10, 2021

City and County of Honolulu
Department of Planning and Permitting, Community Planning Branch
Mr. Raymond Young, Acting Branch Chief
Via email: rcsyoung@honolulu.gov

Subject: Hawai'i State Energy Office Comments on Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Tax Map Keys 9-2-001: 020 portion, 9-2-004:003 portion, 9-2-004:006 portion, 9-2-004:010 portion, and 9-2-004:012 portion, Honouliuli, 'Ewa, O'ahu

Dear Mr. Young,

The Hawai'i State Energy Office (HSEO) offers the following comments to the Department of Planning and Permitting (DPP) on the Special Use Permit (SUP) Application for the Mahi Solar Project (Project) proposed by project developer Longroad Energy (Mahi Solar, LLC) on 620 acres across five (5) different parcels in Kunia, O'ahu. The Project would be a 120-megawatt (MW) alternating current solar photovoltaic (PV) project with a 120 MW/480 megawatt-hour battery energy storage system consisting of approximately 362,000 ground-mounted PV modules mounted on 4,300 single-axis trackers, thirty-two four-MW inverters, an overhead 34 kilovolt (kV) collector line, a 34.5/138 kV substation, and possibly an additional 138 kV collector line. HSEO is supportive of the renewable energy, electricity cost savings, and greenhouse gas (GHG) displacement reduction benefits from the Project. HSEO appreciates many topics are evaluated as part of the SUP but focuses its comments on the stakeholder engagement and energy aspects of the Project.

HSEO's comments are guided by its statutory purpose under Hawai'i Revised Statutes §196-71 and its mission to promote energy efficiency, renewable energy, and clean transportation to help achieve a resilient, clean energy, and ultimately carbon negative economy. As an island community currently dependent on imported fossil fuels for over 60% of its electrical power, Hawai'i is particularly vulnerable to fuel and energy disruptions, unpredictable cost fluctuations, unintended fuel releases into marine environments, and the many impacts of climate change. That is why Hawai'i's 100% renewable energy goal is critical to the health, safety, affordability, and well-being of Hawai'i's residents. It is important that reaching 100% renewable energy generation by 2045 be done in a manner that prioritizes the health, safety, and well-being of Hawai'i's residents, natural resources, culture, and environment.

The Project is the largest solar plus storage project proposed in Hawai'i and would provide, when expected to be operational in December 2023, renewable energy to help replace the 15-16% of O'ahu's electricity generation that will be lost upon the planned retirement of O'ahu's 180 MW coal power plant on September 1, 2022. The SUP states the Project would be capable of generating 271,525 MWh annually, or 4% of O'ahu's annual electricity needs.[1] HSEO asks that the LUC make a timely decision to enable the parties, including Longroad, Hawaiian Electric, DPP, and the Hawai'i Public Utilities Commission (PUC) to in turn take timely action based on the outcome of the LUC's decision.

Longroad would sell power from the Project to Hawaiian Electric at a unit price of $0.097 per kilowatt-hour under a 25-year power purchase agreement (PPA) approved by the PUC on December 30, 2020.[2] The SUP states that over its 25-year lifetime the Project would avoid the consumption of 18 million gallons of oil per year, thus saving O'ahu consumers $175 million over the project lifetime.[3]

According to the U.S. Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator, displacing the Project's annual generating capacity of 271,525 MWh would be equivalent to reducing carbon dioxide emissions by 192,425 metric tons annually.[4]

As part of its solicitation process, Hawaiian Electric required all bidders to develop a comprehensive community outreach and communications plan to work with and inform neighboring communities and stakeholders about the projects before developers could submit project bids to Hawaiian Electric for consideration. Accordingly, Exhibit 8 of the PPA submitted to the PUC for the Project on September 15, 2020, includes copies of the public comments from Longroad's community outreach efforts and a summary of Longroad's community outreach efforts conducted before the PPA was executed.[5]

The SUP identifies the following community and stakeholder engagement activities:

- virtual public meetings for the Project were held on July 15, 2020, and October 29, 2020;
- meetings with various State and City and County of Honolulu agencies occurred in 2020;
- Longroad is conducting ongoing outreach with key community stakeholders through presentations to organizations such as Kunia Ridge Farmlands;

---

[1] 271,525 is 4.39% of 6,183,093, the amount of electricity in MWh sold by Hawaiian Electric to its customers in 2020.

[2] https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A20L30B45115B00135

[3] Oil prices are projected to rise (United State Energy Information Administration https://www.eia.gov/outlooks/steo/report/prices.php); HSEO has calculated that if oil prices over the project lifetime are similar to actual historical O'ahu oil prices over the past 15 years, savings would be $389 million over the lifetime of the project.

[4] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[5] https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A20I16B32131I01172

- Longroad is conducting one-on-one interviews with cultural practitioners from the region; and,
- presentations are being planned for the two neighborhood Boards in the Project area: Waipahu (No. 22) and Mililani-Waipi'o-Melemanu (No. 25).

The SUP states the following issues and concerns were most prevalent during this outreach and includes the mitigation measures proposed by Longroad for each:

1. Loss of agricultural land for renewable energy projects.
2. Concerns about ability to successfully co-locate solar panels and plants or crops.
3. Potential impacts to the 'elepaio, pueo, and Hawaiian hoary bat due to the Project's proximity to their habitats.
4. Loss of access to cultural resources and impacts to historic sites.
5. Use of equipment made outside the United States.
6. Glare from the panels and the possibility of the 'heat island effect.'
7. Decommissioning and disposal of the Project materials (panels, etc.) upon the end of the Project lifetime.
8. Stormwater runoff due to the impervious surface of the panels and impacts to stormwater fees.
9. Impacts to views and public view planes.
10. Renewable energy contribution.

HSEO encourages Longroad to continue its stakeholder engagement and agency consultation to address these impacts and any others identified. Every project has some degree of impacts and through close coordination with community members and stakeholders can the impacts be mitigated or minimized to an acceptable degree.

Thank you for the opportunity to provide these comments. If you have any questions, please feel free to contact me at scott.glenn@hawaii.gov.

Sincerely,

Scott J. Glenn

Scott J. Glenn
Chief Energy Officer

LAND USE COMMISSION
Department of Business, Economic Development & Tourism
State of Hawai`i

May 17, 2021

Dean Uchida, Director
Department of Planning and Permitting
650 South King Street, 7th Floor
Honolulu, HI 96813

RE: State Special Permit Application No. 2020/SUP-7
Mahi Solar Project, TMK Nos. 9-2-001:020 (por.), 9-2-004:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por.), and 9-2-004:012 (por.)
Honouliuli, `Ewa, O`ahu

The Commission staff has the following comments to your email received April 9, 2021, regarding this matter:

The proposed site is within the State Agricultural District and on designated Important Agricultural Lands ("IAL"). Pursuant to Hawai`i Revised Statutes ("HRS") §205-50(b) requires the County to send the application to both the State Department of Agriculture ("DOA") and the State Office of Planning ("OP") for review and comments. Additionally, sections (c) to (e) specifically identify the standards and criteria required for analysis of any use proposed in the State Agricultural District where IAL are involved. Findings and an ultimate decision should reflect these sections in addition to the decision-making guidelines used in determining an "unusual and reasonable use" as found in Hawai`i Administrative Rules ("HAR") §15-15-95(c)(1) to (5).

Staff would also like to make sure there has been coordination with the State Historic Preservation Division and DLNR's Aha Moku Council; and a Ka Pa`akai analysis is provided as part of the petition.

235 SOUTH BERETANIA STREET ❁ SUITE 406 ❁ HONOLULU, HAWAI`I 96813 ❁ TEL (808) 587-3822 ❁ FAX (808) 587-3827 ❁ EMAIL: dbedt.luc.web@hawaii.gov
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Should you have any questions please contact me or Scott A.K. Derrickson, AICP at 587-3822.

Aloha,

Daniel E. Orodenker
Executive Officer

cc: Mary Alice Evans, OP
Earl Yamamoto, DOA

DAVID Y. IGE
Governor

JOSH GREEN
Lt. Governor

PHYLLIS SHIMABUKURO-GEISER
Chairperson, Board of Agriculture

MORRIS M. ATTA
Deputy to the Chairperson

State of Hawaii
DEPARTMENT OF AGRICULTURE
1428 South King Street
Honolulu, Hawaii 96814-2512
Phone: (808) 973-9600 FAX: (808) 973-9613

May 14, 2021

Mr. Dean Uchida, Director
Department of Planning and Permitting
City and County of Honolulu
650 South King Street 7th Floor
Honolulu, Hawaii 96813

Dear Mr. Uchida:

Subject: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
TMK: 9-2-01: por. 20, 9-2-04: por. 03, 9-2-04: por. 06, 9-2-04: por. 10, and 9-2-04: por. 12
Honouliuli, Ewa, Oahu
Area: 620 acres of 2,952.3 gross acres

The Department of Agriculture (Department) has reviewed the SUP application and offers the following comments and recommendations.

Background

The 620-acre project site consists of five project areas located to the west of Kunia Road . (Application, Figure 2.2, page 2-4; and Appendix B, Figures 2 through 6, unpaginated)

Project Area	Project Area Acreage	Landowner	Historic Agricultural Use
1	21.5	Hartung Bros. Hawaii	irrigated sugar
1, 2A, 2B, 2C, and 3	240.1	Hartung Bros. Hawaii	Irrigated sugar
3	12.1	Hartung Bros. Hawaii	Unirrigated pine
4A, 4B, and 4C	305.6	Fat Law's Farm	Unirrigated pine
5	40.7	Monsanto Technology	Irrigated sugar

Planning and zoning status
All project areas are in the State Agricultural District, within the Agriculture and Preservation Area of the Central Oahu Sustainable Communities Plan and the Ewa Development Plan, and zoned AG-1 (Restricted Agricultural).

Soil index classifications
The soils and historic agricultural uses on the five project areas reflect the availability of irrigation. Irrigated sugarcane was grown makai of the Waiahole Ditch and unirrigated pineapple grown mauka of the Waiahole Ditch. About 400 acres (65 percent) of the project site has "B"-rated soils according to the Land Study Bureau's (LSB) Overall Productivity Rating. "C"-rated soils comprise 115 acres (18 percent), and "D" and "E" soil are 69 acres (11 percent). (Application, Figure 4.2, page 4-5) A cursory review of the project site using the original LSB maps (147, 162, 163, 177) shows that the unirrigated "B", "C", and "D" rated soils would have had their Overall Productivity Ratings improved to "A", "B", and "C", respectively, if irrigation had been available for these soils at the time of the study.

The Agricultural Lands of Importance to the State of Hawaii (ALISH) system classifies the former unirrigated pineapple lands in project areas 4A, 4B, and 4C as mostly "Unique" agricultural lands and "Other Important" agricultural lands in the more sloped areas. "Prime" agricultural lands are found in the project areas makai of the Waiahole Ditch. (Application, Figure 4.3, page 4-8)

The Soil Survey Geographic Database (SSURGO) of the Natural Resource Conservation Service, U. S. Department of Agriculture describes slight to moderately sloped topography for the majority of the project areas with the exception of the southwestern most section of project area 1 and the easternmost section of 2A and 2C. (Application, Figure 4.1, page 4-2) Despite the slope, Appendix B, Figure 2 (unpaginated) indicates installation of solar panel arrays in these three areas.

Designated and proposed Important Agricultural Land status
About 69.5 acres of the 620-acre project site are designated as Important Agricultural Lands (IAL) (Application, Figure 4.4, page 4-10). On page 5-20 of the Application, 85 acres is identified as designated IAL. Assuming the 69.5 acres as the correct acreage, their location and current use are as follows:
29.3 acres in project area 1 (Hartung Bros., unspecified total acreage) and not in agricultural use, and
40.2 acres in project area 5 (Monsanto, total acreage of 40.7) and not in agricultural use.

About 305.6 acres of the 620-acre project site is recommended by the City and County of Honolulu for IAL designation (Application, Figure 4.5, page 4-11). Their location and current use are as follows:
305.6 acres in project area 4 (A, B, and C, Fat Law's Farm) of which about 99 acres is in basil and other vegetables (Application, Figure 3.1, page 3-10), about 200 acres in seed corn, and 51.7 acres located in the gap between 4A and 4B are not in agricultural use. (Application, page 4-9).

Current agricultural use
Of the 620 acres in the project site, 314 acres are currently not in agricultural production. The 306 acres in agricultural production is comprised of seed corn (197 acres), basil and other vegetables (56 acres), and other vegetables (43 acres). (Application, Figure 3.1, page 3-10; Appendix C, Mahi Solar Agricultural Plan, Figure 8, Current Agricultural Activity Map, page 8) The food crops are found in project areas 4B and 4C (Fat Law's Farm) along Kunia Road. (Application, page 3-9)

Irrigation water
The availability of sufficient irrigation water when needed is fundamental to ensuring maximal agricultural productivity for conventional soil-based agricultural production. This is particularly critical during the dry and windy summer months experienced in the area and for crops such as alfalfa. The Kunia Water Association (KWA) provides water service to the project site pursuant to KWA's "lease agreements for the property" (Application, page 6-1) but it is unclear if water will be available to each of the project areas to meet projected needs. The current agricultural activity map (Appendix C, page 23) indicate that irrigation water of unknown quantity is supplied to project areas 2B, 2C, 3, 4A, 4B and 4C.for seed corn and basil/other vegetables. Crop irrigation for future agricultural uses will be done by soft hoses (*usually as part of a traveling sprinkler or cable-tow system*) and drip feeder line (*typically drip tape*) (Appendix C, page 39). The Application states that the Agribusiness Development Corporation (ADC) is proposing improvements to the Waiahole Ditch, however "all proposed construction for Mahi Solar project will take place outside of the ADC's proposed improvement areas". (Application, page 6-2)

Department staff notes that Fat Law's Farms has a permit from the Commission on Water Resource Management (CWRM) allowing the withdrawal of up to 0.551 million gallons per day from the Waiahole Ditch to irrigate 329 acres of diversified agriculture, the area of which encompasses all of project areas 4A, 4B, and 4C. Use of the water by parties other than the permittee and the crops that may be irrigated may require

CWRM approval. The cost of water from the KWA ranges from $1.47 to $2.04 per thousand gallons. In comparison, Waiahole Ditch water is noted to be $0.517 (now, $0.87) per thousand gallons for agricultural usage.

Appendix C (pages 25-26) state that the area to be provided with water infrastructure will increase from the current 262 acres to 442 acres of the of the project site but does not provide further details.

Mean annual rainfall is about 30 inches with January being the wettest month at 4.8 inches. (Application, page 4-1)

The Department strongly recommends that data and information on maximum water demand, sources, storage, pumping, delivery, and year round availability to all five project areas be developed prior to Phase Two of the Agricultural Plan described in Appendix C. Further, this data and information should be provided to agricultural operators interested in the project site or specific project areas for agricultural production including livestock, hydroponic, and aquaponic.

Solar panel coverage by project area

There will be a net area of 147 acres of solar panel coverage on the project site (Application, page 3-7). Department staff was unable to find a breakdown of this area by project area. From Appendix B (Site Plan and Drawings, Prepared by Revamp Engineers and Walters, Kimura, Motoda, Inc. February 2021, Figures 2-5, unpaginated) nearly all of project areas 4A and 4B, and most of 4C (all Fat Law's Farm) will be covered by solar panels. There is a gap between 4A and 4B (described as 51.7 acres in Application, page 4-9) that may be used for "solar panels and/or farming/ranching."
Department staff roughly estimates solar panel coverage as follows:
Nearly all of project area 3 (Hartung Bros.) will be under solar panels.
About 70% of project area 5 (Monsanto) will be under solar panels.
About 50% of project area 1 (Hartung Bros.) in the far western portion of the area will be covered by solar panels and the remainder that may be used for "solar panels and/or farming/ranching."
About 60% of project areas 2A, 2B, and 2C (Hartung Bros.) will be under solar panels and the remainder may be used for "solar panels and/or ranching."

The solar arrays will be six- to eight-feet off the ground when panels are zero degrees tilt (parallel to the ground) At maximum rotation (50 degrees tilt) the arrays will have the lowest edge of the solar panels one- to three-feet off the ground. There will be nine-foot spacing between adjacent arrays of panels at zero degrees tilt. (Application, page

3-4; Appendix B, "Site Plan and Drawings...", Figure 7, unpaginated; and Appendix C, "Agricultural Plan", pages 15-16)

The Agricultural Plan, research, and field testing should include the soft hose irrigation system being proposed for future agricultural activities that may occur under and adjacent to the solar panel arrays.

Fencing

Fencing is important to discourage trespassing and crop or animal theft and to keep livestock from dislocation.

Department staff notes that there will be fencing on the perimeters of the solar paneled areas, however the "solar panels and/or ranching" areas appear to not be fenced. (Appendix B: Site Plan and Drawings, Prepared by Revamp Engineers and Walters, Kimura, Motoda, Inc. February 2021, Figures 2-5)

The extent and type of fencing and gating to be in place prior to full operation of the solar energy facility should reflect the needs of the anticipated agricultural activities and not just providing security for the solar energy facility.

Mahi Solar Agricultural Plan

The proposed agricultural plan would utilize 610 of the 620-acre project. Of the 610 acres, 488.9 acres will be cultivated in crops and used for livestock grazing and bee keeping. (Application, pages 3-10 to -11) Department staff notes that livestock grazing and crop cultivation are not compatible in the same area if they are not effectively separated. The aforementioned proposed fencing can contain livestock under the solar panels to do weed control but that will likely preclude the cultivation of in-ground crops within the same area. Further, as noted on page 3 of this letter, irrigation water in sufficient quantity and availability on demand is fundamental to any crop or livestock operation. There is scant mention of irrigation water and no mention of water for livestock in the Application and Appendix C (Mahi Solar: Agricultural Plan), although water infrastructure is planned for all project areas (Appendix C, Table 1, page 7)

The Agricultural Plan has three phases –

Phase One is two years of research to be done by the Hawaii Agriculture Research Center (HARC) that will include field trials of identified crops at the Clearway solar facility just south of Mililani Town. Conventional and hydroponic cultivation will be used for crops such as lettuce, basil, and alfalfa and other legumes and grasses for livestock forage. The field trials are to determine what crops can be productively grown with what practices under and between solar panels. (Appendix C, pages 19-21)

Phase Two occurs atter Mahi Solar is in operation, they "will make available" 610 of the 620-acre project site "to local farmers to grow agricultural products at a commercial scale." (Application, page 3-12). Department staff find this phase confusing as the Application further states that Mahi Solar will coordinate with local farmers and ranchers, along with HARC and local experts "to propose agrivoltaic projects that they believe will be successful". (Application, page 3-12) This differs considerably from the description of Phase Two further on in the Application - "As each new agricultural use is tested at the project site in research trials or grown in the solar fields by farmers, HARC and Mahi Solar will gather data and evaluate the results. This will help farmers and ranchers learn and modify their work, in an iterative process." (Application, page 5-2) Similarly, the linkage between Phase One and Two is made in the Agricultural Plan (Appendix C, page 5), where land and water will be provided to farmers and ranchers to grow out these crops (from Phase One) at commercial scale. This is more in line with the description of Phase Two in the Agricultural Plan (Appendix C, pages 22-26) Mahi Solar needs to make consistent its intention to link the research in Phase One and its application by farmers and ranchers in Phase Two.

Phase Three is the sharing of data collected on agrivoltaic farming.

The Department supports proof-of-concept as the best way to determine the suitability of the to-be-determined agricultural activities to be researched and field trialed by HARC and interested farming operations at the Clearway Mililani solar facility.

The proposed agricultural activities (Appendix C, Figure 4, page 6) shows about 41 percent (250 acres) of the 610 acres available for agricultural uses may be in directly edible commodities such as honey, vegetable, sweet potatoes, and hydroponic lettuce. Another 19 percent (121 acres) will be in livestock grazing, presumably sheep, as cattle and goats are not mentioned.

Oahu Grazers has expressed interest in using a few hundred acres of the project site as additional pasture land for their sheep (500 head) and maybe calves. This operation already runs sheep on existing solar energy facilities on Oahu.

With respect to the market for sheep and lambs, the Department understands that Oahu's primary livestock slaughter facility has expressed reluctance to offer services to hogs. The Department is not aware that this reluctance also applies to sheep and lambs. The Department recommends Oahu Grazers to confirm their agreement(s) with their slaughter facilities.

While sales of sheep/lamb is not required by State law (Section 205-4.5(21), HRS), it is the generation of revenue by agricultural operators selling their agricultural products such as vegetables, melons, fruits, honey, and so forth that will ensure continued agricultural activity. This is why the Department focuses on the application's references and commitments to infrastructure, research, and field trials that affect agricultural operators and the establishment and continuation of their agricultural activities.

The Department has read the HARC Solar White Paper (Appendix B within Appendix C "Agricultural Plan") and has every confidence that this venerable Hawaii agricultural institution will follow through on their commitments to the best of their ability and produce data and information that will help those agricultural operators who are committed to the project site be economically viable.

Conclusion

The Department strongly encourages Mahi Solar to fulfill its commitments and assertions and go beyond the minimum statutory requirement of making the project site available for agricultural activities at a lease rate that is at least 50 percent below the fair market rent for comparable properties. The Department believes that research alone is not a satisfactory outcome, nor is sheep used only for weed control. The majority of the land area under the project site contains some of the State's most potentially productive soils for intensive agricultural production. The Department expects the research to be done by HARC along with the field trials with interested farmers to result in intensive agricultural activity on the project site.

Thank you for the opportunity to provide our input on this very important application. Should you have any questions, please contact Earl Yamamoto at 973-9466 or email at earl.j.yamamoto@hawaii.gov.

Sincerely,

Phyllis Shimabukuro-Geiser

Phyllis Shimabukuro-Geiser
Chairperson, Board of Agriculture

c: Office of Planning
Land Use Commission

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

April 22, 2021

LD 0413
2020/SUP-7

MEMORANDUM

TO: **DLNR Agencies:**
___Div. of Aquatic Resources
___Div. of Boating & Ocean Recreation
_X_Engineering Division *(via email: DLNR.Engr@hawaii.gov)*
_X_Div. of Forestry & Wildlife *(via email: Rubyrosa.T.Terrago@hawaii.gov)*
___Div. of State Parks
_X_Commission on Water Resource Management *(via email: DLNR.CWRM@hawaii.gov)*
___Office of Conservation & Coastal Lands
_X_Land Division – Oahu District *(via email: DLNR.Land@hawaii.gov)*

FROM: Russell Y. Tsuji, Land Administrator *Russell Tsuji*
SUBJECT: **Special Use Permit Application No. 2020/SUP-7**
Mahi Solar Project
LOCATION: Honouliuli, Ewa, Island of Oahu, Hawaii; TMKs: (1) 9-2-001-020 (por.), 9-2-4:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por.), and 9-2-004:012 (por.)
APPLICANT: **Department of Planning and Permitting, City & County of Honolulu**

Transmitted for your review and comment is information on the above-referenced project. Please review the attached information and submit any comments by the internal deadline of **Friday, May 07, 2021** to the Land Division at DLNR.Land@hawaii.gov, and copied to barbara.j.lee@hawaii.gov.

If no response is received by the above due date, we will assume your agency has no comments at this time. If you have any questions, please contact Barbara Lee at barbara.j.lee@hawaii.gov. Thank you.

( ) We have no objections.
( ) We have no comments.
( ) We have no additional comments.
(☑) Comments are attached.

Signed: DGS
Print Name: DAVID G. SMITH, Administrator
Division: Division of Forestry and Wildlife
Date: May 12, 2021

Attachments
Cc: Central Files

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE
MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 12, 2021

LD 0413

Raymond Young, Acting Branch Chief
Community Planning Branch
Department of Planning & Permitting
City and County of Honolulu
650 S. King Street, 3rd Floor
Honolulu, HI 96813

(Via email: fkraintz@honolulu.gov)

Dear Sirs:

SUBJECT: **Special Use Permit (SUP) Application No. 2020/SUP-7**
Mahi Solar Project
Honouliuli, Ewa, Island of Oahu
TMK: (1) 9-2-001:020 (por.), 9-2-4:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por.), and 9-2-004:012 (por.)

Thank you for the opportunity to review and comment on the subject project. In addition to previous comments sent to you from the Department of Land and Natural Resources (DLNR) dated May 07, 2021, and May 10, 2021, enclosed are comments received from DLNR's Division of Forestry and Wildlife.

Should you have any questions, please feel free to contact Barbara Lee via email at barbara.j.lee@hawaii.gov. Thank you.

Sincerely,

Russell Tsuji

Russell Y. Tsuji
Land Administrator

Attachments

Cc: Central Files

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ROBERT K. MASUDA
FIRST DEPUTY

M. KALEO MANUEL
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
1151 PUNCHBOWL STREET, ROOM 325
HONOLULU, HAWAII 96813

May 7, 2021

MEMORANDUM

Log no. 3118

TO: RUSSELL Y. TSUJI, Administrator
Land Division

FROM: DAVID G. SMITH, Administrator
Division of Forestry and Wildlife

SUBJECT: Division of Forestry and Wildlife Comments for the Special Use Permit (SUP) Application No.2020/SUP-7 Mahi Solar Project

The Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) has received your inquiry regarding the SUP application for the Mahi Solar Project in Ewa on O'ahu, Hawai'i, TMKs: (1) 9-2-001:020 (por.), 9-2-004:003 (por.), 006 (por.), 010 (por.) and 012 (por.). The proposed project consists of constructing a 120-megawatt alternating current solar and energy storage facility which includes a ground-mounted, single-axis tracking photovoltaic (PV) arrays on a 480-megawatt-hour Battery Energy Storage System on 620 of existing agricultural land.

The State SUP application identifies State listed endangered and threatened wildlife species that are known to occur, may occur, or may transit the project site. DOFAW agrees that the listed species possibly impacted by the development of the project include the O'ahu 'Elepaio (*Chasiempis ibidis*), Hawaiian Short-eared Owl or Pueo (*Asio flammeus sandwichensis*), Hawaiian Moorhen (*Gallinula galeata sandvicensis*), Hawaiian Stilt (*Himantopus mexicanus knudseni*), Hawaiian Coot (*Fulica alai*),Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), Hawaiian Petrel (*Pterodroma sandwichensis*), Newell's Shearwater (*Puffinus auricularis newelli*), and the Band-rumped Storm Petrel (*Oceanodroma castro*).

We appreciate the inclusion of recommended mitigation, monitoring and avoidance measures in Appendix D of the Biological Resources Report by SWCA intended to avoid construction and operational impacts to State listed species. Based on the information from the SWCA's report, DOFAW provides the following comments on the potential of the proposed work to affect listed species in the vicinity of the project area.

DOFAW recommends conducting follow-up ground surveys using playback to determine if 'Elepaio are present in the vicinity of the proposed project site. We recommend a qualified biologist with a Section 6 ESA permit conduct these surveys. Please contact DOFAW at (808) 587-0166 for further guidance and information.

Survey records indicate endangered plant species, such as *Abutilon menziesii* and *Gardenia brighamii*, have the potential to occur within or near the proposed project area. DOFAW recommends that a qualified botanist survey for these rare and endangered plants that may occur

and be impacted in the proposed project area. If any of these species are found, please notify DOFAW for futher guidance.

The State endangered Pueo has been observed in the project site vicinity. Pueo are a crepuscular species, most active during dawn and dusk twilights. DOFAW recommends twilight pre-construction surveys by a qualified biologist prior to clearing vegetation for construction. If Pueo nests are present, a buffer zone of 46 m (150 feet) should be established in which no clearing occurs until nesting ceases, and DOFAW staff should be notified. Work should not resume until directed by DOFAW.

State listed waterbirds such as the Hawaiian Stilt, Hawaiian Coot, and Hawaiian Common Gallinule have the potential to occur in the vicinity of the proposed project site. It is against State law to harm or harass these species. If any of these species are present during construction activities, then all activities within 100 feet (30 meters) should cease, and the bird should not be approached. Work may continue after the bird leaves the area of its own accord. If a nest is discovered at any point, please contact the O'ahu DOFAW Office at (808) 973-9778.

The State listed Hawaiian Hoary Bat or 'Ōpe'ape'a has the potential to occur in the vicinity of the project area and may roost in nearby trees. If any site clearing is required this should be timed to avoid disturbance during the bat birthing and pup rearing season (June 1 through September 15). If this cannot be avoided, woody plants greater than 15 feet (4.6 meters) tall should not be disturbed, removed, or trimmed without consulting DOFAW. It has been documented that hoary bats can become ensnared in barbed wire during flight and die. We therefore recommend the use of barbed wire be avoided, and are pleased to note that your plan states that barbed wire will not be installed at the project site.

We note that artificial lighting can adversely impact seabirds that may pass through the area at night by causing disorientation. This disorientation can result in collision with manmade artifacts or grounding of birds. For nighttime lighting that might be required, DOFAW recommends that all lights be fully shielded to minimize impacts. Nighttime work that requires outdoor lighting should be avoided during the seabird fledging season from September 15 through December 15. This is the period when young seabirds take their maiden voyage to the open sea. For illustrations and guidance related to seabird-friendly light styles that also protect the dark, starry skies of Hawai'i please visit: https://dlnr.hawaii.gov/wildlife/files/2016/03/DOC439.pdf.

DOFAW appreciates the applicant's commitment to implementing a Downed Wildlife Observation Program program that informs site personnel of species that may occur in the project vicinity and could potentially be harmed by solar panels. Site personnel should document sightings of threatened or endangered species, as well as immediately report any mortality or injury of these species to DOFAW so that we may assist in avoiding and minimizing impacts.

DOFAW recommends minimizing the movement of plant or soil material between worksites, such as in fill. Soil and plant material may contain invasive fungal pathogens (e.g. Rapid 'Ōhi'a Death), vertebrate and invertebrate pests, or invasive plant parts that could harm Hawai'i's native species and ecosystems. We recommend consulting the O'ahu Invasive Species Committee at (808) 266-7994 during planning, design, and construction of the project to be informed of any high-risk invasive species in the area and ways to mitigate their spread. All equipment, materials, and personnel should be cleaned of excess soil and debris to minimize the risk of spreading invasive species.

We appreciate your efforts to work with our office for the conservation of Hawai'i's native species. Should the scope of the project change significantly, or should it become apparent that threatened or endangered species may be impacted, please contact our staff as soon as possible. If you have any questions, please contact Paul Radley, Protected Species Habitat Conservation Planning Coordinator at (808) 587-0010 or paul.m.radley@hawaii.gov.

Sincerely,

DAVID G. SMITH
Administrator

Emailed to Franz Kraintz at 9:43am on 5/10/21

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 07, 2021

LD 0413

Raymond Young, Acting Branch Chief
Community Planning Branch
Department of Planning & Permitting
City and County of Honolulu
650 S. King Street, 3rd Floor
Honolulu, HI 96813

(Via email: fkraintz@honolulu.gov)

Dear Sirs:

SUBJECT: **Special Use Permit (SUP) Application No. 2020/SUP-7**
Mahi Solar Project
Honouliuli, Ewa, Island of Oahu
TMK: (1) 9-2-001:020 (por.), 9-2-4:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por.), and 9-2-004:012 (por.)

Thank you for the opportunity to review and comment on the subject project. The Land Division of the Department of Land and Natural Resources (DLNR) distributed copies of your request to various DLNR divisions for their review and comment.

Attached are comments received from our Division of Engineering. Should you have any questions, please feel free to contact Barbara Lee via email at barbara.j.lee@hawaii.gov. Thank you.

Sincerely,

Russell Tsuji

Russell Y. Tsuji
Land Administrator

Attachments

Cc: Central Files

Emailed to Franz Kraintz at 9:43am on 5/10/21

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

April 22, 2021

LD 0413
2020/SUP-7

MEMORANDUM

FROM:

~~TO:~~ **DLNR Agencies:**
___Div. of Aquatic Resources
___Div. of Boating & Ocean Recreation
_X_ Engineering Division *(via email: DLNR.Engr@hawaii.gov)*
_X_ Div. of Forestry & Wildlife *(via email: Rubyrosa.T.Terrago@hawaii.gov)*
___Div. of State Parks
_X_ Commission on Water Resource Management *(via email: DLNR.CWRM@hawaii.gov)*
___Office of Conservation & Coastal Lands
_X_ Land Division – Oahu District *(via email: DLNR.Land@hawaii.gov)*

TO:

~~FROM:~~ Russell Y. Tsuji, Land Administrator *Russell Tsuji*

SUBJECT: **Special Use Permit Application No. 2020/SUP-7**
Mahi Solar Project

LOCATION: Honouliuli, Ewa, Island of Oahu, Hawaii; TMKs: (1) 9-2-001-020 (por.), 9-2-4:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por.), and 9-2-004:012 (por.)

APPLICANT: **Department of Planning and Permitting, City & County of Honolulu**

Transmitted for your review and comment is information on the above-referenced project. Please review the attached information and submit any comments by the internal deadline of **Friday, May 07, 2021** to the Land Division at DLNR.Land@hawaii.gov, and copied to barbara.j.lee@hawaii.gov.

If no response is received by the above due date, we will assume your agency has no comments at this time. If you have any questions, please contact Barbara Lee at barbara.j.lee@hawaii.gov. Thank you.

( ) We have no objections.
( ) We have no comments.
( ) We have no additional comments.
(✓) Comments are attached.

Signed: _____
Print Name: Carty S. Chang, Chief Engineer
Division: Engineering Division
Date: Apr 26, 2021

Attachments
Cc: Central Files

DEPARTMENT OF LAND AND NATURAL RESOURCES
ENGINEERING DIVISION

LD/Russell Y. Tsuji
Ref: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Location: Honouliuli, Ewa, Oahu
TMK(s): (1) 9-2-001-020 (por.), 9-2-4:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por), and 9-2-004:012 (por.)
Applicant: Department of Planning and Permitting, City & County of Honolulu

COMMENTS

The rules and regulations of the National Flood Insurance Program (NFIP), Title 44 of the Code of Federal Regulations (44CFR), are in effect when development falls within a Special Flood Hazard Area (high-risk areas). State projects are required to comply with 44CFR regulations as stipulated in Section 60.12. Be advised that 44CFR reflects the minimum standards as set forth by the NFIP. Local community flood ordinances may stipulate higher standards that can be more restrictive and would take precedence over the minimum NFIP standards.

The owner of the project property and/or their representative is responsible to research the Flood Hazard Zone designation for the project. Flood Hazard Zones are designated on FEMA's Flood Insurance Rate Maps (FIRM), which can be viewed on our Flood Hazard Assessment Tool (FHAT) (http://gis.hawaiinfip.org/FHAT).

If there are questions regarding the local flood ordinances, please contact the applicable County NFIP coordinating agency below:

- Oahu: City and County of Honolulu, Department of Planning and Permitting (808) 768-8098.
- Hawaii Island: County of Hawaii, Department of Public Works (808) 961-8327.
- Maui/Molokai/Lanai County of Maui, Department of Planning (808) 270-7253.
- Kauai: County of Kauai, Department of Public Works (808) 241-4896.

Signed: _____
CARTY S. CHANG, CHIEF ENGINEER

Date: Apr 26, 2021

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
LAND DIVISION

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 10, 2021

LD 0413

Raymond Young, Acting Branch Chief
Community Planning Branch
Department of Planning & Permitting
City and County of Honolulu
650 S. King Street, 3rd Floor
Honolulu, HI 96813

(Via email: fkraintz@honolulu.gov)
at 10:36am on 5/10/21

Dear Sirs:

SUBJECT: **Special Use Permit (SUP) Application No. 2020/SUP-7**
Mahi Solar Project
Honouliuli, Ewa, Island of Oahu
TMK: (1) 9-2-001:020 (por.), 9-2-4:003 (por.), 9-2-004:006 (por.), 9-2-004:010 (por.), and 9-2-004:012 (por.)

Thank you for the opportunity to review and comment on the subject project. In addition to previous comments sent to you from the Department of Land and Natural Resources (DLNR) dated May 07, 2021, enclosed are comments received from DLNR's Commission on Water Resource Management.

Should you have any questions, please feel free to contact Barbara Lee via email at barbara.j.lee@hawaii.gov. Thank you.

Sincerely,

Russell Tsuji

Russell Y. Tsuji
Land Administrator

Attachments

Cc: Central Files

E-mailed to fkrantz@honolulu.gov at 10:36am on 5/10/21

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON

KAMANA BEAMER, PH.D.
MICHAEL G. BUCK
ELIZABETH A. CHAR, M.D.
NEIL J. HANNAHS
WAYNE K. KATAYAMA
PAUL J. MEYER

M. KALEO MANUEL
DEPUTY DIRECTOR

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT
P.O. BOX 621
HONOLULU, HAWAII 96809

May 7, 2021

REF: RFD.5656.3

TO: Mr. Russell Tsuji, Administrator
Land Division

FROM: M. Kaleo Manuel, Deputy Director
Commission on Water Resource Management

SUBJECT: Special Use Permit Application No. 202/SUP-7; Mahi Solar Project

FILE NO.: RFD.5656.3
TMK NO.: (1) 9-2-001:020, (1) 9-2-004:003, (1) 9-2-004:006, (1) 9-2-004:010, (1) 9-2-004:012

Thank you for the opportunity to review the subject document. The Commission on Water Resource Management (CWRM) is the agency responsible for administering the State Water Code (Code). Under the Code, all waters of the State are held in trust for the benefit of the citizens of the State, therefore all water use is subject to legally protected water rights. CWRM strongly promotes the efficient use of Hawaii's water resources through conservation measures and appropriate resource management. For more information, please refer to the State Water Code, Chapter 174C, Hawaii Revised Statutes, and Hawaii Administrative Rules, Chapters 13-167 to 13-171. These documents are available via the Internet at http://dlnr.hawaii.gov/cwrm.

Our comments related to water resources are checked off below.

☐ 1. We recommend coordination with the county to incorporate this project into the county's Water Use and Development Plan. Please contact the respective Planning Department and/or Department of Water Supply for further information.

☐ 2. We recommend coordination with the Engineering Division of the State Department of Land and Natural Resources to incorporate this project into the State Water Projects Plan.

☐ 3. We recommend coordination with the Hawaii Department of Agriculture (HDOA) to incorporate the reclassification of agricultural zoned land and the redistribution of agricultural resources into the State's Agricultural Water Use and Development Plan (AWUDP). Please contact the HDOA for more information.

☐ 4. We recommend that water efficient fixtures be installed and water efficient practices implemented throughout the development to reduce the increased demand on the area's freshwater resources. Reducing the water usage of a home or building may earn credit towards Leadership in Energy and Environmental Design (LEED) certification. More information on LEED certification is available at http://www.usgbc.org/leed. A listing of fixtures certified by the EAP as having high water efficiency can be found at http://www.epa.gov/watersense.

☐ 5. We recommend the use of best management practices (BMP) for stormwater management to minimize the impact of the project to the existing area's hydrology while maintaining on-site infiltration and preventing polluted runoff from storm events. Stormwater management BMPs may earn credit toward LEED certification. More information on stormwater BMPs can be found at http://planning.hawaii.gov/czm/initiatives/low-impact-development/

☐ 6. We recommend the use of alternative water sources, wherever practicable.

☐ 7. We recommend participating in the Hawaii Green Business Program, that assists and recognizes businesses that strive to operate in an environmentally and socially responsible manner. The program description can be found online at http://energy.hawaii.gov/green-business-program.

☐ 8. We recommend adopting landscape irrigation conservation best management practices endorsed by the Landscape Industry Council of Hawaii. These practices can be found online at http://www.hawaiiscape.com/wp-content/uploads/2013/04/LICH_Irrigation_Conservation_BMPs.pdf.

☐ 9. There may be the potential for ground or surface water degradation/contamination and recommend that approvals for this project be conditioned upon a review by the State Department of Health and the developer's acceptance of any resulting requirements related to water quality.

☐ 10. The proposed water supply source for the project is located in a designated water management area, and a Water Use Permit is required prior to use of water. The Water Use Permit may be conditioned on the requirement to use dual line water supply systems for new industrial and commercial developments.

☐ 11. A Well Construction Permit(s) is (are) are required before the commencement of any well construction work.

☐ 12. A Pump Installation Permit(s) is (are) required before ground water is developed as a source of supply for the project.

☐ 13. There is (are) well(s) located on or adjacent to this project. If wells are not planned to be used and will be affected by any new construction, they must be properly abandoned and sealed. A permit for well abandonment must be obtained.

☐ 14. Ground-water withdrawals from this project may affect streamflows, which may require an instream flow standard amendment.

☒ 15. A Stream Channel Alteration Permit(s) is (are) required before any alteration can be made to the bed and/or banks of a steam channel.

☐ 16. A Stream Diversion Works Permit(s) is (are) required before any stream diversion works is constructed or altered.

☐ 17. A Petition to Amend the Interim Instream Flow Standard is required for any new or expanded diversion(s) of surface water.

☐ 18. The planned source of water for this project has not been identified in this report. Therefore, we cannot determine what permits or petitions are required from our office, or whether there are potential impacts to water resources.

☐ OTHER:

If you have any questions, please contact Dean Uyeno of the Commission staff at 587-0234.

DAVID Y. IGE
GOVERNOR

JADE T. BUTAY
DIRECTOR

Deputy Directors
LYNN A.S. ARAKI-REGAN
DEREK J. CHOW
ROSS M. HIGASHI
EDWIN H. SNIFFEN

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:
DIR 0365
STP 8.3162

May 4, 2021

Mr. Dean Uchida
Director
Department of Planning and Permitting
City and County of Honolulu
650 South King Street, 7th Floor
Honolulu, Hawaii 96813

Attention: Mr. Raymond Young

Dear Mr. Uchida:

Subject: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Ewa, Oahu, Hawaii
Tax Map Keys: Portions of (1) 9-2-001: 020 and 9-2-004: 003, 006, 010, 012

Thank you for your letter dated April 9, 2021, requesting the State of Hawaii Department of Transportation's (HDOT) review and comment on the subject SUP application. HDOT understands that Mahi Solar, LLC is proposing a 120-megawatt (MW) photovoltaic (PV) energy generation system, a 480-megawatt hour battery storage system, and other supporting facilities on approximately 620 acres of land in Kunia.

Access to the project will be via Kunia Road (State Route 750) at three existing unsignalized, stop-controlled intersections with private roads as follows: Palawai Road, Plantation Road, and an unnamed road to the Monsanto Technology LLC parcel.

HDOT has the following comments:

Airports Division (HDOT-A)

1. The subject solar project is located just outside the transitional airspace for the Daniel K. Inouye International Airport. PV systems that are located in or near the protected approach and departure air space can create a hazardous condition for pilots because of possible glint and glare reflected from the PV array. If glint or glare from the PV array creates a hazardous condition for pilots, the owner of the PV system shall be prepared to immediately mitigate the hazard upon notification by the HDOT-A and/or Federal Aviation Administration (FAA).

   PV systems have also been known to emit radio frequency interference (RFI) to aviation-dedicated radio signals, thereby disrupting the reliability of air-to-ground communications. Again, the owner of the PV system shall be prepared to immediately mitigate the RFI hazard upon notification by the HDOT-A and/or FAA.

2. Thick smoke from uncontrolled fires are potential obstruction hazards to flight operations. Therefore, the energy or battery storage facility for the solar project shall have sufficient firefighting/fire suppressant ability to prevent hazardous smoke in the protected air space.

Highways Division (HDOT-HWY)

The HDOT-HWY reviewed the application, including Appendix J, Draft Mahi Solar Construction Traffic Assessment (CTA), dated September 2020 and have the following comments relevant to State highways:

1. We note that the site plan includes a 30-foot easement from Kunia Road along a segment of the frontage. Verify with the landowner that the easement was designated in anticipation of future Kunia Road widening.

2. Agricultural crossing points and cane haul roads may not be considered legal access to HDOT highways. Although the CTA did not identify operations-phase traffic impacts to Kunia Road, verify with HDOT-HWY Oahu District that these driveways meet current standards for the proposed use.

3. The CTA included the following assumptions and findings:

    a. The heavy truck access route is likely to originate at Sand Island, and travel east on Interstate H-1 to the Kunia Road Exit. All three project access driveways on Kunia Road would be used by construction vehicles.

    b. Eight intersections, including the three project access driveways were included in the analysis. Baseline 2020 Level of Service (LOS) is unacceptable (LOS D or E) during AM and/or PM peak traffic hours at the following intersections: 1) Kunia Road/H-1 eastbound ramp (AM only), 2) Site Access: Kunia and Plantation Road (AM and PM), and 3) Site Access: Kunia Road and Palawai Road (AM only). The through traffic on Kunia Road is uncontrolled and operates at a LOS A. The unacceptable LOS at the site access driveways is associated with the traffic delays on the private roads.

    c. Year 2022 was projected to be the horizon year for peak project construction. The cumulative effect of concurrent construction of two other planned solar farms (i.e., Hoohana, Kupehau) in the vicinity was included in the 2022 horizon year; however, it is unlikely the construction schedules would overlap.

    d. The project-related peak construction workforce is estimated at 340 workers and the number of vehicles was adjusted to 227, based on carpooling assumptions. The scenario assumes all construction personnel trips would occur during peak traffic hours and 50 percent would be to/from Honolulu.

    e. In 2022, the LOS at all three site access intersections with Kunia Road was projected to be unacceptable. The Kunia Road/H-1 ramp would remain at an unacceptable LOS. The Kunia Road and Anonui Road intersection would degrade to LOS E during PM peak traffic conditions.

    f. The heavy truck traffic was assumed to occur outside of peak traffic hours.

    g. The construction-related impacts would be temporary and largely attributed to the assumed concurrent construction of three solar projects. No capacity-building recommendations are warranted or proposed to mitigate the regional traffic impacts.

h. The report recommends specific elements be included in the Construction Traffic Management Plan (TMP) to improve safety at the three site access intersections.

4. The HDOT-HWY shares the CTA concern for construction-phase traffic safety at the three access intersections and supports the CTA recommendations for specific elements to be included in the Construction TMP. Submit the Construction TMP to HDOT-HWY Oahu District for review and acceptance. Access improvements may be required to accommodate heavy and oversized vehicles.

5. HDOT-HWY agrees the impact of the solar farm operations on State highways would be negligible; however, the operational analysis should describe the anticipated trips generated by the farming activities within the project lease area as well as landowner land use plans for the parcel areas outside of the lease areas, with respect to each of the three access intersections with Kunia Road. The application suggests more land area within the project lease area would be in production relative to existing conditions and the number of farming operations within the project lease area would increase. Describe the existing and future operational access control at the intersections. Identify recommendations, as warranted, for safety improvements to address the additional operational traffic.

6. No additional discharge of surface water run-off onto Kunia Road right-of-way (ROW) is permitted. This includes the use of the existing State drainage culverts and channels. All additional stormwater runoff from the project site shall be managed and mitigated onsite.

7. No work appears to be proposed within the State ROW. Note that any work within the State ROW requires a Permit to Perform Work Upon State Highways and a TMP. Construction plans prepared by a Hawaii licensed engineer shall be submitted to the HDOT-HWY Oahu District for review and approval prior to applying for a permit to perform work.

If there are any questions, please contact Mr. Blayne Nikaido of the HDOT Statewide Transportation Planning Office at (808) 831-7979 or via email at blayne.h.nikaido@hawaii.gov.

Sincerely,

JADE T. BUTAY
Director of Transportation

OFFICE OF PLANNING
STATE OF HAWAII

235 South Beretania Street, 6th Floor, Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

DAVID Y. IGE
GOVERNOR

MARY ALICE EVANS
DIRECTOR
OFFICE OF PLANNING

Telephone: (808) 587-2846
Fax: (808) 587-2824
Web: http://planning.hawaii.gov/

DTS 202104161004NA

May 11, 2021

Mr. Dean Uchida
Director
Department of Planning and Permitting
City and County of Honolulu
650 South King Street, 7th Floor
Honolulu, Hawaii 96813
Attn: Franz Kraintz

Dear Mr. Uchida:

Subject:	Special Use Permit (SUP) Application, Mahi Solar Project, 2020/SUP-7
Applicant:	Mahi Solar, LLC
Land Area:	Approximately 620 Acres
Location:	Kunia, Central Oahu, Oahu, Hawaii
TMKs:	(1) 9-2-001: 020 Por.; 9-2-004: 003 Por., 006 Por., 010 Por., and 012 Por.

The Office of Planning (OP) has reviewed the subject proposal to establish a solar photovoltaic and battery energy storage system on approximately 620 acres of land in five separate areas west of Kunia Road and mauka of the H-1 Freeway. The proposed project would provide 120 Megawatts (MW) of solar energy with a 480-MW Battery Storage system. The project also includes a 34.5 kilovolt substation and a new 138 KV transmission circuit west of Kunia Road.

According to the submittal, the Project site is designated as Agriculture and Preservation in the Central Oahu Sustainable Communities Plan ("SCP") and the Ewa Development Plan ("DP"). The Project site is within the State Agricultural Land Use District and zoned AG-1 Restricted Agricultural District. The site is bounded by agricultural lands to the north, south and east, and the Honouliuli Forest Reserve, designated as conservation land, to the west side. Kunia Loa Ridge Farmlands are located adjacent to areas 4A and 4B. The Honouliuli National Historic Site administered by the National Park Service is located south of Area 5.

Approximately 98.8 acres are currently in diversified agricultural production. 109.9 acres are fallow and about 204 acres are overgrown. The applicant proposes to increase the agriculture productivity on the project area by utilizing about 600 acres for agriculture.

Special Permit Guidelines

The guidelines for Special Permits (SP) are contained within Hawaii Administrative Rules (HAR) § 15-15-95 which allow certain "unusual and reasonable" uses within Agricultural and Rural Districts other than those for which the district is classified. HAR § 15-15-95 lists five (5) guidelines for determining whether a proposed use is "unusual and reasonable." The following assesses the proposed project relative to the Special Permit guidelines:

1. **The use shall not be contrary to the objectives sought to be accomplished by Chapters 205 and 205A, HRS, and the rules of the Land Use Commission (LUC).**

   Hawaii Revised Statutes (HRS) Chapter 205 seeks to protect agricultural lands and ensure their continued availability for agricultural use. It provides that the Agricultural District shall include lands with a high capacity for agricultural production, grazing, or other agricultural uses. Chapter 205 also recognizes, however, that some lands in the Agricultural District may not be suitable for the uses permitted in the Agricultural District and, therefore, other uses may be allowed with a Special Permit.

   Page 7-2. The document indicates that the applicant will make available about 610 acres of the project area for agricultural use through an Agrivoltaics Program in cooperation with the Hawaii Agricultural Research Center.

   Page 4-5 to 4-7. The document indicates that, under the Agricultural Lands of Importance to the State of Hawaii (ALISH) classification, the project area contains Prime, Unique and Other Important Agricultural Lands.

   Page 4-5 to 4-6. There are no A rated lands as designated by the Land Study Bureau. Other soils on the proposed West Oahu Solar project site are designated by the Land Study Bureau as:

B Lands	399.8 Acres
C Lands	115.6 Acres
D Lands	36.8 Acres
E Lands	61.9 Acres
Unclassified	5.9 Acres
Total	620 Acres

As noted in HRS § 205-4.5(a)(21), solar facilities on lands classified as B for which a special permit is granted pursuant to HRS § 205-6 may be permitted under certain restrictions relating to the decommissioning of the solar project, and the use in conjunction with compatible agricultural uses at reduced rates.

Page 4-7 to 4-12. Important Agricultural Lands (IAL). Approximately 415.3 acres, or 67% of the project lands are in IAL-designated or recommended IAL areas. The document indicates that approximately 69.5 acres located within Area 1 are lands designated as IAL via Land Use Commission (LUC) Docket No. DR18-61 by the owner Hartung Brothers. Another 40.2 acres of IAL located within Area 5 are owned by Monsanto and designated as IAL via LUC Docket No. DR17-59. Also, about 305.6 acres owned by Fat Law's Farm, Inc. have been included in the City's IAL recommendations currently before the LUC.

Page 4-21 to 4-27. Cultural and Historic Resources and Ka Paakai Analysis. The document provides a Cultural Analysis (Appendix E) and an Archaeological Inventory Survey (AIS) (Appendix F). Several features were discovered on the project site, and the AIS notes that the Honouliuli Internment Camp, designated a National Park, is adjacent to Area 5. The study also indicates that there may also be possible impacts to the Pohakea Trail which is located along some of the proposed project areas, and portions of the historic Waiahole Ditch are also located within the project area. While the studies include proposed mitigation measures, these should be included as conditions of approval for the project.

We note that the Application does not include a letter from the Department of Land and Natural Resources, State Historic Preservation Division ("SHPD") for the review and approval of the AIS, mitigation and preservation measures for the proposed project. Any recommendations from SHPD should be included as conditions of approval.

The Application does not specifically incorporate the mitigation recommendations on Page 52 of the Cultural Assessment relative to the Pohakea trail, native plant resources, and archaeological resources in fulfillment of the Ka Paakai Analysis requirements. These recommendations should be incorporated as conditions of approval.

OP is concerned with these omissions and strongly recommends that a complete description, analysis, and mitigation measures, including approval of the AIS from SHPD, be provided for the Planning Commission's consideration, and included in the record of the Special Permit decision that is sent to the LUC for approval.

2. **The desired use would not adversely affect surrounding property.**

The 620-acre project area is located in Kunia, Central Oahu, bounded by agricultural land to the north, south and east sides. The Honouliuli Forest Reserve is located to the west side. Kunia Loa Ridge Farmlands is located adjacent to Areas 4A and 4B. The Honouliuli National Historic Site Internment Camp is located nearby Area 5 to the south side. The nearest residential area is about 1.2 miles to the southeast.

Section 4.9 Views. The Petitioner has assessed visual impacts to the surrounding areas. The solar arrays would have a relatively low profile and would not be visible from surrounding locations. The panels would be most visible from Palawai Street. Landscaping would be installed along the fence line to provide screening.

The application also includes Attachment H, a Glare Study. The study indicates that there would be no impacts to airport operations from the solar panels. The State Department of Transportation should be contacted to provide comments on the project. The DOT may also require that a radiofrequency study be included. However, we note that the proposed site is about 10 miles from Kalaeloa Airport.

Sections 4.4 and 7.2.3. Potential Impacts and Mitigation Measures. Biological Resources. The project areas border and is close to the Oahu Elepaio critical habitat. Also, other endangered species such as the Hawaiian short-eared Pueo and the Hawaiian Hoary Bat may use the project sites for nesting and foraging. The application provides proposed mitigation measures on page 7-4 that should be included as conditions if the application is approved. The application also indicates that there were no federally or State-listed endangered, threatened, or candidate plant species identified in the project area. We note that other species may transit the site, such as various migratory seabirds. However, the document did not indicate migratory seabird species as a possible biological resource.

3. **The use would not unreasonably burden public agencies to provide streets, sewers, water, drainage, schools, fire, and police resources.**

According to the application, the proposed project would not require additional infrastructure support from public agencies for the proposed solar project. A Traffic Impact Study was provided, indicating little to no impacts. Stormwater runoff was assessed and would not have adverse impacts on drainage. The proposed project will incorporate multiple layers of fire prevention and suppression measures on the property such that it will not impact fire protection services.

4. **Unusual conditions, trends, and needs have arisen since the district boundaries and rules were established.**

   OP recognizes the State interest in encouraging renewable energy in appropriate locations around the State to promote energy self-sufficiency and reduce the State's dependence on fossil fuels. We note that the proposed solar project is within the State Agricultural District, however the proposal will be utilizing lands that are classified as B, C, D and E lands. Solar facilities are allowed via the Special Permit procedures under HRS § 205-4.5(a)(21) on lands classified as B rated lands under certain restrictions relating to the decommissioning of the solar project, and the use in conjunction with compatible agricultural uses at reduced rates. The application appears to meet these requirements.

5. **The land upon which the proposed use is sought is unsuited for the uses permitted within the district.**

   The land upon which the proposed use is sought is suitable for the uses permitted within the district. As noted above, the project would be located on approximately 620 acres of Class B, C, D and E lands, as rated by the LSB productivity rating system. The project site lands would be considered suitable for agricultural uses which allow solar energy facilities.

State Issues and Concerns

OP also offers the following comments on other matters of concern.

A. Pursuant to Hawaii Administrative Rules § 15-15-95(b), Special Permits for areas greater than 15 acres require approval of both the county planning commission and the LUC. Since the proposed project site is larger than 15 acres, the LUC must approve the project and can impose additional conditions of approval.

B. HRS § 205-4.5(a)(21) provides that:
   (A) The area occupied by the solar energy facilities is also made available for compatible agricultural activities at a lease rate that is at least fifty per cent below the fair market rent for comparable properties;
   (B) Proof of financial security to decommission the facility is provided to the satisfaction of the appropriate county planning commission prior to date of commencement of commercial generation; and
   (C) Solar energy facilities shall be decommissioned at the owner's expense according to the following requirements:

(i) Removal of all equipment related to the solar energy facility within twelve months of the conclusion of operation or useful life; and
(ii) Restoration of the disturbed earth to substantially the same physical condition as existed prior to the development of the solar energy facility.

Recommendation

Having reviewed the application relative to State interests and the applicable Special Permit guidelines, OP recommends approval of the State Special Permit to establish the Mahi Solar Project subject to appropriate conditions. OP concurs that the proposed project meets the Special Permit guidelines for an unusual and reasonable use within the State Agricultural Land Use District. The applicant has met the requirements for the issuance of a Special Permit for the proposed use, and appropriate conditions can be imposed to mitigate any adverse impacts from the proposed project. Accordingly, the following are OP's recommended conditions of approval:

1. The State Department of Land and Natural Resources shall be consulted regarding additional mitigation measures for State-recognized endangered, threatened, and candidate species. Any recommendations shall be incorporated in the development and operation of the solar project.

2. The recommendations of the Cultural Assessment relative to the Pohakea Trail, native plant resources, and archaeological resources shall be undertaken by the Applicant.

3. Approval of the Archaeological Inventory Survey from the State Historic Preservation Division shall be obtained prior to the Planning Commission decision. Any recommendations from the SHPD shall be included in such decision. Should SHPD approval of the AIS and recommended mitigation measures not be obtained prior to the Planning Commission's decision, the identified historic sites shall be preserved in place with an adequate buffer to avoid disturbance of the sites.

Thank you for the opportunity to review the Special Permit application. If you have any questions, please contact Lorene Maki of our Land Use Division at Lorene.k.maki@hawaii.gov

Mahalo,

Mary Alice Evans

Mary Alice Evans
Director

c: Land Use Commission
Department of Agriculture

POLICE DEPARTMENT

CITY AND COUNTY OF HONOLULU

801 SOUTH BERETANIA STREET · HONOLULU, HAWAII 96813
TELEPHONE: (808) 529-3111 · INTERNET: www.honolulupd.org

RICK BLANGIARDI
MAYOR

SUSAN BALLARD
CHIEF

JOHN D. McCARTHY
AARON TAKASAKI-YOUNG
DEPUTY CHIEFS

OUR REFERENCE EO-DC

April 21, 2021

MEMORANDUM

TO: Dean Uchida, Director
Department of Planning and Permitting

VIA: Raymond Young, Acting Branch Chief, Community Planning Branch

ATTENTION: Franz Kraintz, Planner VI

FROM: Darren Chun, Assistant Chief of Police, Support Services Bureau

SUBJECT: Special Use Permit Application No. 2020/SUP-7
Mahi Solar Project
Tax Map Keys 9-2-001: 020 portion, 9-2-004: 003 portion, 9-2-004: 006 portion, 9-2-004: 010 portion, and 9-2-004: 012 portion

Thank you for the opportunity to review the subject application request for the proposed establishment of a 120-megawatt photo-voltaic energy generation system and accessory 480-megawatt-hour battery storage system, and ancillary support facilities.

The Honolulu Police Department (HPD) recommends that all necessary signs, lights, barricades, and other safety equipment be installed and maintained by the contractor during the construction phase of the project. The impact of the ingress/egress of construction vehicles, equipment, and deliveries should be evaluated to ensure the traffic flow is not adversely affected.

The HPD recommends that the contractor address potential security issues with regards to the equipment and machinery to be used to construct the project, as well as the location of the solar modules and battery storage to be kept on site when the project is completed.

If there are any questions, please call Major Gail Beckley of District 8 (Kapolei, Waianae) at 723-8400.

Darren Chun
Assistant Chief of Police
Support Services Bureau

HONOLULU FIRE DEPARTMENT

CITY AND COUNTY OF HONOLULU

636 South Street
Honolulu, Hawaii 96813-5007
Phone: 808-723-7139 Fax: 808-723-7111 Internet: www.honolulu.gov/hfd

RICK BLANGIARDI
MAYOR

LIONEL CAMARA JR.
ACTING FIRE CHIEF

SHELDON K. HAO
ACTING DEPUTY FIRE CHIEF

April 26, 2021

TO: DEAN UCHIDA, DIRECTOR
DEPARTMENT OF PLANNING AND PERMITTING

ATTN: RAYMOND YOUNG, ACTING BRANCH CHIEF
COMMUNITY PLANNING BRANCH

FROM: LIONEL CAMARA JR., ACTING FIRE CHIEF

SUBJECT: SPECIAL USE PERMIT APPLICATION NO. 2020/SUP-7
MAHI SOLAR PROJECT
TAX MAP KEYS: 9-2-001: 020 PORTION; 9-2-004: 003 PORTION; 9-2-004: 006 PORTION; 9-2-004: 010 PORTION; AND 9-2-004: 012 PORTION
HONOULIULI, EWA, OAHU

In response to a memorandum from Mr. Raymond Young dated April 9, 2021, regarding the abovementioned subject, the Honolulu Fire Department (HFD) requires that the following be complied with:

1. Fire department access roads shall be provided such that any portion of the facility or any portion of an exterior wall of the first story of the building is located not more than 150 feet (46 meters) from fire department access roads as measured by an approved route around the exterior of the building or facility. (National Fire Protection Association [NFPA] 1; 2012 Edition, Section 18.2.3.2.2.)

   A fire department access road shall extend to within 50 feet (15 meters) of at least one exterior door that can be opened from the outside and that provides access to the interior of the building. (NFPA 1; 2012 Edition, Section 18.2.3.2.1.)

2. A water supply approved by the county, capable of supplying the required fire flow for fire protection, shall be provided to all premises

upon which facilities or buildings, or portions thereof, are hereafter constructed, or moved into or within the county. When any portion of the facility or building is in excess of 150 feet (45,720 millimeters) from a water supply on a fire apparatus access road, as measured by an approved route around the exterior of the facility or building, on-site fire hydrants and mains capable of supplying the required fire flow shall be provided when required by the AHJ [Authority Having Jurisdiction]. (NFPA 1; 2012 Edition, Section 18.3.1, as amended.)

3. The unobstructed width and unobstructed vertical clearance of a fire apparatus access road shall meet county requirements. (NFPA 1; 2012 Edition, Sections 18.2.3.4.1.1 and 18.2.3.4.1.2, as amended.)

4. Adherence to applicable requirements for stationary storage battery systems. (NFPA 1; 2012 Edition, Chapter 52)

5. Submit civil drawings to the HFD for review and approval.

Should you have questions, please contact Assistant Chief Socrates Bratakos of our Planning and Development division at 723-7106 or sbratakos@honolulu.gov.

LIONEL CAMARA JR.
Acting Fire Chief

LCJ/MI:jl

HONOLULU EMERGENCY SERVICES DEPARTMENT
CITY AND COUNTY OF HONOLULU
3375 KOAPAKA STREET, SUITE H-450 • HONOLULU, HAWAII 96819-1814
Phone: (808) 723-7800 • Fax: (808) 723-7836

RICK BLANGIARDI
MAYOR

JAMES H.E. IRELAND, MD
DIRECTOR DESIGNATE

IAN T.T. SANTEE, MPA
DEPUTY DIRECTOR

April 23, 2021

MEMORANDUM

TO: Raymond Young, Acting Branch Chief
Department of Planning and Permitting

FROM: James H.E. Ireland, MD, Director Designate
Honolulu Emergency Services Department

SUBEJCT: Special Use Permit – Mahi Solar Project

This is in response to your memorandum dated April 9, 2021. The Honolulu Emergency Services Department (HESD), submits the following comments:

Our Emergency Medical Services (EMS) and Ocean Safety (OS) Divisions find no objections or hindrances presented by this project. However, HESD requests receiving updated site-safety plans to keep our responders apprised of any specific concerns, any anticipated inference with one or both Division's radio/communications and if possible, a walk-through near or upon completion of construction for response pre-planning purposes.

Should you have any questions, please contact me at 723-7800 or james.ireland@honolulu.gov.

Thank you for the opportunity to input on this Special Use Permit application.

cc: Christopher Sloman, TA EMS Chief, EMS
John Titchen, Chief, Ocean Safety

DEPARTMENT OF DESIGN AND CONSTRUCTION
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 11TH FLOOR
HONOLULU, HAWAII 96813
Phone: (808) 768-8480 • Fax: (808) 768-4567
Web site: www.honolulu.gov

RICK BLANGIARDI
MAYOR

ALEX KOZLOV, P.E.
DIRECTOR

HAKU MILLES, P.E.
DEPUTY DIRECTOR

April 30, 2021

MEMORANDUM

TO: Raymond Young, Acting Branch Chief
Community Planning Branch

FROM: for Alex Kozlov, P.E., Director
Department of Design and Construction

SUBJECT: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
TMK 9-2-001; 020 portion, 9-2-004; 003 portion,
9-2-004: 006 portion, 9-2-004: 010 portion, and 9-2-004: 012 portion,
Honouliuli, Ewa, Oahu

Thank you for the opportunity to review and comment. The Department of Design and Construction does not have comments to offer at this time.

Should there be any questions, please contact Alex Kozlov at x88480.

AK:krn (848511)

DEPARTMENT OF ENVIRONMENTAL SERVICES
CITY AND COUNTY OF HONOLULU
1000 ULUOHIA STREET, SUITE 308, KAPOLEI, HAWAII 96707
TELEPHONE: (808) 768-3486 ● FAX: (808) 768-3487 ● WEBSITE: http://envhonolulu.org

RICK BLANGIARDI
MAYOR

WESLEY T. YOKOYAMA, P.E.
DIRECTOR

MICHAEL O'KEEFE
DEPUTY DIRECTOR

ROSS S. TANIMOTO, P.E.
DEPUTY DIRECTOR

IN REPLY REFER TO:
PRO 21-036

April 21, 2021

MEMORANDUM

TO: Dean Uchida, Director
Department of Planning and Permitting

ATTN: Raymond Young, Acting Branch Chief
Community Planning Branch

FROM: Wesley T. Yokoyama, P.E.
Director

SUBJECT: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Tax Map Keys 9-2-001: 020 portion, 9-2-004: 003 portion,
9-2-004: 006 portion, 9-2-004: 010 portion, and 9-2-004: 012 portion,
Honouliuli, Ewa, Oahu

We have reviewed the subject SUP application as transmitted to us by your memo dated April 9, 2021, reference no. 2020/SUP-7 (fk). We have no comments, and no objections to the proposed project.

Should you have any questions, please call Marisol Olaes, Civil Engineer, at 768-3467.

DEPARTMENT OF FACILITY MAINTENANCE

CITY AND COUNTY OF HONOLULU

1000 Ulu`ohia Street, Suite 215, Kapolei, Hawaii 96707
Phone: (808) 768-3343 • Fax: (808) 768-3381
Website: www.honolulu.gov

RICK BLANGIARDI
MAYOR

ROGER BABCOCK, JR., Ph.D., P.E.
DIRECTOR AND CHIEF ENGINEER

TYLER K. SUGIHARA, P.E.
ACTING DEPUTY DIRECTOR

IN REPLY REFER TO:
DRM 21-231

April 27, 2021

MEMORANDUM

TO: Dean Uchida, Director
Department of Planning and Permitting

ATTENTION: Frank Kraintz

FROM: Roger Babcock, Jr., Ph.D., P.E.
Director and Chief Engineer
Department of Facility Maintenance

SUBJECT: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Tax Map Keys 9-2-001:020 portion, 9-2-004:003 portion,
9-2-004:006 portion, 9-2-004:010 portion, and 9-2-004:012 portion,
Honouliuli

Thank you for the opportunity to review and comment on the subject project.

We have no comments at this time, as we do not have any facilities or easements on the subject property.

If you have any questions, please call Mr. Kyle Oyasato of the Division of Road Maintenance at 768-3697.

DEPARTMENT OF PARKS & RECREATION

CITY AND COUNTY OF HONOLULU

1000 Uluohia Street, Suite 309, Kapolei, Hawaii 96707
Phone: (808) 768-3003 • Fax: (808) 768-3053
Website: www.honolulu.gov

RICK BLANGIARDI
MAYOR

LAURA H. THIELEN
DIRECTOR

April 19, 2021

MEMORANDUM

TO: Dean Uchida, Director
Department of Planning and Permitting

FROM: Laura H. Thielen
Director

SUBJECT: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Tax Map Keys 9-2-001:020 portion, 9-2-004: 003 portion,
9-2-004:006 portion, 9-2-004:010 portion and 9-2-004:012 portion,
Honouliuli, Ewa, Oahu

Thank you for the opportunity to review and comment on the subject Special Use Permit for a 120-megawatt photo-voltaic energy generating system and accessory 480-megawatt-hour battery storage system and ancillary support facilities.

The Department of Parks and Recreation has no comment. As the proposed project will not impact any program or facility of the Department, you may remove us as a consulted party to the balance of the EIS process.

Should you have any questions, please contact Mr. John Reid, Planner, at 768-3017.

Sincerely,

Laura H. Thielen
Director

LHT:jr
(848514)

DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU
650 SOUTH KING STREET, 3RD FLOOR
HONOLULU, HAWAII 96813
Phone: (808) 768-8305 • Fax: (808) 768-4730 • web: www.honolulu.gov

RICK BLANGIARDI
MAYOR

J. ROGER MORTON
DIRECTOR

JON Y. NOUCHI
DEPUTY DIRECTOR

TP4/21-848519

May 10, 2021

MEMORANDUM

TO: Raymond Young, Acting Branch Chief – Community Planning Branch
Department of Planning and Permitting

FROM: J. Roger Morton, Director
Department of Transportation Services

SUBJECT: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Tax Map Keys 9-2-001: 020 portion, 9-2-004: 003 portion, 9-2-004: 006 portion, 9-2-004: 010 portion, and 9-2-004: 012 portion,
Honouliuli, Ewa, Oahu

Thank you for the opportunity to provide written comments on file number 2020/SUP-7. We have the following comments.

1. **Traffic Management Plan**. Construction materials and equipment should be transferred to and from the project site during off-peak traffic hours (8:30 a.m. to 3:30 p.m.) to minimize any possible disruption to traffic on the local streets.

2. **Shoulder Bikeway**. The 2019 Oahu Bike Plan proposes a shoulder bikeway on Kunia Road from Wilikina Drive to Farrington Highway as a Priority 1 Project. Contact Department of Transportation Services, Traffic Engineering Division at (808) 768-8335 or csayers@honolulu.gov to coordinate.

3. **Neighborhood Impacts**. The area representatives, neighborhood board, as well as the area residents, businesses, emergency personnel (fire, ambulance, and police), Oahu Transit Services, Inc. (TheBus and TheHandi-Van), etc., should be kept apprised of the details and status throughout the

project and the impacts that the project may have on the adjoining local street area network.

4. **Disability and Communication Access Board (DCAB)**. Project plans (vehicular and pedestrian circulation, sidewalks, parking and pedestrian pathways, vehicular ingress/egress, etc.) should be reviewed and approved by DCAB to ensure full compliance with Americans with Disabilities Act requirements.

Should you have any questions, please contact Greg Tsugawa, of my staff, at 768-6683.

Kraintz, Franz

From: Winter, Frank J II CIV (USA) <Frank.J.Winter@usace.army.mil>
Sent: Thursday, May 13, 2021 9:56 AM
To: Kraintz, Franz
Subject: RE: Special Use Permit - Mahi Solar Project Ewa Oahu

Aloha Mr. Kraintz,

Thank you for reaching out to the Corps in regards to the Mahi Solar Project Ewa, Oahu. The Honolulu District, U.S. Army Corps of Engineers (Corps), Regulatory Branch has received your request for comments on May 10, 2021 for a Department of the Army (DA) scoping comments. Your request has been assigned DA file number POH-2021-00093. Please reference this number in all future correspondence with our office relating to this action.

To determine if a DA permit is required for a proposed action, the Corps must first determine whether the proposed project is located within the Corps' geographic jurisdiction (i.e., whether the activity is located within a water of the U.S.). If the activity is within a water of the U.S., the Corps must then determine whether the proposed project is a regulated activity under Section 10 and/or Section 404 or if the activity is exempt. The determination provided in this letter pertains only to the question of geographic jurisdiction.

Based on our review of the information you provided we are not able to determine if the project area contains waters of the U.S., and/or wetlands, under the Corps' regulatory jurisdiction. I'm providing the following information in regards to the Regulatory program.

DA authorization is required if you propose to place dredged and/or fill material into waters of the U.S., including wetlands and/or perform work in navigable waters of the U.S.

Section 404 of the Clean Water Act requires that a DA permit be obtained for the placement or discharge of dredged and/or fill material into waters of the U.S., including jurisdictional wetlands (33 U.S.C. 1344). The Corps defines wetlands as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Section 10 of the Rivers and Harbors Act of 1899 requires that a DA permit be obtained for structures or work in or affecting navigable waters of the U.S. (33 U.S.C. 403). Section 10 waters are those waters subject to the ebb and flow of the tide shoreward to the mean high water mark, and/or other waters identified by the Honolulu District.

Based on the information provided, it would appear that there is a high probability that portions of the land being used would have waters of the US present on the site. As you are preparing the EA, it would be prudent to include a delineation of waters of the US for the Corps review. The Corps is requesting that all requests be submitted electronically to our general inbox (CEPOH-RO@usace.army.mil) which is monitored daily. If you have any questions or would like to discuss further please contact me via email at Frank.J.Winter@usace.army.mil, by phone at (808) 835-4107 if you have questions. I appreciate your cooperation with the Corps' Regulatory Program.

Thank you,

Frank J. Winter
Biologist, Regulatory Branch
Honolulu District
U.S. Army Corps of Engineers
Building 230
Fort Shafter, Hawaii 96858-5440
808-835-4107
Frank.J.Winter@usace.army.mil

-----Original Message-----
From: Kraintz, Franz <fkraintz@honolulu.gov>
Sent: Wednesday, May 12, 2021 9:37 AM
To: Speerstra, Linda CIV USARMY CEPOH (USA) <Linda.Speerstra@usace.army.mil>; Winter, Frank J II CIV (USA) <Frank.J.Winter@usace.army.mil>
Cc: CEPOH-RO, POH <CEPOH-RO@usace.army.mil>; Hipolito, Ailene <ailene.hipolito@honolulu.gov>
Subject: [Non-DoD Source] RE: Special Use Permit - Mahi Solar Project Ewa Oahu

Good morning

Just wondering if there might be a chance we will be getting comments from the USACE on the above-referenced project today or tomorrow? We are trying to close out our draft report and would like to include as many comments as possible. If they cannot be submitted by today or tomorrow, please send in and we will make sure that your comments reach the Planning Commission for their public hearing on June 23.

Mahalo.

Franz Kraintz, AICP
Urban Planner
Community Planning Branch
Planning Division
Department of Planning and Permitting
City and County of Honolulu
650 S. King Street, 7th Floor
Honolulu, Hawaii 96813
(808) 768-8046
fkraintz@honolulu.gov
Blockedwww.honoluludpp.org

-----Original Message-----
From: Kraintz, Franz
Sent: Tuesday, May 04, 2021 10:31 AM
To: 'Speerstra, Linda CIV USARMY CEPOH (USA)' <Linda.Speerstra@usace.army.mil>; Winter, Frank J II CIV (USA) <Frank.J.Winter@usace.army.mil>
Cc: CEPOH-RO, POH <CEPOH-RO@usace.army.mil>; Hipolito, Ailene <ailene.hipolito@honolulu.gov>
Subject: RE: Special Use Permit - Mahi Solar Project Ewa Oahu

Aloha Linda

E-mailed to RYoung, cc'd FKua
@ 5:45pm on 5/10/21

HISTORIC HAWAI'I FOUNDATION

680 Iwilei Road Suite 690, Honolulu HI 96817 • (808) 523-2900 • preservation@historichawaii.org • www.historichawaii.org

May 10, 2021

Raymond Young, Acting Branch Chief
Community Planning Branch
Department of Planning and Permitting
City and County of Honolulu
650 South King Street, Seventh Floor
Honolulu, Hawaii 96813

Re: Special Use Permit (SUP) Application No. 2020/SUP-7
Mahi Solar Project
Honouliuli, 'Ewa, Island of O'ahu
TMKs: (1) 9-2-01:020 portion, 9-2-004:003 portion, 9-2-004:006 portion, 9-2-004:010 portion, 9-2-004:012 portion

Dear Mr. Young:

Historic Hawai'i Foundation received notice and request for comments from the Department of Planning and Permitting, City & County of Honolulu on a Special Use Permit (SUP) for the proposed photo-voltaic energy gereration system, accessory battery storage system, and ancillary support facilities. Thank you for the opportunity to comment.

Interests of Historic Hawai'i Foundation

Historic Hawai'i Foundation (HHF) is a statewide nonprofit organization established in 1974 to encourage the preservation of sites, buildings, structures, objects and districts that are significant to the history of Hawai'i. HHF is providing these comments as an organization that is concerned with the effect of the project on historic properties.

Project Summary

The Mahi Solar project is a 120-megawatt alternating current solar and energy storage facility located in Kunia, O'ahu. The site will be developed in five areas identified as Areas 1, 2A/2B/2C, 3, 4A/4B/4C, and 5, across portions of five TMK parcels. The total project area is approximately 620 acres, while the project parcels total approximately 2,952.3 acres.

The project will be interconnected to HECO's Kahe-Waiʻau 138 kV transmission circuit located west of Kunia Road. The medium voltage collection system will transmit generation from the solar array inverters to the BESS and substation along overhead lines to be installed as part of the project.

Project Context

The SUP Application notes that "the Kunia lands are some of the best agricultural sites in Hawaiʻi with deep soil, excellent sunlight and available water. As such, it is vital that agricultural operations be included as an important part of the solar project providing both energy and food products." Specifically, Area 5 and part of Area 1 are categorized as "Important Agricultural Lands."

Numerous historic properties and features are located in the project area, with a cluster of sites and objects in Area 5 (SIHP 50-80-12-7346). The Waiāhole Ditch system (SIHP 50-80-09-2268), which is exceptionally significant, also has numerous contributing features in the project area.

Summary of HHF Comments and Concerns

Historic Hawaiʻi Foundation does not have significant concerns with the PV development in Areas 1-4 (except for the portion designated as Important Agricultural Lands) subject to review and conditions as determined in consultation with the State Historic Preservation Division of the Department of Land and Natural Resources.

However, HHF is very concerned with the proposed industrial development in Area 5 and recommends that this portion of the proposed project be eliminated from the development.

HHF's concerns include:

1. The majority of the historic sites identified and described in the Archaeological Inventory Survey lie within Area 5 (SUP Appendix F, Figure 39 on page 67). It would be prudent to avoid that area if at all possible. Otherwise, a detailed preservation plan to avoid specific features and to mitigate for the effect overall will be needed.
2. The southern boundary of Area 5 is adjacent to the Honouliuli National Historic Site, which is listed on the National Register of Historic Places and is a unit of the National Park system. The areas adjacent and surrounding this historic property need to be treated with extreme sensitivity and care to avoid adverse effects to the setting, location and feeling of the site. With the National Park Service currently engaging in long-range planning with the intent to open the historic park in the coming years, the City and adjacent landowners should avoid inflicting any significant impacts or irreversible development that could irreparably harm this national historic resource.
3. Area 5, and a portion of Area 1, are designated as Important Agricultural Lands and should be available for high level agricultural use. In addition to the importance for food production, the rural and agricultural context of this area is also part of its historic character. While some level of new development is expected, Important Agricultural Lands are inappropriate locations for intense energy or industrial development. A more harmonious use that is compatible with the rural and agricultural history of the area would be more appropriate.

Historic Property Mitigation Commitments

The SUP application outlines proposed mitigation commitments to address effects to the historic properties. HHF recommends additional mitigation, which should enhance and continue documentation of the Waiāhole Ditch System that has been required for other projects (including PV development) for parcels that affected other segments of the historic irrigation system. For example, the features should be added to the Historic American Engineering Report (HAER) and an update or amendment to the "Waiāhole Ditch Context Study" (Mason Architects, 2018) may be needed.

If the existing documentation is deemed complete and sufficient, then additional mitigation would be appropriate. For example, public history and educational materials could be developed using the source materials from the technical studies.

Thank you for the opportunity to comment. Please let me know if you have any questions or would like to discuss these recommendations.

Very truly yours,

Kiersten Faulkner

Kiersten Faulkner, AICP
Executive Director

Copies via email:

Hawai'i State Historic Preservation Division

- Susan Lebo [Susan.A.Lebo@hawaii.gov]
- Stephanie Hacker [stephanie.hacker@hawaii.gov]
- Julia Flauaus [julia.flauaus@hawaii.gov]

2021/ELOG-761

2021 APR 22 AM 7:58

DEPT OF PLANNING AND PERMITTING
CITY & COUNTY OF HONOLULU

The Senate

STATE CAPITOL
HONOLULU, HAWAI'I 96813

April 20, 2021

Dean Uchida, Director
Department of Planning and Permitting
650 S. King Street, 7th Floor
Honolulu, HI 96813

Aloha Mr. Dean Uchida,

I am writing in STRONG OPPOSITION of the Mahi Solar Project for the following Tax Map Keys 9-2-001:020 portion, 9-2-004:003 portion, 9-2-004:006 portion, 9-2-004:010 portion, and 9-2-004:012 portion, Honouliuli, Ewa, Oahu. The project will establish a 120-megawatt photo-voltaic energy system and 480-megawatt hour battery storage. I am in opposition of this project because there were no community public discussion or transparency about this development. There is a disadvantage use of battery storage which is a very high concern because it can cause Fire and Smoke Hazard. In 2012, at the Kahuku First Wind Project there was a battery fire that occurred, spewing toxic lead smoke into the air for three days as the First Wind battery warehouse burned to the ground. The battery storage also contains acid and lead that can leak and contaminate the ground. I am also concerned with more agricultural lands being taken out of farming and sustainability to accommodate more solar farm projects. The renewable energy process is flawed, and we need to inform the community of all effects these projects will have on the danger, health, safety, and welfare that it will impose on the public and community.

I hope that you take this letter as a serious concern because we should be notifying the community of any future developments that will affect the health and safety of those surrounding the project area. Should you have any further questions please contact my office by email reply or by phone at (808) 586-6360.

Sincerely,

Kurt Fevella

Senator Kurt Fevella
State of Hawaii, District 19
Minority Leader/ Minority Floor Leader

State Capitol, Room 217
415 S. Beretania Street,
Honolulu, HI 96813
Phone: (808) 586-6360
Fax: (808) 586-6361
senfevella@capitol.hawaii.gov

Hawaii Agriculture Research Center

P.O. Box 100, Kunia, HI 96759
Ph: 808-621-1350
www.harc-hspa.com

Comments regarding SUP application No. 2020/SUP-7
Mahi Solar Project

PER 6/16
EMAIL

Dear Commissioner Jonathan Likeke Scheuer, Chair
Commissioner Edmund Aczon, Vice Chair
Commissioner Nancy Cabral, Vice Chair
and other State of Hawaii Land Use Commissioners:

I am the Executive Director of the Hawaii Agriculture Research Center, Stephanie Whalen. I am currently out of the state but have asked Dora Nakafiji to read my comments. She brings the same passion for agriculture with a ton of energy experience in addition. She will be able to address any questions you may have regarding my comments on the subject of this meeting.

I want to start by saying how pleased the Hawaii Agriculture Research Center is to be a part of a solution orientated process. For too long agriculture and other sectors are pitted against one another in loud, noisy conflicting issues without mutual beneficial resolutions considered.

Agrivoltaics was conceived in the early 1980s. The pioneering scientists, A.Goetzberger and A. Zastrow recognized that both agriculture systems and solar arrays harvest energy from the sun. They reasoned that there would be benefits to both systems using the same land. Since then, many studies have validated their assumptions. This permit is about the solar sector and the agricultural sector working together to transfer this technology to Hawaii and help its 2 goals of food and energy self-sufficiency. While the state has classified about 2 million acres as agricultural land; it is clear that the best lands for food production are the same for power production: both use the power of the sun. To date the history of this dual use in Hawaii has produced nothing but controversy. For the first time here is an opportunity to move beyond conflict to a solution benefiting both sectors. But as with any challenging situation the resolution is in the details.

No doubt historically in these permit processes many promises are made only later to be broken often without recourse. I believe there is still a strong bias by all concerned to feel this is no different. To help alleviate that understandable reluctance it is HARC's goal to find additional funding both from the private and public sectors. It is committed to solutions to ensure its Agrivoltaic Research and Development Center will continue finding crops that are both efficient and economical under, beside and between the various PV panel types that exist now and in the future in Hawaii. It has reached out to the University of Hawaii to collaborate in this effort; it is applying to HEI for contributing funds and to the national energy and agricultural research funding sources; all to ensure the expansion and continuation of the program already initiated by Mahi Solar.

I do want to be clear here as folks often equate the word research to projects that do not produce near term results. This collaboration is about technology transfer not basic research. Technology transfer

has been the culture of HARC, formerly the Hawaii Sugar Planters' Association, the research arm of the sugar industry. Its effectiveness for the industry speaks for itself. It helped keep a commodity product (high volume/low margin), sugar, situated 2500 miles from its nearest market and competing against over 140 lower cost countries in business for over 100 years. The key was technology transfer. Comb the globe for the latest and most efficient ideas and bring them to Hawaii to modify to its unique situations. The best example of that was drip irrigation for water use efficiency. An industry team went to Israel where this technology was being developed and brought it to the Hawaiian sugar industry. It is now the standard irrigation practice here for field crops. It was Hawaii's agricultural first huge step for water conservation. Agrivoltaics will be another step for water conservation in conjunction with solar panels. This is just one of the benefits agricultures will realize in this partnership. Both industries have proven benefits to realize with agrivoltaics.

Addressing the permit conditions:
A recent publication by A.S. Pascaris, C Schelly and J.M. Pearce, A First Investigation of Agriculture Sector Perspectives on the Opportunities and Barriers for Agrivoltaics (attached) concluded that there are some critical barriers to the use of this technology which can be addressed. The most important ones identified by farmers either actively using this technology or seriously considering it are long term land productivity, market potential, just compensation and system flexibility. These are important considerations when agreements/contracts are developed between the landowner, solar company, farmer, and regulatory agency. None are insurmountable but all necessarily need to be considered for this technology to transfer.

Defining the irrigation as specific to drip will reduce flexibility in the infrastructure design; do you really want to limit it?

Any agricultural plan needs to be flexible as crops and markets change throughout the years.
Rigid planning for decades is difficult to say the least.

Be mindful that some farmers will want to keep their production data confidential. Depending on number of farms; number of different crops, import or export all these factors can be important to a specific farm operation and how closely it wants to hold its data. Many small specialty crop farmers value their uniqueness for marketing purposes.

Trends may be more useful to determine if activities are increasing. It will be difficult to get 600+ acres into active agricultural production in a short time frame. I estimate 2 to 5 years. Which is really a guess. If you look at Hawaii in general over the past few years, the process has been slow and painful. The advantages of this proposal are affordable land, water and infrastructure and demonstrated crop production success. HARC's plan is to start with sheep and bees onto some of the poor crop areas that are sloped and rocky. That should be the easiest to move forward on as there is significant literature available for these and some sheep already are being used by other solar companies. The horticulture crops will depend on the work HARC is starting now and what it is able to do in the years leading up to and through construction completion. As I mentioned before it is collaborating with the University of Hawaii, is seeking additional funds to be able to put more effort into this area and demonstrate more crops. Some crop information is available in the literature but much of it is with different solar arrays and different environmental conditions.

In conclusion, this is a promising new approach to a tiring parade of controversies regarding the sustainability of agriculture and energy in Hawaii.

agronomy

MDPI

Article

A First Investigation of Agriculture Sector Perspectives on the Opportunities and Barriers for Agrivoltaics

Alexis S. Pascaris [1,*], Chelsea Schelly [1] and Joshua M. Pearce [2,3,4]

1 Department of Social Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, USA; cschelly@mtu.edu
2 Department of Materials Science and Engineering, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, USA; pearce@mtu.edu
3 Department of Electrical & Computer Engineering, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, USA
4 School of Electrical Engineering, Aalto University, Aalto, 02150 Espoo, Finland
* Correspondence: aspascar@mtu.edu; Tel.: 906-487-2113

Received: 21 October 2020; Accepted: 24 November 2020; Published: 28 November 2020

Abstract: Agrivoltaic systems are a strategic and innovative approach to combine solar photovoltaic (PV)-based renewable energy generation with agricultural production. Recognizing the fundamental importance of farmer adoption in the successful diffusion of the agrivoltaic innovation, this study investigates agriculture sector experts' perceptions on the opportunities and barriers to dual land-use systems. Using in-depth, semistructured interviews, this study conducts a first study to identify challenges to farmer adoption of agrivoltaics and address them by responding to societal concerns. Results indicate that participants see potential benefits for themselves in combined solar and agriculture technology. The identified barriers to adoption of agrivoltaics, however, include: (i) desired certainty of long-term land productivity, (ii) market potential, (iii) just compensation and (iv) a need for predesigned system flexibility to accommodate different scales, types of operations, and changing farming practices. The identified concerns in this study can be used to refine the technology to increase adoption among farmers and to translate the potential of agrivoltaics to address the competition for land between solar PV and agriculture into changes in solar siting, farming practice, and land-use decision-making.

Keywords: agrivoltaics; solar energy; agriculture; energy innovation; technology adoption; photovoltaics

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) Carbon and Other Biogeochemical Cycles report [1] reveals the predominant sources of anthropogenic greenhouse gas (GHG) emissions are the use of fossil fuels as sources of energy and land use changes, particularly agriculture. Agrivoltaics, the strategic codevelopment of land for both solar photovoltaic (PV) energy production and agriculture, can meet growing demands for energy and food simultaneously while reducing fossil fuel consumption [2–4]. Integrated energy and food systems have the potential to increase global land productivity by 35–73% [2] and to minimize agricultural displacement for energy production [5–7]. Agrivoltaic systems are a strategic and innovative approach to combine renewable energy with agricultural production, effectively addressing the predominant sources of anthropogenic GHG emissions as identified by the IPCC.

The viability of emerging agrivoltaic innovation has been investigated in various contexts. In conjunction with solar PV, there are emu farms in Australia [8] as well as sheep grazing [6,9,10] and pollinator-friendly sites proliferating in the U.S. (e.g., [11]). There is also the potential to use agrivoltaics with rabbits [12] and aquaponics (aquavoltaics) [13]. Experimental agrivoltaic research is

occurring in diverse locations and climates. Examples include cultivation of corn and maize [14,15], lettuce [16,17], aloe vera [18], grapes [19], and wheat [20]. Mow [6] describes agrivoltaics as low-impact solar development that can alleviate agricultural displacement and assume varied designs: a solar-centric design that prioritizes solar output while growing low-lying vegetation; a vegetation-centric design that prioritizes crop production but incorporates solar panels and a colocation design that integrates both solar and agriculture for equal maximum dual output. Colocation designs have produced an estimated 3–8% per watt reduction in overall installation cost during site preparation due to cost reductions in land clearing and grubbing, soil stripping and compaction, grading and foundation for vertical supports, when compared to conventional solar industry development practices [6]. Further, Mavani et al. [4] found over a 30% increase in economic value for farms deploying such systems. Previous studies demonstrated that the dual-use of land for both PV and agriculture generates a mutually beneficial partnership that provides unique market opportunities to farmers and reduced operation and maintenance fees to solar developers, particularly in the case of grazing livestock [3,6,21–23].

The growing land footprint of solar PV presents social and spatial challenges, which are exacerbating the competition for land between agriculture versus energy production [5,23–25]. The U.S. Department of Energy Sunshot Vision Study forecasts that solar energy capacity will be nearly 329GW by 2030, which will necessitate approximately 1.8 million acres of land for ground-mounted systems [26]. Guerin [23] posits that the colocation of energy and agriculture will be stunted if there is absence of support from farmers and rural landowners, as the potential of agrivoltaic systems to address land-use competition will be contingent on farmer acceptance of agrivoltaics as a sociotechnological innovation. Brudermann et al. [27] found that PV adoption by farmers is primarily driven by environmental and economic considerations, which suggests factors that will be critical in agriculture sector decision-making concerning agrivoltaics.

Diffusion is a spatial and temporal phenomenon by which an innovation disseminates amongst adopters through a gradual process of filtering, tailoring and acceptance [28–30]. Rogers' [28] diffusion of innovations theory explains how and why some technological innovations are widely accepted while some are not, specifically referring to the adoption of an innovation by farmers over time in a rural diffusion model. The diffusion of innovations theory has been used to study diffusion of an innovation among physicians [31], among industrialized firms [32] and in terms of policy diffusion [33], among many other applications. Wilson & Grübler [34] applied the theory distinctly to energy innovations and described four phases of diffusion in which agrivoltaics can be categorized as existing in the first stage of an extended period of experimentation, learning, diversity of designs and small unit and industry-scale technologies. Grübler [30] warns that the existence of an innovation in itself does not promise proper diffusion, and while innovations have the capacity to induce change, it is the process of diffusion that realizes this potential as changes in social practice. By applying the diffusion of i theory to the agrivoltaic innovation, this study seeks to offer insight into potential refinements to the innovation of agrivoltaics in terms of its social acceptance to enable continued diffusion. This study uses Rogers' theory [28] as a practical framework for informing the diffusion of agrivoltaic innovation to discern the future potential and challenges for this technology to diffuse sufficiently to address energy and agricultural demands sustainably. While the technical viability of colocating solar PV and agriculture has been demonstrated [2,3,16,17], research in this field is incomplete with regard to placing the innovation within a social context to determine barriers to diffusion as perceived by industry experts.

Recognizing the fundamental importance of farmer adoption in the successful diffusion of agrivoltaics, this study investigates agriculture sector experts' perceptions on the opportunities and barriers to dual land-use agrivoltaic systems. Using in-depth, semistructured interviews, this study seeks to further the potential of agrivoltaics by identifying challenges to farmer adoption in an effort to address them by responding to societal concerns. In the following sections, the results are discussed, and conclusions are drawn on barriers to be overcome for agrivoltaic diffusion as identified by industry experts. The organization of the results and discussion are based on concepts from the diffusion of innovations theory [28], with a focus on relevant innovation characteristics (observability, relative

advantage and compatibility), stages of the adoption process and categories of adopters. Finally, the implications of these findings for the future development of agrivoltaics and farmer adoption are considered.

2. Materials and Methods

This study investigates agriculture sector experts' perceptions of the opportunities and barriers to agrivoltaics using in-depth, semistructured interviews. Interview methodology is exploratory by nature and, most appropriately, collects and analyzes data about perceptions, opinions and attitudes of people [35]. Aimed at providing an inclusive and nuanced perspective of the phenomenon under study, interviews were employed to directly engage relevant informants related to agriculture and agrivoltaics.

Prior to commencement, this research obtained approval from Michigan Technological University's Institutional Human Subjects Review Board (code: 1524021-1) to ensure compliance with institutional ethics in human subjects research. The initial interview protocol can be found in Appendix A. Email was used to introduce the agrivoltaic concept and the study while inviting prospective participants to video conferencing discussions, which resulted in 10 online interviews lasting between 30 to 90 min. All participants provided informed consent for the recording of conversations, which were anonymized for the protection of their privacy. Data collection occurred between February and July 2020 until saturation was attained, known as the point when no new additional insight is derived from conversations with participants and stabilization of data patterns occur [36,37].

A total of 10 interviews were conducted with 11 agriculture sector professionals (one interview engaged two individuals simultaneously), including livestock and crop farmers, solar grazers (individuals who graze their livestock underneath solar panels) and an agriculture policy expert. Sampling for logical representativeness, variance, diversity, and relevance to agriculture, participants were pursued based on their potential to provide insight into the opportunities and barriers to agrivoltaics because they have direct experience in the agricultural sector. Both theoretical and snowball sampling methods are nonprobability techniques that were employed to construct a sample capable of representing a wide range of perceptions. Theoretical sampling intentionally captures individuals with certain characteristics [38,39], whereas snowball sampling progressively follows a chain of referrals from study participants to other potential contributors [40,41]. Table 1 details the sample of participants that was generated using these sampling methods, ranging in profession, geographic location and gender. While credible and valuable, samples constructed through nonprobability sampling do not lend themselves to generalization [42], nor are the findings generated through interview methodology suitable for statistical generalization or analysis. However, all of the themes discussed as findings were raised by the majority of participants and identify the primary opportunities and barriers to agrivoltaics according to this sample but cannot be quantified or suggested to represent a broader population. Therefore, the findings are not discussed quantitatively to steer clear from suggesting these results are statistically generalizable to the entire agriculture sector.

Table 1. Interview Participant Characteristics.

Profession	Geographic Region (United States)	Gender
Livestock farmer: 5	North East: 4	
Crop farmer: 1	South East: 1	Male: 5
Solar grazer: 4	Midwest: 5	Female: 6
Policy: 1	South West: 1	

Drawing from grounded theory methodology [41,43], data collection and data analysis occurred in parallel to strategically shape subsequent inquiry. Responses that emerged in initial interviews instructed the development of ensuing questions, allowing for gradual pursuit and refinement of relevant issues. Interview themes were generally organized around: (1) the participants' experience in agriculture and details of their current operation; (2) experience with and perceptions of agrivoltaics (e.g., attitudes,

opinions, perceived opportunities and barriers); (3) willingness to engage in an agrivoltaic project (e.g., perceived benefits and challenges). Interview protocol matured over time to explicate what agriculture sector professionals perceived as relevant opportunities and barriers to agrivoltaic development.

All interviews were recorded, manually transcribed and analyzed using the qualitative data analysis program NVivo 12 Pro (QSR International, Melbourne, Australia) [44]. Data were studied on a line-by-line basis using a series of coding and analytic induction to explore relationships, patterns and processes. Line-by-line coding is the fundamental step in interview analysis that moves beyond concrete statements to make analytic interpretations [41]. Coding in grounded theory methodology helps anchor analysis to participants' perspectives, explore nuances of meaning, identify implicit and explicit issues, as well as cluster similarities and observe differences among responses [41]. As outlined by Znaniecki [45] and Robinson [46], analytic induction involves identifying patterns, themes and categories in qualitative data in preparation for comparison amongst the varied findings. Employing rigorous, iterative and comparative grounded theory techniques, analysis of these data has captured and condensed the most relevant opportunities and barriers to agrivoltaics according to this sample of agriculture sector professionals.

3. Results

This section organizes findings based on frequency and expressed magnitude of the barriers and opportunities to agrivoltaics as defined by study participants. Both direct quotations (italicized) and analysis of results are presented jointly. Sections 3.2 and 3.3 are aligned with three of the five innovation characteristics defined by Rogers' diffusion of innovations theory [28] (observability, relative advantage and compatibility), which were identified by participants as the most critical when considering the adoption of agrivoltaic technology. These results offer insights into the main challenges to farmer adoption of agrivoltaics and suggest opportunities for interested stakeholders to further diffuse this innovation. A discussion considering the implications of these results is followed in Sections 4 and 5.

3.1. Long-Term Land Productivity and Planning

The underlying fundamental challenge of agrivoltaic systems, as perceived by participants, concerns long-term land viability. Land viability is intrinsically proportionate to the livelihood of agriculturalists, as farmers explained that the quality of their land is of critical importance and cannot be compromised. Interviews with farmers revealed their temporal approach to decision-making as they prioritize the protection of long-term land viability above all. One farmer expressed this concern when considering the use of an agrivoltaic system:

> *I'm concerned too, if you're pouring a bunch of concrete and putting in permanent structures, what does this look like in the end of 20 or 30 years?*

Encompassed within concerns of long-term land viability are more nuanced challenges related to land productivity in the presence of permanent solar panel structures. Participants explained that in order to maintain their agricultural land status and thrive in their farming venture, land must stay actively agricultural. The challenge that permanent solar structures could potentially impose on land productivity was unsettling:

> *Given the permanency of all of the solar panels and the permanency of the size of the plot, maintaining it to be continually productive for the animals would be a challenge. One of the challenges that I foresee is learning how to get the production that you want navigating around all of those structures.*

When considering an agrivoltaic system, participants' concerns were largely technical and economic in nature, reflecting their dependence on land productivity. Considerations about long-term land use and farmland preservation constituted the basis for decision-making, suggesting that anything that jeopardizes land viability will not be tolerated by farmers. Thinking beyond protecting the soil

itself, various participants expressed potential opportunities that agrivoltaic systems could bring to agriculturalists:

> *When we talk about farmland preservation, it's not just about preserving the physical ground, it's also about preserving the viability of the farm. If a farmer is going to go under because of lack of revenue, why wouldn't you want them to open up an additional revenue stream to be able to actually preserve that land?*

> *There's going to be ground that goes into the solar panels and I think the idea that here you can integrate mixed-use with this makes a lot of sense. I think you have to have the right farmers and the right producers that are committed to making some of these things work.*

Participants explained that long-term land viability and productivity implies required long-term planning. When discussing the prospect of engaging in an agrivoltaic project, participants proposed that incorporating some type of land-use agreement or long-term plan would relieve concerns around the future of their farm. Providing certainty of farmland preservation surfaced as a recurring consideration of agrivoltaic adoption, as articulated by one participant:

> *Restoring the land back to what it was having the right land agreements to where when that lease is up, they have to return it to prelease form.*

To address the need for long-term planning and prioritization of agricultural interests, agrivoltaic project contracts are widely used by current stakeholders. As described by interviewees who identify as solar grazers, agrivoltaic contracts provide certainty and prevent against loss for both parties involved. The temporal concerns of agriculturalists with regards to long-term land viability can be reassured by agreement and engagement on both sides, as a solar grazer explains:

> *You can't have any business planning when you have that degree of uncertainty. So, it was getting people to have contracts. What the contract did is give certainty to both sides. It meant the farmers could plan their businesses, because there is a whole bunch of this remote targeted grazing, there's tons of mechanics, tons of money, staffing, and planning around breeding schedules, you name it. And then on the other side you got people wanting to make sure that the insurance is okay, and that their wiring is going to be okay, and how they'll interface with all their service work, the whole picture. I just knew the contract was the first key to the puzzle.*

> *If you don't have a real contract and if you don't have someone really interested engaging in a 10-year kind of way on both sides, the whole thing is not going to work.*

The majority of participants communicated that to the extent that the solar infrastructure of an agrivoltaic project does not threaten long-term land productivity, there are opportunities for increased revenue to farmers and mutually beneficial land-use agreements. These interviews reveal that addressing concerns about the viability of land after project decommissioning and protecting the livelihoods of farmers will involve long-term planning and partnership between agriculture and solar industries. The establishment of agrivoltaic contracts has proven valuable to current solar grazers and provides a direct way to alleviate uncertainties in land-use planning.

3.2. Market (Un)certainty and Observability of Benefits

When considering barriers to farmer adoption of agrivoltaics, economic concerns were raised by participants only second to concerns described above regarding long-term planning for technical considerations. At a basic level, farming is a business, and is thus accompanied by a set of risks, uncertainties and investments. Participants explained that risk is especially unwelcome in the business of farming and that certainty in productivity and security in investment are vital. One participant articulated that the market unknowns are potentially more critical than the technical unknowns of agrivoltaics:

> *There's a lot of unknowns for the producer in this as well. Having established markets, alleviating some of the unknowns and the risks are probably as much of a piece of this as anything. So, sketching out the long-term financial return of like, "Here's what these markets look like for livestock production." And what the guaranteed revenue is for solar panels, for instance. In terms of just making it happen out there in the field, there's some requirements to make that happen, but they aren't insurmountable, I wouldn't imagine.*

Others stressed the need for a secure market for an agrivoltaic system to be successful:

> *You would probably want to package it more as, "Do we have a food and farm system in place that allows somebody to have solar and grow these crops that are tolerant to that condition?" And then importantly, "Do we have a market to send that stuff to?" Because then all of a sudden it becomes this closed loop, kind of circular economy feel to it. But without that end market side of it, I think people would say, "That's great if you want to grow that stuff."*
>
> *As long as the market is there, I would think a lot of these things could work.*

As business owners, considerations of financial return and security in the marketplace are at the forefront of decision-making for farmers. For the majority of participants, the agrivoltaic innovation is unfamiliar and imposes constraints on business planning borne of unknowns and uncertainties. Building flexibility into the system to accommodate for changes in market conditions and farming practice could potentially alleviate some of the concern of uncertainty, as explained:

> *If we're looking at a 25-year kind of investment with the solar panels and when you're talking about integrating them within the livestock species too, that market for livestock might look totally different within 10 years. So, implementing some flexibility there that if we're not going to run rabbits, maybe we're running something else in there in 20 years. But having some flexibility in the system that you could respond to the livestock markets in there as well, I think is important.*

Flexibility and adaptation to changing market conditions emerged as key elements to be incorporated into planning for an agrivoltaic system, highlighting again the temporal component to farmer decision-making and identifying concerns to be addressed for successful adoption. While the future unknowns of market acceptance of a product are difficult to ascertain, participants suggested that integrating flexibility into system design would reduce financial unease.

Coupled with concerns of a stable and reliable market for their product, were expectations for just compensation and tangible benefits from participation in an agrivoltaic project. When considering the adoption of the agrivoltaic innovation, participants also questioned if such an endeavor would be justified in terms of monetary gains. Participants perceived the adoption of such technology as an increased labor commitment and thus expected to reasonably gain from it. When asked if they would engage in an agrivoltaic project, one participant answered:

> *Essentially, they would have to pay me if they wanted me to be there because it's so much work to remediate soil and bring it up to a productive level, especially if this has been formally row cropped conventionally. So, it would really depend on what it had been earlier, how much I trusted the people who were starting this operation, and how much I felt that there would be ease of incorporating it into my schedule. I also think that it's not free pasture, you know what I mean? Even if they didn't charge me a single thing, there would be a lot of investment. So, I'd be going for like- I don't even know- I almost want to see like co-ownership, we own this land together, you get the profits from the solar and I get whatever everything else is. Or putting the solar panels on my own farm and then I get the revenue from the solar panels.*

When judging the adoption of agrivoltaic innovation, participants expressed critical valuations of its worth and asserted that observable and substantial benefits would have to be derived in order

for them to commit. Of the 10 farmers interviewed, four were already engaging with the technology and five others said they would get involved if they would derive more benefit than cost from it. Thus, the vast majority (nine of 10) of the farmers interviewed were open to using or already using agrivoltaics. Improving the agrivoltaic innovation to increase diffusion to these interested farmers will require establishment of just compensation for farmers, as explained by two solar grazers:

> *The biggest misconception to clear up immediately when people start thinking about this is that it can be anything like free grass. Because there's so much commitment on my end, and the cost of setting up all that equipment is very high. The time and labor of going there and servicing the sheep is a big commitment.*

> *I'm really trying to get out of is the idea that the farmer should be doing all this work for free. The solar firms are making—maybe not tons of money—but reasonable amounts of money off these investments. For them, they need to know that the performance guarantee is there, the sun has to shine on their panels, there shouldn't be interference with that. They need that steady assurance. And the farmers need to get paid for recognizing that there is a performance guarantee to meet.*

Participants explained that their willingness to be involved with the agrivoltaic innovation would be contingent on the near-term observability of direct benefits to them and the long-term certainty and security in the marketplace for their product. Observability is an innovation characteristic explained by Rogers (1962) that concerns the degree to which the results of an innovation are visible to potential adopters. When assessing their potential adoption of agrivoltaics, agriculture sector experts framed their considerations in terms of direct and tangible benefits, suggesting that observability of benefits is a characteristic of the agrivoltaic innovation that is of decisive importance to adopters. As discussed by participants in Section 3.1, agrivoltaic contracts are currently recognizing the rights and duties of involved parties, and provide opportunity to establish legitimate, mutually beneficial partnerships. With nine of 10 farmers inclined to partake in an agrivoltaic partnership, the above concerns about economic uncertainty and gains are active considerations for all involved stakeholders in project development.

Relative Advantage

The degree to which agrivoltaics are perceived by participants to be advantageous to current practice was identified as important when considering adoption. While participants expressed that financial compensation for farmers is both necessary and attractive, they also spoke of other benefits they anticipate as a result of engaging with the agrivoltaic technology. Participants discussed potential marketing advantages:

> *It's got a great story; it's got a wonderful marketing edge from that perspective. So, your advantage is a great story to tell from a marketing standpoint.*

> *I think that's where you have a very unfair advantage for whoever would be doing this rabbit production, you might be getting paid for land maintenance and then have rabbits for free. So, your profitability could be way up or your price could be way lower because you wouldn't have land expenses. There's a lot of opportunity to create some advantage from a production standpoint. From that perspective they may sell better or have an [edge] in the marketplace because of that aspect.*

Another participant expressed other technical synergies when grazing animals underneath solar panels:

> *I think it sounds like a great idea. It sounds like a great way to maintain, and not have to mow. I can see the panels providing shade and protection from the rain in a way that seems very valuable.*

Perceiving a multitude of potential benefits, participants speculated how the adoption of the agrivoltaic innovation could provide them benefits and competitive advantages in the marketplace. Foreseeing a unique opportunity to derive a revenue stream from land maintenance, some participants postulated that there were economic gains associated with combined solar and agriculture systems. Rogers' (1962) innovation characteristic, relative advantage, explains that innovations that are perceived to be superior to business as usual have higher potential for adoption. Participants described the relative advantage of agrivoltaics worthwhile, and thus identified this innovation characteristic as critical when considering the adoption of the innovation, suggesting that if an agrivoltaic system could provide an advantage to a farmer, the likelihood of adoption would be greater.

3.3. Compatibility with Current Practice

A considerable opportunity for farmers in agrivoltaic projects is the potential for integration of the innovation into their current practice. Participants expressed disinterest in increased complications in their business, and rather actively seek ways to reduce labor through harnessing the synergies of innovative practices. The ease of integration and compatibility of solar with current production was frequently considered amongst participants, highlighting the opportunity to plan overlapping operations to increase farmer acceptance. The attractiveness of agrivoltaic integration was explained by two participants:

> *Most of my exposure to this is from sheep, and I think that it's a great idea. For my own particular system, it would definitely reduce the amount of labor for one aspect of the system, which is moving the fencing. So, I'm all for it. I think it'd be a really nice mesh.*

> *Alternative energy is expensive to people like us. But it's something that I guess, if it could be integrated into something I'm already doing and could potentially help protect the animals, or do whatever, and then also run the homestead, it's just another perk of having something like that. It's another reason to have it besides just having the electricity.*

As elucidated by participants, compatibility of the agrivoltaic innovation with current practice could reduce labor and create an incentive to engage in the technology. When considering the value of agrivoltaics to them personally, farmers offered calculated and context-dependent perspectives, making judgments on the benefits in terms of their own operation rather than speaking generally about dual-use solar systems. Speaking from a place of personal considerations and interests, participants revealed that there is a context-dependent nature of success for agrivoltaic projects. Reflecting their own practices, one participant stated:

> *I've also heard them say in meetings the fact that we're going to farm soybeans underneath solar panels, which is just asinine. Like, it's not going to happen. The size of our equipment doesn't permit that kind of thing. Putting livestock under, kind of a grazing operation, seems to make sense.*

Compatibility with current practice not only includes size of equipment, but also scale of the farming operation, as explained by one participant:

> *The work that would be involved with that, I think, or potentially having to hire someone to manage them, it would decrease our profit so much that it wouldn't make sense. I could see how that would be to someone's benefit though, but not at our scale.*

To justify the labor involved in engaging in an agrivoltaic project, farmers evaluated their own enterprise by mentally applying the innovation and determining the potential compatibilities. As suggested by participants, the benefits of agrivoltaics are noteworthy, but will only be fully realized if there is ease of integration into their current farming practice. Compatibility is an innovation characteristic defined by Rogers (1962) that explains the degree to which an innovation is perceived to be consistent with needs, norms and sociocultural values is decisive to potential adopters. The theme

of compatibility among most participants was viewed as an opportunity rather than a barrier for agrivoltaics, suggesting that the innovation's context-dependent nature provides flexibility and potential to leverage the solar system to derive synergistic benefits to compliment current farming practices.

4. Discussion: The Opportunities & Barriers for Agrivoltaic Diffusion

This research provides insight from the agricultural sector into the challenges and opportunities for farmer adoption of the agrivoltaic innovation. Results indicate that participants see potential benefits for themselves in combined solar and agriculture technology and identify barriers to adoption including desired certainty of long-term land productivity, market potential and just compensation, as well as the need for predesigned system flexibility to accommodate different scales of operation and adjustment to changing farming practice. The findings suggest that these barriers to adoption are not insurmountable and can be sufficiently addressed through prudent planning and mutually beneficial land agreements between solar and agriculture sector actors. Table 2 below organizes the identified barriers and opportunities to address them. All of the participants of this study assented to agrivoltaics as a synergistic and innovative approach to combined land-uses, while nine of the 10 participants who are currently active farmers stated they would engage in the use of a dual-use system given the discussed concerns are considered (four of the nine already are). Interviews with industry professionals informed the current state of diffusion of the agrivoltaic innovation and identified opportunities to further stimulate farmer adoption of the technology. These findings may be used to translate the potential of agrivoltaics to address the competition for land between solar PV and agriculture into changes in solar siting, farming practice and land-use decision-making.

Table 2. Barriers, opportunities, and directions for future work regarding the diffusion of agrivoltaics.

Barrier	Opportunity	Future Work
End-of-life impacts from solar infrastructure	-Driven piles (constructed of galvanized steel I-beams, channel-shaped steel or posts), helical piles (galvanized steel posts with split discs welded to the bottom at an angle) and ground screws (galvanized steel posts with welded or machined threads) can be removed and recycled [47,48]. -Photovoltaic (PV) racking can be put on removeable ballasted foundations or skids of precast or poured-in-place concrete ballasts to minimize land disturbances [47]. -Impacts from modules such as leaching of trace metals [49–51] and compromised future agricultural productivity [52] have been proven highly unlikely. -Contracted agreements that establish plans to return land back to prelease form after decommissioning of solar system.	-Empirical research investigating the magnitude of long-term impacts of solar infrastructure on land (e.g., [53]), soil, and pasture-grass productivity.
Permanent structures interfering with agricultural production and future farming practice	-A variety of plants have proven to maintain higher soil moisture, greater water efficiency, and experience increase in late season biomass underneath PV panels [54]. -Improvements in water productivity and additional shading are projected to increase crop production in arid regions experiencing climate change [55]. -Semitransparent PV [56] (Thompson et al., 2020) or vertical bifacial PV [57]. -Raised racking systems provide clearance for agricultural equipment, which could allow for nearly any crop to be used in agrivoltaic production [58]. -Design flexible open source racking systems [59,60] that have adjustable panel height, tilt angle and spacing [61], as well as a combination of permanent and portable fencing. -East-west tracking array configurations allow optimal conditions for plant growth when compared to conventional south-facing designs [62].	-Empirical research aimed at understanding the implications of solar PV infrastructure on perennial pasture grass maintenance. -Optimized agrivoltaic PV -Cost-benefit analysis of open source PV racking systems designed with adjustable panel height, tilt angle and spacing. -Cost-benefit analysis of permanent and portable fencing for animal grazing agrivoltaics.

Table 2. *Cont.*

Barrier	Opportunity	Future Work
Uncertainties in operation and business planning	-Legitimate partnerships and contracts that establish up-front costs and compensation for both parties -Local government policy aimed at supporting development of solar PV [63,64] -Education and outreach from PV industry to farming industry to reduce barriers to knowledge and increase trust.	-Policy research focused on market mechanisms to incentivize agrivoltaic systems for both solar and agriculture sector. -Increased efforts from university extension programs to increase information sharing and partnership between energy and agriculture.

4.1. Diffusing the Agrivoltaic Innovation—Where Are We Now?

The diffusion of innovations theory [28] identifies five stages in the process of technology adoption. Participants of this study predominantly fell into the decision or evaluation stage of adoption, which is understood as the stage in which an individual mentally applies an innovation to their present and perceived future circumstances to arrive at a decision to try it or not. Beyond the initial knowledge or interest stages of Rogers' adoption model [28], the majority of participants (six of 11) considered their potential adoption of agrivoltaics beneficial but dependent on factors related to context. Speaking from a place of receptivity, these participants saw value in the innovation and felt inclined to engage with it, while voicing a few concerns about compatibility with their practice and uncertainties about long-term land productivity. Four of the 11 participants were already functioning in the confirmation or adoption stage of the adoption process, making full use of the innovation. Based on these findings, it is observed that the current state of the diffusion of agrivoltaics is advancing towards wider implementation and has surpassed initial phases of information gathering and persuasion. Participants in the decision or evaluation stage of adoption identified barriers to their engagement with agrivoltaics, giving interested stakeholders the ability to directly respond to these concerns by improving the technology to enable further diffusion.

Further, most participants of this study were early majority adopters, characterized by wanting proven and reliable applications, reference from trusted peers and being prudent in financial risk and uncertainty. Rogers [28] asserts that an innovation must meet the needs of all categories of adopters, making clear in the context of agrivoltaic adoption where efforts should be focused to successfully move early majority adopters into acceptance of the innovation. Technological diffusion is a process of filtering, tailoring and accepting [30], and the identified concerns of the agriculture sector professionals in this study can be used to tailor or refine the technology to increase adoption among farmers. The following section will elaborate upon the critical characteristics of agrivoltaic systems as identified by participants and suggest recommendations for improvement with the intention of facilitating accelerated diffusion.

4.2. Diffusing the Agrivoltaic Innovation—What Needs to Happen?

Rogers [28] posited that there are five distinct innovation characteristics that help explain why some innovations are widely accepted and some are not. Understanding the characteristics of the agrivoltaic innovation is valuable for interested stakeholders when assessing areas for improvement and pursuing further acceptance of the technology. The results of this study identify the most critical characteristics of agrivoltaics and point to opportunities to directly respond to farmers concerns.

Of these five characteristics, observability of benefits, relative advantage and compatibility with current practice were identified by participants as the most critical when considering their personal adoption of the agrivoltaic technology. What this means for further diffusion is that the solar industry actors involved in the development of agrivoltaic systems must devise mutually beneficial land agreements with farmers that establish compensation for their labor, articulate plans for land restoration after the decommissioning of the system and be sensitive to contextual differences among agriculturalists by designing a system that is flexible enough to meet the needs of the current and

future users. Participants in this study saw immediate value in personal adoption of the technology but sought long-term security in terms of farmland preservation and financial return.

There are a handful of practical actions to be taken to enable further diffusion of agrivoltaics. Table 2 presents a summary of the identified barriers, existing opportunities to overcome them and directions for future work. First, the establishment of agrivoltaic contracts has proven valuable to current solar grazers. Robust and forward-thinking land use agreements will provide a direct way to alleviate uncertainties in land-use planning and secure compensation for farmer's labor. Second, system designers need to integrate flexibility in design by accommodating current land practices and allowing for future changes. Concerns about market uncertainty and rigid systems can be addressed by crafting a combined solar and agricultural project that is adaptable to changing market and farming conditions. Third, agrivoltaics systems should be designed with compatibility in mind. By strategically harnessing the synergy of compatibility with current practice, these results suggest that farmers would be more inclined to engage with a project if it generated advantages in their operation. Being sensible in scaling a system to current practice, rather than creating increased labor burden on farmers, will increase the likelihood of their participation with the technology.

The potential for increased utilization of the agrivoltaic technology is ripe. While previous research has demonstrated its technical viability, this study recognizes that technology innovations exist within a social context and thus depend upon social acceptance and adoption. It is concluded that continued farmer adoption of agrivoltaics is likely, yet contingent on observable benefits in farming practice and assurance of financial gain. Future research should investigate how perceptions vary across geographic regions and agriculture professions (i.e., animal versus crop farming) to study the unique opportunities and barriers for agrivoltaics in the context of local climate and agricultural practice. Increased education and outreach concerning the end-of-life impacts, negligible effects of solar PV on agricultural productivity and potential for agrivoltaic systems to protect crop production during climate change, is necessary to inform and stimulate further farmer adoption. Empirical experimental research should investigate the long-term impacts of solar PV infrastructure on perennial pasture grasses to better understand the possible effects of agrivoltaic systems on future grazing productivity. Economic cost-benefit analysis will be valuable for quantifying the potential cost disadvantages of designing flexible PV arrays that can be adjusted to accommodate different panel heights and spacing requirements. Future policy research can investigate the role of market mechanisms, such as incentives, in prompting further development of agrivoltaics. Based on these findings, policy makers should consider implementing financial instruments that stimulate both solar and agriculture sector adoption of the technology, while building flexibility into such policies to allow diverse, innovative and contextually appropriate system designs. To do this, agrivoltaic proponents can model their efforts on the successful diffusion of wind farm/solar farm integration that focuses on local support [65,66]. Previous research examining diffusion of solar as an innovation among residential adopters highlighted the role of communities of information sharing for promoting adoption [67]. The study presented here is unique in examining the diffusion of agrivoltaic solar innovation as a community level consideration, but also demonstrates how diffusion of innovation can occur within a social context. Moving forward, placing the agrivoltaic technology in a social context will be essential to identify the barriers to its diffusion and will offer relevant solutions to increase its adoption.

5. Conclusions

Agrivoltaic systems are a strategic and innovative approach to combine renewable energy with agricultural production. Recognizing the fundamental importance of farmer adoption in the successful diffusion of agrivoltaics, this study investigates agriculture sector experts' perceptions on the opportunities and barriers to dual land-use systems. Results indicate that participants saw potential benefits for themselves in combined solar and agriculture technology and identified barriers to adoption including desired certainty of long-term land productivity, market potential and just compensation, as well as the need for predesigned system flexibility to accommodate different scales

and types of operations and adjustment to changing farming practice. The identified concerns of the agriculture sector professionals in this study can be used to refine the technology to increase adoption among farmers and to translate the potential of agrivoltaics to address the competition for land between solar PV and agriculture into changes in solar siting, farming practice and land-use decision-making. Ultimately, building integrated energy and food systems can increase global land productivity, minimize agricultural displacement and reduce greenhouse gas emissions from fossil fuels. Informed and concerted efforts at enabling further diffusion of this innovation are imperative for meeting growing demands for energy and food simultaneously.

Author Contributions: Conceptualization, C.S. and J.M.P.; methodology, A.S.P. and C.S.; validation, A.S.P. and C.S.; formal analysis, A.S.P. and C.S.; investigation, A.S.P.; resources, C.S. and J.M.P.; data curation, A.S.P.; writing—original draft preparation, A.S.P.; writing—review and editing, A.S.P., C.S. and J.M.P.; supervision, C.S. and J.M.P.; project administration, J.M.P.; funding acquisition, C.S. and J.M.P. All authors have read and agreed to the published version of the manuscript.

Funding: This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technology Office Award Number DE-EE0008990 and the Witte Endowment.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A

Initial interview protocol as approved by IRB

1. Please tell me about your experience as a farmer.
    a. What is your geographic location?
    b. How long have you been doing it?
2. Who [markets, restaurants] are your biggest customers?
    a. How do you go about opening new accounts with potential customers?
    b. What is your greatest barrier to gaining access to new markets/customers?
3. How large is your operation? Would you consider it small-medium-large?
4. Are you familiar with both crop and animal farmers that incorporate solar panels on their land?
    a. If so, what are your thoughts on this?
5. Would you ever consider embracing the mixed-use of solar on your farm to harness co-benefits of solar energy generation and agricultural production?
    a. If so, why?
        i. What is your minimum acceptable rate of return?
    b. It not, why?
        i. What type of barriers are there?

6. Would you consider renting land on a prefenced solar-farm meant for agricultural production?
    a. If so, why?
        i. What is your minimum acceptable rate of return?
    b. It not, why?
        i. What type of barriers are there?
7. What is needed to make a mixed-use solar farm more attractive to you?
8. A new study that is sponsored by the D.O.E. has shown an opportunity to incorporate rabbit farming with solar photovoltaic farms that make electricity. This study has shown substantial economic opportunity from this mixed-use scheme: upwards of 24% increase in site revenue. Now I would like to ask you specifically about mixed-use solar involving farmed meat rabbits.
    a. What do you think are the biggest opportunities for this kind of mixed-use solar development?
    b. What do you think are the biggest barriers for this kind of mixed -use solar development?
9. Do you anticipate solar farm pasture-raised livestock selling for a premium or increasing sales?
10. Is there anything else you would like to tell me about your perspectives of mixed-use solar PV development?
11. Do you have suggestions of other experienced farmers I should speak with?

References

1. Ciais, P.; Sabine, C.; Bala, G.; Bopp, L.; Brovkin, V.; Canadell, J.; Chhabra, A.; DeFries, R.; Galloway, J.; Heimann, M.; et al. Carbon and Other Biogeochemical Cycles. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2013.
2. Dupraz, C.; Marrou, H.; Talbot, G.; Dufour, L.; Nogier, A.; Ferard, Y. Combining solar photovoltaic panels and food crops for optimising land use: Towards new agrivoltaic schemes. *Renew. Energy* **2011**, *36*, 2725–2732. [CrossRef]
3. Dinesh, H.; Pearce, J.M. The potential of agrivoltaic systems. *Renew. Sustain. Energy Rev.* **2016**, *54*, 299–308. [CrossRef]
4. Mavani, D.D.; Chauhan, P.M.; Joshi, V. Beauty of Agrivoltaic System regarding double utilizati on of same piece of land for Generation of Electricity & Food Production. *Int. J. Sci. Eng. Res.* **2019**, *10*.
5. Calvert, K.; Mabee, W. More solar farms or more bioenergy crops? Mapping and assessing potential land-use conflicts among renewable energy technologies in eastern Ontario, Canada. *Appl. Geogr.* **2015**, *56*, 209–221. [CrossRef]
6. Mow, B. Solar Sheep and Voltaic Veggies: Uniting Solar Power and Agriculture|State, Local, and Tribal Governments|NREL [WWW Document], n.d. URL. 2018. Available online: https://www.nrel.gov/state-local-tribal/blog/posts/solar-sheep-and-voltaic-veggies-uniting-solar-power-and-agriculture.html (accessed on 2 July 2020).
7. Adeh, E.H.; Good, S.P.; Calaf, M.; Higgins, C.W. Solar PV Power Potential is Greatest Over Croplands. *Sci. Rep.* **2019**, *9*, 11442. [CrossRef]
8. Renewable Energy World (REW). Getting Out of the Weeds: How to Control Vegetative Growth under Solar Arrays. 2014. Available online: https://www.renewableenergyworld.com/articles/2014/07/weed-control-at-solar-installations-what-works-best.html (accessed on 7 February 2020).
9. Ouzts, E. Farmers, Experts: Solar and Agriculture 'Complementary, not Competing' in North Carolina [WWW Document]. Energy News Network. 2017. Available online: https://energynews.us/2017/08/28/southeast/farmers-experts-solar-and-agriculture-complementary-not-competing-in-north-carolina/ (accessed on 2 July 2020).
10. Andrew, A.C. *Lamb Growth and Pasture Production in Agrivoltaic Production System*; Oregon State University: Corvallis, OR, USA, 2020.

11. Dunbar, E. Pollinator-Friendly Solar Energy Becomes the Norm in Minnesota. 2019. Available online: https://www.mprnews.org/story/2019/06/20/pollinatorfriendly-solar-energy-becomes-the-norm-in-minnesota (accessed on 23 September 2020).
12. Lytle, W.; Meyer, T.K.; Tanikella, N.G.; Burnham, L.; Engel, J.; Schelly, C.; Pearce, J.M. Conceptual Design and Rationale for a New Agrivoltaics Concept: Pastured-Raised Rabbits and Solar Farming. *J. Clean. Prod.* **2020**, 124476. [CrossRef]
13. Pringle, A.M.; Handler, R.M.; Pearce, J.M. Aquavoltaics: Synergies for dual use of water area for solar photovoltaic electricity generation and aquaculture. *Renew. Sustain. Energy Rev.* **2017**, *80*, 572–584. [CrossRef]
14. Amaducci, S.; Yin, X.; Colauzzi, M. Agrivoltaic systems to optimize land use for electric energy production. *Appl. Energy* **2018**, *220*, 545–561. [CrossRef]
15. Sekiyama, T.; Nagashima, A. Solar Sharing for Both Food and Clean Energy Production: Performance of Agrivoltaic Systems for Corn, A Typical Shade-Intolerant Crop. *Environments* **2019**, *6*, 65. [CrossRef]
16. Marrou, H.; Wery, J.; Dufour, L.; Dupraz, C. Productivity and radiation use efficiency of lettuces grown in the partial shade of photovoltaic panels. *Eur. J. Agron.* **2013**, *44*, 54–66. [CrossRef]
17. Elamri, Y.; Cheviron, B.; Lopez, J.M.; Dejean, C.; Belaud, G. Water budget and crop modelling for agrivoltaic systems: Application to irrigated lettuces. *Agric. Water Manag.* **2018**, *208*, 440–453. [CrossRef]
18. Ravi, S.; Macknick, J.; Lobell, D.; Field, C.; Ganesan, K.; Jain, R.; Elchinger, M.; Stoltenberg, B. Colocation opportunities for large solar infrastructures and agriculture in drylands. *Appl. Energy* **2016**, *165*, 383–392. [CrossRef]
19. Malu, P.R.; Sharma, U.S.; Pearce, J.M. Agrivoltaic potential on grape farms in India. *Sustain. Energy Technol. Assess.* **2017**, *23*, 104–110. [CrossRef]
20. Marrou, H.; Guilioni, L.; Dufour, L.; Dupraz, C.; Wéry, J. Microclimate under agrivoltaic systems: Is crop growth rate affected in the partial shade of solar panels? *Agric. For. Meteorol.* **2013**, *177*, 117–132. [CrossRef]
21. Santra, P.; Pande, P.C.; Kumar, S.; Mishra, D.; Singh, R.K. Agri-voltaics or Solar farming-the Concept of Integrating Solar PV Based Electricity Generation and Crop Production in a Single Land use System. *Int. J. Renew. Energy Res.* **2017**, *7*, 694–699.
22. Barron-Gafford, G.A.; Pavao-Zuckerman, M.A.; Minor, R.L.; Sutter, L.F.; Barnett-Moreno, I.; Blackett, D.T.; Thompson, M.; Dimond, K.; Gerlak, A.K.; Nabhan, G.P.; et al. Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands. *Nat. Sustain.* **2019**, *2*, 848–855. [CrossRef]
23. Guerin, T.F. Impacts and opportunities from large-scale solar photovoltaic (PV) electricity generation on agricultural production. *Environ. Qual. Manag.* **2019**. [CrossRef]
24. Nonhebel, S. Renewable energy and food supply: Will there be enough land? *Renew. Sustain. Energy Rev.* **2005**, *9*, 191–201. [CrossRef]
25. Marcheggiani, E.; Gulinck, H.; Galli, A. Detection of Fast Landscape Changes- The Case of Solar Modules on Agricultural Land. In *International Conference on Computational Science and Its Applications*; Springer: Berlin/Heidelberg, Germany, 2013; pp. 315–327.
26. U.S. Department of Energy (DOE). *SunShot Vision Study (Rep.)*. Available online: https://www.energy.gov/sites/prod/files/2014/01/f7/47927.pdf (accessed on 24 February 2020).
27. Brudermann, T.; Reinsberger, K.; Orthofer, A.; Kislinger, M.; Posch, A. Photovoltaics in agriculture: A case study on decision making of farmers. *Energy Policy* **2013**, *61*, 96–103. [CrossRef]
28. Rogers, E. *Diffusion of Innovations*, 1st ed.; Free Press: New York, NY, USA, 1962.
29. Robertson, T.S. The process of innovation and the diffusion of innovation. *J. Mark.* **1967**, *31*, 14–19. [CrossRef]
30. Grübler, A. Time for a change: On the patterns of diffusion of innovation. *Daedalus* **1996**, *125*, 19–42.
31. Coleman, J.; Katz, E.; Menzel, H. The diffusion of an innovation among physicians. *Sociometry* **1957**, *20*, 253–270.
32. Mansfield, E. Technical change and the rate of imitation. *Econom. J. Econom. Soc.* **1961**, *29*, 741–766. [CrossRef]
33. Shipan, C.R.; Volden, C. The mechanisms of policy diffusion. *Am. J. Political Sci.* **2008**, *52*, 840–857. [CrossRef]
34. Wilson, C.; Grübler, A. Lessons from the History of Technological Change for Clean Energy Scenarios and Policies. In *Natural Resources Forum*; Blackwell Publishing Ltd.: Oxford, UK, 2011; Volume 35, pp. 165–184.
35. Goetz, J.P.; LeCompte, M.D. *Ethnography and Qualitative Design in Educational Research*; Academic Press: New York, NY, USA, 1984.
36. Strauss, A.; Corbin, J. *Basics of Qualitative Research-Grounded Theory Procedures and Techniques*; Sage Publications: Newbury Park, CA, USA, 1990.

37. Fusch, P.I.; Ness, L.R. Are we there yet? Data saturation in qualitative research. *Qual. Rep.* **2015**, *20*, 1408.
38. Corbin, J.; Strauss, A. Theoretical sampling. In *Basics of Qualitative Research*; SAGE Publications: Thousand Oaks, CA, USA, 2008.
39. Lindlof, T.R.; Taylor, B.C. Sensemaking: Qualitative data analysis and interpretation. *Qual. Commun. Res. Methods* **2011**, *3*, 241–281.
40. Biernacki, P.; Waldorf, D. Snowball sampling: Problems and techniques of chain referral sampling. *Sociol. Methods Res.* **1981**, *10*, 141–163. [CrossRef]
41. Charmaz, K. *Constructing Grounded Theory*; SAGE Publications: Thousand Oaks, CA, USA, 2014.
42. Bhattacherjee, A. *Social Science Research: Principles, Methods, and Practices*; Open University Press: Tampa Bay, FL, USA, 2012.
43. Charmaz, K.; Belgrave, L.L. Grounded Theory. In *The Blackwell Encyclopedia of Sociology*; Blackwell Publications: Malden, MA, USA, 2007.
44. Unlock Insights in Your Data with Powerful Analysis. QSR International. NVivo (Version 12.0 Pro) [Computer Software]. Available online: https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home (accessed on 11 May 2020).
45. Znaniecki, F. *The Method of Sociology*; SAGE Publications: Thousand Oaks, CA, USA, 1934.
46. Robinson, W.S. The logical structure of analytic induction. *Am. Sociol. Rev.* **1951**, *16*, 812–818. [CrossRef]
47. Lorenz, E. Types of PV Racking Ground Mounts. 2016. Available online: https://www.cedgreentech.com/article/types-pv-racking-ground-mounts (accessed on 14 October 2020).
48. Turney, D.; Fthenakis, V. Environmental impacts from the installation and operation of large-scale solar power plants. *Renew. Sustain. Energy Rev.* **2011**, *15*, 3261–3270. [CrossRef]
49. Fthenakis, V. *Could CdTe PV Modules Pollute the Environment?* National Photovoltaic Environmental Health and Safety Assistance Center, Brookhaven National Laboratory: Upton, NY, USA, 2002.
50. *Potential Health and Environmental Impacts Associated with the Manufacture and Use of Photovoltaic Cells*; EPRI: Palo Alto, CA, USA; California Energy Commission: Sacramento, CA, USA, 2003.
51. NC Clean Energy Technology Center. Balancing Agricultural Productivity with Ground-Based Solar Photovoltaic (PV) Development. 2017. Available online: https://energizeohio.osu.edu/sites/energizeohio/files/imce/Handout_Balancing-Ag-and-Solar-final-version-update.pdf (accessed on 14 October 2020).
52. Armstrong, A.; Ostle, N.; Whitaker, J. Solar Park Microclimate and Vegetation Management Effects on Grassland Carbon Cycling. *Environ. Res. Lett.* **2016**, *11*, 074016. [CrossRef]
53. Hernandez, R.R.; Hoffacker, M.K.; Murphy-Mariscal, M.L.; Wu, G.C.; Allen, M.F. Solar energy development impacts on land cover change and protected areas. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, 13579–13584. [CrossRef] [PubMed]
54. Hassanpour Adeh, E.; Selker, J.S.; Higgins, C.W. Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency. *PLoS ONE* **2018**, *13*, e0203256. [CrossRef] [PubMed]
55. Weselek, A.; Ehmann, A.; Zikeli, S.; Lewandowski, I.; Schindele, S.; Högy, P. Agrophotovoltaic systems: Applications, challenges, and opportunities. A review. *Agron. Sustain. Dev.* **2019**, *39*, 25. [CrossRef]
56. Thompson, E.; Bombelli, E.L.; Simon, S.; Watson, H.; Everard, A.; Schievano, A.; Bocchi, S.; Zand Fard, N.; Howe, C.J.; Bombelli, P. Tinted semi-transparent solar panels for agrivoltaic installation. *Adv. Energy Mater.* **2020**, *10*, 1614–6840. [CrossRef]
57. Riaz, M.H.; Younas, R.; Imran, H.; Alam, M.A.; Butt, N.Z. Module Technology for Agrivoltaics: Vertical Bifacial vs. Tilted Monofacial Farms. *arXiv* **2019**, arXiv:1910.01076.
58. REM TEC (Revolution Energy Maker TEC). 2017. Available online: http://www.remtec.energy/en/#agrovoltaico; https://www.youtube.com/watch?v=gmbfb4vZOuQ (accessed on 14 October 2020).
59. Buitenhuis, A.J.; Pearce, J.M. Open-source development of solar photovoltaic technology. *Energy Sustain. Dev.* **2012**, *16*, 379–388. [CrossRef]
60. Wittbrodt, B.; Pearce, J.M. 3-D printing solar photovoltaic racking in developing world. *Energy Sustain. Dev.* **2017**, *36*, 1–5. [CrossRef]
61. Denholm, P.; Margolis, R.M. *Impacts of Array Configuration on Land-Use Requirements for Large-Scale Photovoltaic Deployment in the United States (No. NREL/CP-670-42971)*; National Renewable Energy Lab (NREL): Golden, CO, USA, 2008.

62. Perna, A.; Grubbs, E.K.; Agrawal, R.; Bermel, P. Design Considerations for Agrophotovoltaic Systems: Maintaining PV Area with Increased Crop Yield. In Proceedings of the 2019 IEEE 46th Photovoltaic Specialists Conference (PVSC), Chicago, IL, USA, 19 June 2019; pp. 0668–0672.
63. Prehoda, E.; Pearce, J.M.; Schelly, C. Policies to overcome barriers for renewable energy distributed generation: A Case study of utility structure and regulatory regimes in Michigan. *Energies* **2019**, *12*, 674. [CrossRef]
64. Corwin, S.; Johnson, T.L. The role of local governments in the development of China's solar photovoltaic industry. *Energy Policy* **2019**, *130*, 283–293. [CrossRef]
65. Mulvaney, K.K.; Woodson, P.; Prokopy, L.S. A tale of three counties: Understanding wind development in the rural Midwestern United States. *Energy Policy* **2013**, *56*, 322–330. [CrossRef]
66. Groth, T.M.; Vogt, C.A. Rural wind farm development: Social, environmental and economic features important to local residents. *Renew. Energy* **2014**, *63*, 1–8. [CrossRef]
67. Schelly, C. Residential solar electricity adoption: What motivates, and what matters? A case study of early adopters. *Energy Res. Soc. Sci.* **2014**, *2*, 183–191. [CrossRef]